

Encyclopedia of Public Health

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Encyclopedia of Public Health

Edited by Lester Breslow

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DARWIN, CHARLES ROBERT

Now recognized as a towering figure in the study of biology, Charles Darwin had an undistinguished academic career during his own lifetime. Though he barely scraped through his degree at Cambridge, Darwin was interested in natural history from early childhood. From 1831 to 1836, he served as naturalist on HMS *Beagle*, a small ship that circumnavigated the world, surveying to enhance the quality of navigational charts and gathering scientific specimens for the advancement of natural history. Darwin's account of the voyage of the *Beagle* was a literary success but contained little hint of the paradigm shift in biological thought for which Darwin soon became notorious. Darwin reflected for over twenty years after returning from his travels, and before publishing *On the Origin of Species by Means of Natural Selection* (1859). In this and later works, Darwin developed his theory of evolution by drawing upon his empirical observations of wildlife, fossils, and the complex relationships of localized variations in the anatomy of birds, butterflies, lizards, and other animals to their environment. Darwin's theory outraged orthodox religious beliefs in the creation (based on the myths described in Genesis that God had created the world and all that lived in it in seven days). For a time, he was reviled by a large proportion of the British establishment, but his supporters, including the eminent physician and biologist Thomas Huxley (1825–1895), encouraged him and scientific evidence eventually prevailed. Much further support for Darwin's theory of evolution is contained in his prolific writings

after the *Origin of Species*. Evolution can no longer be described as a mere theory. There is such a huge body of hard scientific evidence, including much recently acquired support from molecular genetics, that evolution may be considered a fundamental fact of life.

JOHN M. LAST

DATA SOURCES AND COLLECTION METHODS

Health data are the facts that, when assembled and analyzed, yield the information required by health care planners, providers, and users in order to maintain effective and efficient public health services. Potential sources of information about health are numerous and diverse, but in practice four main sources are used: medical records, certificates of vital and other health-related events, responses in surveys, and facts obtained in the course of conducting research. An interesting fifth source, unobtrusive data, is also considered here.

MEDICAL RECORDS

Even the simplest medical records contain something in each of the following categories:

1. Personal identifying data: name, age (birth date), sex, and so on.
2. Socio-demographic data: sex, age, occupation, place of residence.

3. Clinical data: medical history, investigations, diagnoses, treatment regimens.
4. Administrative data: referrals, sites of care.
5. Economic data: insurance coverage, method of payment.
6. Behavioral data: adherence to the recommended regimen (or otherwise).

In modern clinics and hospitals, and in many public health departments, data in each of these categories can be found in the records of individuals who have received services there, but not all the data are in the same file. Administrative and economic data are usually in separate files from clinical data; both are linked by personal identifying information. Behavioral information, such as the fact that an individual did not obtain prescribed medication or fails to keep appointments can be extracted by linking facts in a clinical record with the records of medications dispensed and/or appointments kept. Records in hospitals and clinics are mostly computer-processed and stored, so it is technically feasible to extract and analyze the relevant information, for instance, occupation, diagnosis, and method of payment for the service that was provided, or behavioral information. Such analyses are often conducted for routine or for research purposes, although there are some ethical constraints to protect the privacy and preserve the confidentiality of individuals.

RECORDS OF BIRTHS AND DEATHS

Vital records (certifications of births and deaths) are similarly computer-stored and can be analyzed in many ways. Collection of data for birth and death certificates relies on the fact that recording of both births and deaths is a legal obligation—and individuals have powerful reasons, including financial incentives such as collection of insurance benefits, for completing all the formal procedures for certification of these vital events. The paper records that individuals require for various purposes are collected and collated in regional and national offices, such as the U.S. National Center for Health Statistics, and published in monthly bulletins and annual reports. Birth certificates record details such as full name, birthdate, names and ages of parents, birthplace, and birthweight. These items of information can be used to construct a unique sequence of numbers and alphabet

letters to identify each individual with a high degree of precision. Death certificates contain a great deal of valuable information: name at birth as well as at death, age, sex, place of birth as well as death, and cause of death. The personal identifying information can be used to link the death certificate to other health records. The reliability of death certificate data varies according to the cause and place: Deaths in hospitals have usually been preceded by a sufficient opportunity for investigations to yield a reliable diagnosis, but deaths at home may be associated with illnesses that have not been investigated, so they may have only patchy and incomplete old medical records or the family doctor's working diagnosis, which may be no more than an educated guess. Deaths in other places, such as on the street or at work, are usually investigated by a coroner or medical examiner, so the information is reasonably reliable. Other vital records, for example, marriages and divorces and dissolution of marriages, have less direct utility for health purposes but do shed some light on aspects of social health.

HEALTH SURVEYS

Unlike births and deaths, health surveys are experienced by only a sample of the people; but if it is a statistically representative sample, inferences about findings can be generalized with some confidence. Survey data may be collected by asking questions either in an oral interview or over the telephone, or by giving the respondents a written questionnaire and collecting their answers. The survey data are collated, checked, edited for consistency, processed and analyzed generally by means of a package computer program. A very wide variety of data can be collected this way, covering details such as past medical events, personal habits, family history, occupation, income, social status, family and other support networks, and so on. In the U.S. National Health and Nutrition Surveys, physical examinations, such as blood pressure measurement, and laboratory tests, such as blood chemistry and counts, are carried out on a subsample.

Records of medical examinations on school children, military recruits, or applicants for employment in many industries are potentially another useful source of data, but these records tend to be scattered over many different sites and it is

logistically difficult to collect and collate them centrally.

HEALTH RESEARCH DATA

The depth, range, and scope of data collected in health is diverse and complex, so it cannot be considered in detail here. Research on fields as diverse as biochemistry, psychology, genetics, and sports physiology have usefully illuminated aspects of population health, but the problem of central collection and collation and of making valid generalizations reduces the usefulness of most data from health-related research for the purpose of delineating aspects of national health.

UNOBTUSIVE DATA SOURCES AND METHODS OF COLLECTION

Unobtrusive methods and indirect methods can be a rich source of information from which it is sometimes possible to make important inferences about the health of the population or samples thereof. Economic statistics such as sales of tobacco and alcohol reveal national consumption patterns; counting cigarette butts in school playgrounds under collected conditions is an unobtrusive way to get a very rough measure of cigarette consumption by school children. Calls to the police to settle domestic disturbances provide a rough measure of the prevalence of family violence. Traffic crashes involving police reports and/or insurance claims reveal much about aspects of risk-taking behavior, for example, the dangerous practice of using cell phones while driving. These are among many examples of unobtrusive data sources, offered merely to illustrate the potential value of this approach.

JOHN M. LAST

(SEE ALSO: *Birth Certificates; Certification of Causes of Death; National Health Surveys; Record Linkage; Registries; Vital Statistics*)

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DAYCARE

See Child Care, Daycare

DEAFNESS

See Hearing Disorders

DEATH CERTIFICATES

See Certification of Causes of Death

DEATH RATES

See Mortality Rates

DECENTRALIZATION AND COMMUNITY HEALTH

Decentralization is the process of redistributing administrative authority, and sometimes resources, to local communities for planning, program management, and evaluation. Since the early 1960s in the United States and the mid-1970s in Canada, there have been notable efforts to shift decision-making authority away from central governments to the local level in the area of community health.

Decentralization of public health and health planning is intended to facilitate public participation; provide greater local and personal control over the determinants of health; and spur cooperative, intersectoral action among coalitions of stakeholders at the local level. Demands for less involvement of "big government" in local issues and a desire for self-determination fueled the decentralization movement. By bringing decision making closer to home and involving local people, decentralized approaches were expected to result in more appropriate decisions about public health and health planning within local communities. Decentralization was also intended to enhance democratic principles and community

empowerment, and to boost local people's autonomy and capacity to take control over the determinants of their own health.

By increasing the decision-making power of local communities, decentralized public health and health-planning systems place greater fiscal responsibility for health on local governments and agencies. In the United States and Canada, decentralization of responsibility was achieved while leaving intact most of the highly centralized national, state, and provincial taxation and corporate-financing mechanisms. Since the establishment of block grants in the United States in the mid-1980s and revenue sharing in Canada in the early 1990s, federal control has declined in both countries, resulting in less central control. The amount of money available to transfer from federal to state or provincial coffers, however, did not always match the devolution of responsibility. Therefore, many local health initiatives collapsed because the pressure of greater responsibility was combined with fewer resources for program managers.

Managing increased responsibility within the context of scarce resources was not the only problem that arose from efforts to decentralize authority in health matters. Local public health and health-planning goals often conflict with each other and with the rights of individuals pursuing their own well-being and happiness. The social fabric of many communities can be badly torn when local people engage in a decision-making process where there can be only one winner. For example, local communities across the United States and Canada facing decisions about whether to close or maintain hospitals often experience bitter and emotional debates that may generate a sense of disempowerment for many local groups and individuals.

Successful decentralization of public health and health planning depends on the provision of adequate and appropriate assistance to local communities. Providing resources, including both expertise and time, is a critical ingredient for successfully decentralizing responsibility. Many communities lack the local resources to resolve the complex problems they face and have limited control over outside influences. As a result, they have become increasingly beholden to external sources of support.

The issues of ownership and goals becomes problematic when the central funding source requires a health-specific commitment, but the local population wishes to focus on a different problem that is not a priority for the central funding bodies. For example, a community group may receive funding from a research-oriented agency to examine health issues related to cardiovascular disease, while the community's priorities may be focused on creating jobs and stimulating the local economy or dealing with a teenage drug problem.

Similarly, locally funded organizations may not have enough expertise to provide the monitoring most central funding mechanisms require for accountability. These circumstances typically prompt a rush of technical assistance from central to local organizations, welcomed or not. Outside experts often do not know enough about local circumstances to be as helpful as their substantive expertise might make them in more familiar territory, or they are held at arm's length from intruding on local prerogatives.

Will public health and health-planning systems continue to pursue decentralized decision-making? Economic recoveries in many countries have renewed hopes at the local level for increased revenue sharing to support public health and health-planning initiatives. Financial resources represent one part of the solution, but it remains to be seen whether communities can develop sufficient capacity to take control over the determinants of their own health. To date, the evidence has been inconsistent regarding the effectiveness of local planning initiatives in achieving health objectives at affordable costs.

JEAN A. SHOVELLER
LAWRENCE W. GREEN

(SEE ALSO: *Citizens Advisory Boards; Coalitions, Consortia, and Partnerships; Community Health; Community Organization; Health Goals; Healthy Communities; Participation in Community Health Planning; Regional Health Planning*)

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DEMENTIA

Dementia is a condition characterized by a chronic decline in cognitive functions contrasted with a person's usual state of functioning. It is seen most often in people sixty-five years and older, and the incidence increases with age. Dementia occurs in a stable level of consciousness and sensorium, unlike delirium. There are various causes and types of dementia, but they have certain characteristics in common. Persons with dementia often have problems with short-term memory, such as forgetting names and recent events. They may have trouble with visuospatial processing, such as getting lost in familiar places. Language may be affected, causing difficulty in finding the right word to use in a sentence. The affected person may have difficulty with activities of daily living, such as balancing the checkbook or forgetting to turn off the stove when cooking. This condition may also be accompanied by alterations in personality and behavior. Persons with dementia often become depressed, irritable, or have unreasonable fears. They may also say or do inappropriate things in social situations. Visual or auditory hallucinations sometimes occur.

The onset of dementia is usually insidious. Recognition of the condition is often delayed due to lack of insight on the part of the affected person, who often does not notice that anything is wrong.

Families are also slow to recognize the condition and sometimes deny that there is a problem. There is a common false myth that aging is synonymous with poor memory. Although aging results in mild slowing for some cognitive functions, normal aging does not cause significant memory loss. In many cases, the deterioration is progressive. However, some dementias have reversible causes, and this possibility must be investigated thoroughly when the person comes for treatment. Physicians should regularly screen patients who are sixty-five years and older for dementia.

Alzheimer's disease is the most common type of dementia in North America and Europe (50-60 percent of dementias). It is characterized by slow onset and gradual impairment of recent memory. Long-term memory usually remains more intact. This impairment progresses until death. It is thought to be caused by the accumulation of certain proteins in the brain. It is not clear what causes this condition to occur. Alzheimer's disease is usually diagnosed clinically by cognitive testing rather than using laboratory tests.

Dementia may also be caused by problems with the vascular system, such as cerebrovascular accident (stroke), hypertension, and atherosclerosis. This is thought to make up 15 to 20 percent of dementias in North America and Europe. These disorders are characterized by abrupt onset of cognitive dysfunction that progressively worsens in a step-wise pattern as multiple strokes recur and damage to the brain accumulates.

There are many other causes of dementia, including trauma, metabolic imbalances, hereditary illness, drugs (e.g., alcohol), toxins, and infections (e.g., HIV [human immunodeficiency virus], syphilis). Some of these causes are reversible with medical treatment. Unlike Alzheimer's disease, these conditions usually have rapid onset and progression. Whenever dementia is diagnosed, these reversible causes must be ruled out promptly.

Parkinson's disease is a movement disorder characterized by tremor, slow unsteady gait, and a mask-like face. Decreased levels of a chemical called dopamine in the brain cause this condition. Approximately 30 percent of persons with Parkinson's disease also have dementia. This dementia is characterized by fluctuations in alertness and cognitive abilities. It is also associated with visual hallucinations. It can be treated with

medications that increase the levels of dopamine in the brain.

Psychiatric disorders like depression may cause a dementia-like impairment of memory and concentration called pseudodementia. Depression is a common condition in the elderly. People with depression often have problems with sleep, guilt, appetite, sexual drive, low mood, low energy, and loss of interest in activities, and they may be suicidal. They are more likely to be pessimistic and complain of poor memory than a person with true Alzheimer's disease, who usually tries to deny any problems. Pseudodementia improves after the depression is treated, usually by psychotherapy, medications, or social support. Depression may occur in some individuals with dementia as the person becomes aware of the cognitive decline. Treatment of depression may still be very helpful in such cases.

Diagnosis of dementia requires a thorough physical, neurological, and psychiatric exam. Neuropsychological testing consists of a battery of cognition tests and helps determine what functions are specifically impaired. Laboratory tests are required as part of the medical evaluation. Occasionally, brain imaging is used if a brain tumor or head injury is suspected.

BETTY TZENG
STUART J. EISENDRATH

(SEE ALSO: *Alzheimer's Disease; Stroke*)

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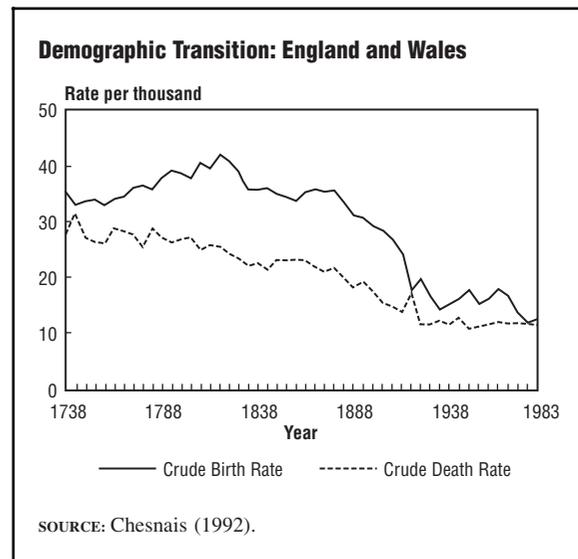
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DEMOGRAPHIC TRANSITION

The term "demographic transition" denotes the effects on population of the social and economic

Figure 1



changes of the Industrial Revolution, which transformed Europe in the eighteenth and nineteenth centuries and spread to the rest of the world in the twentieth century. In simple terms the complete transition would begin with a stationary population with birth and death rates of about 30 per 1,000 persons, a triangular population pyramid, and life expectancy of about 30 years. The transition would end with a stationary population with birth and death rates of 10 per 1,000 persons, and a life expectancy close to the biological limit of 100 years. This final state was not reached by the beginning of the twenty-first century, but in some developed countries the life expectancy of females is over 80 years. Figure 1 shows an example of this transition, with data for England and Wales, the first countries to experience the Industrial Revolution.

The first effect of the transition was a reduction in the death rate, which continued throughout the transition period. The birth rate increased slightly at first, but later fell to the same lower level as the death rate. During the transition, the excess birth rate over the death rate (the rate of natural increase) produced a large increase in the size of the population. Not all European countries experienced the transition in exactly the same way. In particular, the fall in the birth rate began in France in the early nineteenth century, and later spread to

other countries, not reaching Ireland and Russia until the twentieth century.

As an empirical generalization, the above model has proved to be reasonably accurate (see Figure 1). By 1990 the transition to equal birth and death rates was almost completed in the developed regions of the world, especially in Europe. The transition is underway in the less-developed regions of the world, with birth rates falling steeply in all regions except sub-Saharan Africa. The world as a whole was, in 1990, at the same stage of the transition as were the developed regions in 1950.

It is generally accepted that the fall in mortality associated with industrialization was due to improved production and distribution of food, which removed the risk of famine and increased resistance to infectious disease. The risk of epidemic disease was also reduced by public health measures such as vaccination against smallpox, the control of waterborne infections by improved sanitation, and of milk-borne infections by pasteurization. Improved medical treatment had little real effect until the middle of the twentieth century.

The cause of the subsequent fall in fertility, which began in the middle of the nineteenth century, is more complex. In preindustrial societies, fertility is primarily controlled through restrictions on the age at which people can marry. Marital fertility in these societies is high, since children are a valuable resource for families involved in agriculture and domestic industries such as spinning and weaving. A fall in mortality, however, will tend to delay succession to land and hence tighten the restrictions on marriage. Improvements in health will also increase the spacing of children, primarily due to the increased survival of infants and a prolongation of the average duration of lactation. Industrialization might tend to increase fertility at first by providing opportunities for earlier marriage. However, especially after the introduction of legislation controlling the employment of children in factories, industrialization will tend to reduce the income obtained from additional children.

GERRY B. HILL

(SEE ALSO: *Birthrate; Chronic Illness; Demography; Epidemiologic Transition; Mortality Rates; Noncommunicable Disease Control; Population Pyramid*)

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DEMOGRAPHIC TRAP

The survival of a population depends ultimately on a sustainable supply of essential resources, particularly fresh water and food. If these are not available in sufficient quantities to sustain the people living in a nation or region, the population has exceeded the carrying capacity of that nation or region. Both populations and supplies of fresh water and food are dynamic, not static. Usually, in most nations, there is a positive balance—the nation or region either has, or can afford to import, a sufficient supply of fresh water and food to enable all currently living to survive, with enough left over to allow for natural population increase. However, sometimes the rate of increase of a nation's or region's population is greater than the capacity of the local or regional ecosystems to produce the food that is necessary for all to survive, and there are no financial resources to import these necessities for survival. Moreover, natural or manmade disasters can tip the balance by disrupting food supplies.

A population that has exceeded the national or regional carrying capacity is said to be caught in a demographic trap. Such a population must migrate out of the region, or it will starve unless it receives food aid. Another possible consequence may be violent armed conflict if the demographically trapped population encroaches on the territory of neighboring nations who regard them as unwelcome intruders.

The concept of the demographic trap first appeared in the annual report of the Worldwatch Institute in 1987. It was discussed at a major World Health Organization (WHO) conference in 1988,

and has been much discussed since then; a major proponent of the concept has been the English public health specialist Maurice King. It is, however, a controversial concept. Many public health scientists and policymakers see the demographic trap as an inevitable fulfillment of the calculations first published by Thomas Malthus in 1798. Malthus proposed that while populations expand exponentially, food supplies grow only in arithmetical progression, so eventually populations outstrip food supplies, with famine the inevitable result. Empirical observations appear to have confirmed the truth of this in some regions afflicted with famine in Africa and Asia during the latter part of the twentieth century.

Other authorities, notably the Nobel Prize-winning economist Amartya Sen, dispute this concept, asserting that when famines occur, food is in fact available. Those who need it, however, cannot afford it or are denied access to the food supply for logistical or political reasons. The debate over the concept of the demographic trap has involved epidemiologists, economists, political scientists, public-policy analysts, family planning experts, agronomists, and others—including representatives of the religious right wing and advocates of enhanced rights and freedoms for women. The debate has sometimes become polarized along ideological fault lines, with those in favor of population control policies embracing the concept, and those opposed to such policies adjusting to it. Famine and overpopulation are harsh realities, so it is regrettable that ideologies and emotions can cloud the important issues involved.

JOHN M. LAST

(SEE ALSO: *Carrying Capacity; Famine; Malthus, Thomas Robert; Population Growth; Population Policies; Refugee Communities; Sustainable Health*)

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DEMOGRAPHY

Demography is the study of the growth, change, and structure of the human population. Changes in a population's size and structure are caused by changes in the birthrate, the death rate, and the net migration rates. Demographic research focuses on why people have the number of children they do; on factors that affect death rates; and on the reasons for immigration, emigration, and geographic mobility. Understanding a society's demography is an essential tool in determining current and future public health needs.

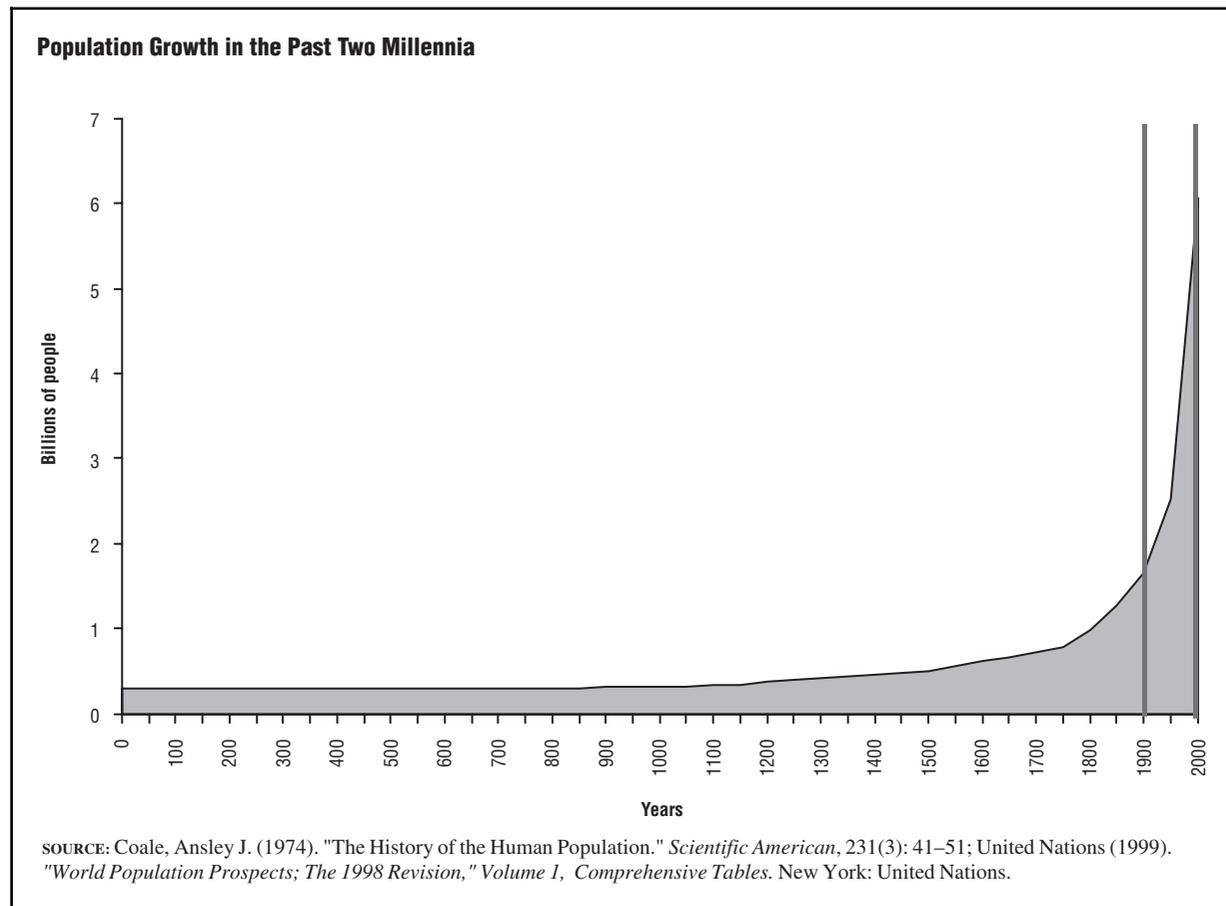
HISTORY OF THE HUMAN POPULATION

The twentieth century was a very unusual period, demographically. World population grew at a more rapid and sustained pace than at any time in human history, as shown in Figure 1. The global population grew from approximately 1.7 billion people in 1900 to 6 billion in 1999. The annual population growth rate averaged 1.3 percent for the entire twentieth century, and was as high as 2.3 percent between 1965 and 1970. (A sustained 2.3 percent annual growth rate would have meant a doubling of the world's population in thirty years.)

By contrast, throughout most of history the human population grew very slowly. Occasionally, in some regions, there were periods of very rapid population growth—and also very rapid population decline. However, these periods generally averaged out over time, and overall population growth was extremely slow. For example, between the years 1 C.E. and 1750, the average annual population growth rate was only 0.06 percent. (At this rate, the population would double, on average, only once every 1,250 years.) A period of rapid population growth began around 1750 in Europe and North America. Rapid population growth in most other parts of the world began between 1920 and 1960.

Why did the population begin to grow rapidly first in Europe and North America, next in Japan,

Figure 1



Australia, and New Zealand, then in most of Asia and Latin America, and finally in Africa and the rest of the world? The answer lies in how a population grows or declines. A change in the size of a population occurs in only a few ways: Either births and immigrants add new members to the population, or deaths and emigrants remove members from the population. Throughout most of human history both birthrates and death rates were high, though birthrates were slightly higher than death rates on average. Slightly higher birthrates than death rates meant that the population was growing, although at a very slow rate. Migration added to some populations and subtracted from others at different periods in history.

Beginning in the eighteenth century, however, death rates began to decline, slowly at first and then more rapidly. For example, death rates declined from about 35 to 45 deaths per 1,000

population in the period from 1750 to 1850 to around 8 to 12 deaths per 1,000 in low-mortality countries (Europe, North America, Japan, and Australasia) in the late twentieth century. This decline began in different parts of the world at different times. In North America and Europe, the timing of the mortality decline was closely tied to the beginning of the Industrial Revolution. In Asia, Latin America, and Africa, declines in death rates took place mostly during the twentieth century. Declining death rates in combination with continuing high birthrates triggered the rapid growth of the population. Simply put, many more people were born into the population each year than left it through death.

Historical research shows that much of the mortality decline in Europe and North America occurred before most modern changes in medical technology and treatment, and therefore was caused

by other factors. These factors include improvements in public health (including sanitation, waste disposal, clean water supply, and quarantine); changes in personal hygiene (including bathing, handwashing, and household cleanliness); improved standards of living (including better nutrition and housing); and improved political, economic, and transportation systems, which led to better responses to food shortages and drought.

These factors also played an important role in reducing death rates in Asia, Latin America, and Africa during the twentieth century. However, improvements in medical and public health technology were also important in these regions. For example, immunization programs, pesticide spraying against mosquitos that spread malaria and yellow fever; oral rehydration therapy for diarrhea; antibiotics; and improved and more widely available health care have all contributed to mortality reduction.

Despite continuing gains in health and survival, the pace of population growth began to slow in industrialized countries in the mid-twentieth century and in other regions of the world in the last three decades of the twentieth century. The reason is that birthrates began to decline. In some European countries, birthrates fell so low by the end of the twentieth century that their population growth rates became slightly negative, meaning that the number of people in these countries is declining slightly. For example, between 1995 and 2000, Italy had a birthrate of 9 per 1,000 population, or an average of about 1.2 births per woman. During this period, Italy's death rate was 10.4 per 1,000 population, so the Italian population became slightly smaller each year. Birthrates have also fallen to historically low levels in many countries in Asia and Latin America. There is also substantial evidence that birthrates are declining in many African countries as well. However, there is still great variability in birth and death rates among regions of the world, as the figures in Table 1 show.

The decline in birthrates is due to dramatic changes in economic and social conditions, ideas about the family and the role of children and women, the availability of family planning programs, and the acceptance and use of contraception. Although much of the fertility decline in

Table 1

Average Annual Birth Rates, Death Rates, Total Fertility Rates, and Life Expectancy for Regions of the World, 1995-2000

	Birth Rate (per 1000 population)	Death Rate (per 1000 population)	Total Fertility Rate (Avg. Births per Woman)	Life Expectancy (Avg. Years of Life)
World Total	22.1	8.9	2.7	65.4
Africa	38.0	13.9	1	51.4
Asia	21.9	7.7	2.6	66.3
Europe	10.3	11.3	1.4	73.3
Latin America and the Caribbean	23.1	6.5	2.7	69.2
Northern America	13.8	8.3	1.9	76.9
Oceania	17.9	7.7	2.4	73.8
United States	14.0	8.5	2.0	76.7

SOURCE: United Nations (1999) *World Population Prospects: The 1998 Revision. Volume I: Comprehensive Tables*. New York: Population Division, Dept. of Economic and Social Affairs, United Nations. ST/ESA/SER.A/177, Table A.1.

Europe and North America occurred before many modern contraceptive methods were available, the development and widespread use of contraceptive methods has played a major role in reducing fertility throughout the world. Contraceptive methods include the hormonal pill, the intrauterine device (IUD), sterilization (vasectomy for men and tubal ligation for women), hormonal injections and implants, and barrier methods such as condoms, spermicidal foam and jelly, diaphragms, and cervical caps. In some countries, such as the former Soviet Union and Japan, induced abortion has also played an important role in reducing the birthrate.

Even though birthrates have fallen substantially in many countries, their populations continue to grow because of the effects of their age structure, or "population momentum." For example, the U.S. population continued to grow at almost 1 percent per year during the 1980s and 1990s despite a very low birthrate. The reason is that a substantial proportion of the population was in their childbearing years because of the "baby boom" in the 1950s and early 1960s. The effects of population momentum is temporary: In the absence of immigration, if birthrates remain low for the next fifty years, the size of the U.S. population

will begin to decline. However, immigration is likely to continue during this period, keeping the U.S. population growing at a relatively slow pace.

MEASURING POPULATION CHANGE

Demographers use several standard ways to measure population processes. Birthrates and death rates are the two most important measures. A birthrate (also called a crude birth rate) is the number of births in a given place and year per 1,000 population:

$$\frac{\text{Number of Births}}{\text{Total Population Size}} \times 1000$$

Similarly, the death rate (also called a crude death rate) is the number of deaths in a given place and year per 1,000 population:

$$\frac{\text{Number of Deaths}}{\text{Total Population Size}} \times 1000$$

The birthrate and death rate for the United States between 1995 and 2000 were 14 births per 1,000 population and 8.5 deaths per 1,000 population.

In a population with no immigration or emigration, the population growth rate is simply the birthrate minus the death rate divided by 10. By convention, population growth rates are expressed in percent (that is, per hundred people) rather than per thousand people. In the United States, the annual population growth rate (which was 0.83 percent for the years 1995 to 2000) is higher than the difference between the birthrates and death rates, because of immigration. In fact, immigration accounted for approximately one-third of the annual growth rate in the United States between 1995 and 2000.

Two other indices are commonly used to measure population change. The Total Fertility Rate (TFR) measures the average number of children that women would have in their lifetime if birthrates remain at current rates in the future. Between 1995 and 2000 the TFR ranged from 1.2 children per woman in Italy to 7.1 children per woman in Uganda. Life expectancy measures the average number of years that people would live if death rates remain at the current in the future. Table 1 shows that the TFR and life expectancy varied substantially among different regions in the world between 1995 and 2000.

DEMOGRAPHIC TRENDS IN THE UNITED STATES

At the start of the twenty-first century, the population of the United States indicates historically low birthrates and death rates and relatively slow population growth. The U.S. average annual population growth rate was 0.83 percent between 1995 and 2000. About two-thirds of this growth rate is accounted for by more births than deaths in the United States each year. About one-third is due to the presence of more immigrants than emigrants each year.

A major influence on the U.S. population in 2000 is the “baby boom” that took place between approximately 1948 and 1965. Birthrates rose substantially in the United States during this period because many couples postponed having children during the Great Depression in the 1930s and during World War II. These couples began to have children at the same time as younger couples who were just getting married. Another reason for the baby boom was the good economic climate conditions during the 1950s, which meant that couples could afford to have more children. Demographers use the term “cohort” to mean all people who were born during a particular year. The cohorts born during the baby boom were much larger than the cohorts born in previous years. Because of the larger cohorts during the baby boom, hospital maternity wards were overcrowded and demand for obstetric and pediatric health services rose substantially. As the baby boom cohorts got older, elementary schools, then high schools, and then colleges bulged at the seams as they tried to cope with a sudden increase in the number of students.

As the baby boom cohorts began to enter their childbearing years (conventionally defined as 15 to 49 years of age for women), they had much lower fertility rates than their parents. For example, the Total Fertility Rate for women during the baby boom years 1955 and 1960 averaged 3.7 children per woman. Women born during the baby boom who were having their children between 1985 and 1990 averaged only 1.9 children per woman. However, because the baby boomers were a large proportion of the U.S. population, the number of births actually rose between 1985 and 1995 compared with earlier years. This is the process of population momentum, described above. The United States has an unusual age structure as

a result of the baby boom. Because of this age structure, the U.S. population will continue to grow for several more decades even if fertility rates remain low.

The baby boom will continue to have another major impact on the demography of the United States in the next several decades—baby boomers will contribute to the aging of the population. People born at the beginning of the baby boom are just beginning to approach retirement age in 2000. Between 2010 and 2030, most people in the baby boom cohorts will reach age 65. America's population will continue to grow older, on average, because of the aging of the baby boom cohorts. Another reason that Americans will be older on average is that fertility and death rates are low. That means that a smaller proportion of the population are young children, and therefore, that a larger proportion of the population are older adults. It also means that people are living longer lives, on average, than in the past.

The aging of the U.S. population has been gradual during the last quarter of the twentieth century. In 1975, 10.5 percent of the population was age 65 and older. By 2000, this figure had grown only to 12.5 percent, a relatively modest increase. However, by 2025, almost 19 percent will be age 65 and older, and by 2050 the figure will be almost one-quarter of the population. Undoubtedly, the aging of the population means that the health needs and problems of older Americans will become an increasingly important focus for public health policy in the early twenty-first century.

Another major demographic trend in the United States is immigration. The United States is a country of immigration. Almost all Americans are descended from immigrants to North America. Even Native Americans, who preceded European and African settlers by many centuries, are believed to have immigrated to North America from Asia. The volume of immigration to the United States has been increasing since the 1950s. Between 1992 and 1999, an average of 800,000 immigrants were legally admitted to the United States every year. This number includes family members of U.S. citizens and residents, as well as refugees, highly skilled workers, and farm workers and lower-skilled workers. An additional 250,000 immigrants probably entered the United States illegally during the same period. Approximately

220,000 people were estimated to emigrate (that is, to move to other countries) each year in the late 1990s.

Between the beginning of European settlement in the 1600s and the Civil War, most immigrants came from northern and western Europe or (generally as slaves) from Africa. Between 1880 and 1914, there was a major wave of immigration to the United States. In 1914, approximately 1.2 million immigrants were admitted, a number which far exceeds the average annual number of legal immigrants in the late 1990s. Although most immigrants arriving during this period continued to come from northern and western Europe, a substantial proportion came from southern and eastern Europe and from Asia.

Among immigrants arriving legally in the 1990s, approximately half came from Latin America, 30 percent from Asia, and 13 percent from Europe. Just as earlier waves of immigration molded the ethnic composition of the United States, recent immigration patterns have contributed to the current ethnic makeup as well. However, other factors have also had an important effect on ethnic composition at the end of the twentieth century, including intermarriage among couples of different ethnic backgrounds and small but significant differences in fertility rates between ethnic groups. In 2000, approximately 72 percent of Americans were white non-Hispanics, 12 percent were African American, 11 percent were Hispanic, 4 percent were Asian, and 1 percent were Native American. The U.S. Census Bureau estimates that by 2025 about 62 percent of the population will be non-Hispanics whites, 13 percent African American, 18 percent Hispanic, 6 percent Asian, and 1 percent Native American. Many Americans have multiple ethnic backgrounds, however, and cannot be classified easily into a single ethnic category. For this reason, the United States 2000 Census allowed people to classify themselves in more than one ethnic group. Estimates of the future ethnic composition of the United States have to realize that classification by a single ethnic origin is likely to be less useful in the future.

DEMOGRAPHY AND PUBLIC HEALTH NEEDS

Understanding a society's demography is an essential tool in determining current and future public

health needs. Demographic structure can affect public health needs in at least three ways: (1) age structure and sex ratio affect the types of health problems encountered, (2) population growth rates affect future needs for health care delivery, and (3) the existence of substantial immigrant and refugee populations can also be important.

The health needs of a population differ considerably by age and by sex. A population's history of birth and death rates changes the age structure in a way that is easy to predict. Generally, a fertility decline reduces the proportion of children in a population, while a decline in death rates increases life expectancy and the proportion of elderly in the population.

The United States provides a good illustration. During the baby boom period the age structure of the population was relatively "young" because birthrates were fairly high. A major emphasis of health care policy during that period was on prenatal and maternity care and on the health problems of mothers and children. In countries with even higher fertility rates, such as many African and some Asian countries, maternal and child health needs are even more of a priority because the proportion of the population at younger ages is even higher. During the last decades of the twentieth century, the population of the United States became older, on average. By 2025, a substantial and growing portion of the American population will be 65 and older. Therefore, health policy is increasingly being focused on the needs of the elderly.

The sex ratio can also affect health care needs. For most age groups, the sex ratio (that is the ratio of males to females) is close to equal. In general, however, men have higher death rates than women. As a result, at older ages sex ratios are generally much lower. That is, there are many fewer men than women. While women are likely to have longer life spans than men, they are also more likely to become widows and to have to care for themselves at older ages.

Population growth rates can affect the size and rate of growth in health care needs in a population. Specifically, provision of health services to a rapidly growing population is more difficult than to a population growing more slowly. In the United States, most policymakers seek to increase access to health services among the poor and underserved

Table 2

Example of the Effects of Population Growth on the Demand for Health Services

	Country A	Country B
1990 Total Population	1,000,000	1,000,000
No. of People Covered by Health Services in 1990 (25%)	250,000	250,000
Annual Population Growth Rate	3.0%	1.5%
1995 Total Population	1,161,834	1,077,884
No. of people covered in 1995 if 25% coverage is maintained	290,459	269,471
No. of people covered in 1995 if target of 35% coverage is met	406,641	377,260

SOURCE: Courtesy of author.

segments of the population. In developing countries, policymakers are even more concerned with expanding access to health services. Rapid population growth can make it difficult to continue to provide the same level of services to all segments of the population, and even harder to increase the level of health services available.

Consider two relatively poor countries, both of which have exactly 1 million people in 1990, as shown in Table 2. In 1990, each country is providing health services to 25 percent of the population, or 250,000 people, and each country has a goal of extending health care to cover 35 percent of the population by 1995. If Country A is growing at 3 percent per year and Country B is growing at 1.5 percent, Country A is going to have a harder time both maintaining 25 percent health-service coverage and expanding its health services to cover 35 percent of the population.

To maintain health care coverage at a level of 25 percent, both countries will have to expand the number of people covered between 1990 and 1995 by training more personnel, building more facilities, and investing more in supplies and equipment. However, as Table 2 shows, Country B will have to cover only 19,471 more people in 1995 while Country A will have to cover an additional 40,459 people in order to maintain 25 percent coverage. To increase coverage to 35 percent, Country B will have to provide services to an additional 127,260 people while Country A will have to cover an additional 156,641 people. As this

example shows, health planners need to take population growth rates into account when estimating the future health care needs of a population. The United Nations Population Division and the United States Census Bureau regularly produce population projections which can be used as guides to the likely future size and structure of a country's or local area's population.

With improvements in transportation and changing political and economic circumstances, immigration and emigration will be an important issue for the United States, and for most of the countries of the world, in the twenty-first century. Governments and international organizations generally divide immigrants into two groups: refugees, who are those fleeing their home countries because of political persecution or war; and labor or economic migrants, who go to other countries seeking employment and a better life. Refugees and economic migrants can move between two countries or within a single country. Note that the distinction between refugees and economic migrants is often not very clear. For example, migrants from a country facing severe drought may be fleeing to seek better economic opportunities and/or because they may face starvation and violence due to drought if they remain at home.

Immigrant populations, and particularly refugees, often pose important challenges for health planners and health-service providers. For example, recent immigrants may have little knowledge of the health care system or health and social-service providers. They often arrive with a different set of health beliefs and they may face language and cultural barriers when seeking health care. Recent immigrants are also likely to have lower incomes and to be more vulnerable to downturns in economic conditions such as recessions. Although immigrants in established migration streams usually have a network of social and family contacts in the country then migrate to, recent migrants often live closer to the margin than long-term immigrant groups.

Refugees often have additional health problems because of the political persecution they have faced. Their special health needs may include psychological treatment for conditions such as post-traumatic stress disorder and depression, as well as treatment for infectious diseases, injuries, and malnutrition. Refugees, like other immigrants,

may also face discrimination in employment or in access to health and social services in the country they migrate to, which is likely to affect their health status.

While many refugees settle in the United States or other industrialized countries, the majority (more than 80%) find asylum in developing countries in Africa, Asia, and Latin America, where health services are often poor. Refugees often face serious barriers to finding employment in countries of asylum for two reasons: (1) farm land is not readily available to outsiders, especially those without funds to purchase land, and (2) few jobs exist in other sectors of the economy. As a result, they can become dependent on international aid organizations for economic support, food aid, and health services. Examples of this situation during the 1990s include Cambodian refugee camps on the Thai-Cambodian border, Ethiopian refugees in Sudan and Somalia, Somalian refugees in Kenya, and Guatemalan and El Salvadoran refugees in Mexico.

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(SEE ALSO: *Behavior; Birthrate; Contraception; Family Planning Immigration; Life Expectancy and Life Tables; Planning for Public Health; Population Forecasts; Population Growth; Population Policies; Population Pyramid*)

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DENTAL FLUOROSIS

Dental fluorosis is a hypomineralization of tooth enamel produced by the chronic ingestion of excessive amounts of fluoride during the period when unerupted teeth are developing. Normal mineralization of permanent teeth, other than third molars, occurs from about the time of birth until about six years of age. After that time, teeth (except third molars) are mineralized to such an extent that they cannot be affected by fluorosis. Nor is it possible after that time to diminish any existing fluorosis by lowering the consumption of ingested fluoride.

The intensity of fluorosis ranges from barely noticeable, whitish flecks or striations that affect only a small portion of the enamel to unsightly confluent pitting of the entire enamel surface with dark brown or black staining. Teeth affected by the mildest degrees of fluorosis generally are not cosmetically compromised and are highly resistant to developing dental decay. Although primary teeth may be affected by dental fluorosis, the condition tends to affect permanent teeth more than primary teeth.

Various indexes or classification systems have been used in surveys to measure the presence and severity of enamel fluorosis. Most indexes score fluorosis according to various scales that range from absent to severe. The index developed by H. Trendley Dean has been used since 1942 and permits important historical comparisons.

Epidemiologic studies done in the 1930s and 1940s of the relation between fluoride concentration in water and dental fluorosis showed that about 10 to 15 percent of persons born and reared in communities with about one part fluoride per million parts of water (ppm) in drinking water had signs of mild forms of fluorosis. When water fluoridation began to be implemented in the United States in 1945, it was the only source of additional ingested fluoride other than that which occurred naturally in some foods and beverages, such as seafood and tea. Since then, many additional sources of fluoride have become available, such as dietary fluoride supplements prescribed as an alternative source of fluoride for areas with fluoride-deficient drinking water, various fluoride solutions, gels and varnishes for professional application, fluoride toothpastes—which currently comprise nearly all toothpaste sales—and fluoride mouth rinses. The use and misuse of these products has led to increased ingestion of fluoride by young children. Consequently, the prevalence, and to a lesser extent, the severity of dental fluorosis has been shown in recent surveys to have increased in both fluoridated and unfluoridated communities. Epidemiologic surveys have shown strong associations between fluorosis and consumption of water with higher than optimal water fluoride concentrations, early use of fluoride toothpastes, use of dietary fluoride supplements, and prolonged use of infant formula in the form of powdered concentrate.

To reduce the risk of developing dental fluorosis, toothbrushing by young children should be supervised closely. They should use only a dab or pea-sized quantity of toothpaste on a child-sized toothbrush and be instructed to spit out thoroughly after brushing. Dietary fluoride supplements should not be prescribed for children who drink fluoridated water. In fluoridated communities, parents who wish to give their children formula beyond the age of one year should use

ready-to-feed varieties or dilute powdered concentrate mixed in bottled water with a low-fluoride concentration.

Fluorosis may be tested by bleaching affected teeth, sometimes accompanied by applying various remineralizing agents. Severe fluorosis may be treated cosmetically by bonding various facings on affected teeth.

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(SEE ALSO: *Community Water Fluoridation; Oral Health*)

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DENTAL HEALTH

See Oral Health

DENTAL SEALANTS

Dental sealants are thin plastic coatings applied to the chewing surfaces of back teeth. While fluoride has played a large role in decreasing smooth surface decay, fluoride has its least preventive effect on the deep grooves, called pits and fissures, of the back teeth. Dental sealants have been shown to be highly effective in the prevention of pit and fissure caries. Data from 1988 to 1991 in the National Health and Nutrition Examination Survey (NHANES III) revealed that while tooth surfaces with pit and fissures accounted for 15 percent of all tooth surfaces, they were the sites of at least 83 percent of the tooth decay in children.

Dental sealants evolved from a technique called enamel bonding that was first reported in the mid-1950s. Dental sealants were introduced in 1967 and their effectiveness was recognized by the American Dental Association in 1971. Current sealant materials are either chemically activated or light polymerized and come in various colors, including clear, white, yellow, green, and pink.

The decision to place sealants is usually based on the patient's disease risk factors, presence of disease, and the morphology of the pits and fissures. Teeth with the highest priorities for sealant placement are usually the first and second permanent molars. Because of their less shallow grooves, primary or baby molars and permanent bicuspids are less susceptible to decay and therefore are at a lower priority for placement.

Although the application process is fairly simple, attention to technique is very important. Inadequate isolation and subsequent contamination by water or saliva will cause the sealant to fail. The teeth to be sealed are first isolated by use of rubber dental dams or cotton rolls. The teeth are then cleaned by rotary instruments, brushing, or wiping the surface with cotton. A mild acidic solution is then applied to the grooves and washed off after approximately twenty seconds. The teeth are then thoroughly dried. The resultant tooth surface has been etched or roughened, allowing the sealant material to adhere to this roughened surface. For continued effectiveness, the sealants should be checked regularly as part of periodic recall visits and replaced as needed.

A sealant is virtually 100 percent effective if fully retained on the tooth. Various studies have shown chemically activated sealants to remain intact 92 to 96 percent of the time after one year, 67 to 82 percent after five years. Other long-term studies have shown retention to be approximately 41 to 57 percent after ten years and 28 to 35 percent after fifteen years. Results for chemically activated sealants versus light polymerized sealants were found to be the same after five years. Pooled results from seventeen studies found that sealants reduced caries over 70 percent.

In 1990, the United States Public Health Service published a health objective for the year 2000, stating that 50 percent of children should have one or more sealants on permanent teeth. NHANES

III data from 1988 to 1991 reported 19 percent of U.S. children had sealants on their teeth.

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(SEE ALSO: *Caries Prevention; Oral Health*)

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DEPENDENCY RATIO

The ratio of persons who are economically dependent on those who provide for them, either by earning incomes or paying taxes, is known as the dependency ratio. In demographic terms, the dependency ratio is defined as the proportion of those aged under fifteen and over sixty-five to all those between these ages, though this definition does not accurately represent economic dependency at the national level, since persons aged fifteen through sixty-four who are economically dependent, such as disabled persons, invalids, the mentally ill, or the unemployed, are counted inappropriately as independent. In public health and public-policy planning, therefore, indicators such as the number of people receiving disability benefits or the use of disability-adjusted life years would be more accurate for tracking dependency.

JOHN M. LAST

(SEE ALSO: *Demography; Economics of Health*)

DEPRESSION

Depression is sometimes referred to as the common cold of mental illness. It is a debilitating

disease with significant societal costs. It is, however, one of the most clearly defined and treatable of mental illnesses. Technically, the term "depression" is used to cover a variety of symptomatic conditions, all characterized by negative mood and a loss of pleasure. Together these conditions comprise a spectrum ranging from major depression to dysthymia to adjustment reactions to normal grief and sadness. At one extreme of this continuum lies major depressive disorder, a syndrome characterized by severe episodes of depressed mood accompanied by loss of sleep, appetite, concentration, energy, and hope. The depressed mood must persist for greater than two weeks in order to warrant this diagnosis. At the other end of the continuum lies the diagnosis of dysthymia, which is characterized by a lower level of mood disturbance that persists chronically; that is, involving more days than not for a period of two years or greater. Many patients complain of depressed mood but do not fit neatly into either of these two categories. These patients' symptoms are frequently best accounted for as a reaction to an acute life stressor. These reactions are typically nonpathological and resolve with time, but they may constitute an adjustment reaction if normal functioning is sufficiently disturbed.

Depression is both common and costly. It has a lifetime prevalence of 5 to 10 percent of women and 2 to 5 percent of men. It is an expensive disorder in both direct and indirect terms, as depression causes a higher degree of functional disability than many medical illnesses including diabetes, chronic lung disease, and arthritis. Additional costs to society result from the effect of untreated depression on the treatment of medical illnesses, where it contributes to longer hospital stays and morbidity. This has been particularly well demonstrated in the treatment of myocardial infarction (heart attack), where the presence of major depression has consistently been found to increase mortality.

Depressive illness is thought to result from a combination of biological and psychological factors. The biological component is strongly suggested by the high genetic concordance of depressive disorders. In the twenty-first century, there are various competing theories about the nature of this genetic/biological contribution, but the available data do not yet indicate the specific

nature of the illness. The psychological component is similarly suggested by the correlation of onset of major depression with negative life events and with the increased risk of depression in individuals who experienced abuse in childhood. A variety of psychological theories exist and are linked to models of psychotherapeutic treatment. Interpersonal psychotherapists, for example, emphasize the role of grieving due to the loss of an important relationship or a transition in social roles (e.g., transition from working to retirement, marriage to divorce). Cognitive therapists emphasize a mind-set of construing life events in a way that leads to depression. Alternately, psychodynamic therapists search for the ways that unconscious coping processes and repetitive relational patterns result in negative effects. A commonly postulated mechanism would include the turning of anger in on the self. For example, a depressed woman may feel critical of herself rather than direct her anger toward an abusive spouse.

Treatment of depression parallels theories of etiology in that both biological and psychological treatments exist and have been efficacious. A number of different antidepressant medications have been developed, including monoamine oxidase (MAO) inhibitors, tricyclic antidepressants, and selective serotonin reuptake inhibitors (SSRI). These medicines have demonstrated efficacy in both the treatment of acute depressive episodes and in the prevention of relapses. A variety of psychological therapies are also employed in the treatment of depression. Interpersonal psychotherapy and cognitive behavioral psychotherapy are psychotherapeutic models for which depression-specific therapeutic techniques have been developed. These tend to be delivered in the form of brief semi-structured treatments, lasting less than a year in duration. One advantage of these approaches is that they have been well tested in research settings and have an established record of effectiveness in appropriately selected patients. There is also some clinical consensus that long-term psychodynamic (emphasizing unconscious mental processes) therapies are also helpful, especially when the mood disorder exists in the context of a long-standing personality disorder.

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(SEE ALSO: *Mental Health*)

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DESCRIPTIVE STUDY

An investigation aimed at ascertaining the status of a set of variables, such as the number and variety of persons with specific conditions in a specified population, but without any critical analysis or attempt to test casual hypotheses, is known as a descriptive study. Examples include the U.S. National Health Care Survey, periodic reports from cancer registries, and needs assessment surveys conducted by a local health department. Descriptive studies can yield valuable information about a population's health status, and they can be used to measure risks and generate hypotheses. Descriptive studies are also useful in health service evaluation and can be used periodically to determine whether a particular service is improving, for instance, if serial description studies all show evidence of reduced sickness or disability rates over a period of years.

JOHN M. LAST

(SEE ALSO: *Cross-Sectional Study; Observational Studies; Statistics for Public Health*)

DIABETES MELLITUS

The term "diabetes mellitus" represents a group of conditions characterized by abnormally high blood glucose levels (hyperglycemia). In 1997, nearly 16 million people in the United States had diabetes; approximately 10.3 million were diagnosed with the conditions, while an estimated 5.4 million were undiagnosed. Diabetes may be complicated by uncontrolled hyperglycemia, and treated diabetes may be complicated by abnormally low blood glucose levels (hypoglycemia). Maternal diabetes

is associated with an increased incidence of major birth defects. Over time, diabetes may cause complications involving the eyes (retinopathy), kidneys (nephropathy), and nerves (neuropathy). Diabetes is also associated with an increased incidence of cardiovascular disease, including stroke, heart attack, and peripheral vascular disease. In the United States today, diabetes is a leading cause of birth defects, blindness, kidney failure, and nontraumatic leg amputations. It is also a major contributor to cardiovascular disease. Diabetes is the seventh leading cause of death in the United States, and medical care for people with diabetes is estimated to cost over \$100 billion per year.

When diabetes is associated with marked hyperglycemia, it produces characteristic symptoms and signs; particularly increased thirst (polydipsia), increased urination (polyuria), and unexplained weight loss. At other times, hyperglycemia sufficient to cause changes in the eyes, kidneys, and nerves, and to increase the risk of cardiovascular disease, may be present without clinical symptoms. During this asymptomatic period, an abnormality in glucose metabolism may be demonstrated by measuring fasting venous glucose or venous glucose after an oral glucose challenge.

DIAGNOSIS

When a patient is symptomatic and the plasma glucose is unequivocally elevated, a diagnosis of diabetes presents no difficulty. When a patient is without clinical symptoms, a diagnosis of diabetes is more difficult. According to a 1997 American Diabetes Association (ADA) report, there are three ways to diagnose diabetes (see Table 1). All require measurement of venous plasma glucose, and each must be confirmed on a subsequent day by any one of the three methods. In general, the oral glucose tolerance test is not recommended for routine clinical use and is performed only in patients with elevated but nondiagnostic fasting plasma-glucose levels with a high index of suspicion for diabetes.

CLASSIFICATION

Once a diagnosis of diabetes mellitus is established, it is necessary to differentiate the various forms of the syndrome. Prior to 1979, diabetes was

Table 1

Criteria for the Three Methods Diagnosis of Diabetes Mellitus in Nonpregnant Adults

1. Symptoms of diabetes plus casual plasma glucose concentration ≥ 200 mg/dL (11.1 mmol/L).^{*} Casual is defined as any time of day without regard to time since last meal. The classic symptoms of diabetes include polyuria, polydipsia, and unexplained weight loss.
2. Fasting Plasma Glucose ≥ 126 mg/dL (7.0 mmol/L).^{*} Fasting is defined as no caloric intake for at least 8 hours.
3. 2-hour Plasma Glucose ≥ 200 mg/dL (11.1 mmol/L) during an Oral Glucose Tolerance Test (OGTT).^{*} The test should be performed using a glucose load containing the equivalent of 75 g. anhydrous glucose dissolved in water.

^{*} In the absence of unequivocal hyperglycemia with acute metabolic decompensation, these criteria should be confirmed by repeat testing on a different day. The third measure (OGTT) is not recommended for routine clinical use.

SOURCE: Expert Committee on the Diagnosis and Classification of Diabetes Mellitus: Report of the Expert Committee on the Diagnosis and Classification of Diabetes Mellitus (1997). *Diabetes Care* 20:1183-1197.

classified on the basis of age at diagnosis as either juvenile-onset diabetes mellitus (JODM) or adult-onset diabetes mellitus (AODM). In the late 1970s and early 1980s, a new classification system recognized two major forms of diabetes: insulin-dependent diabetes mellitus (IDDM or type I diabetes) and non-insulin-dependent diabetes mellitus (NIDDM or type II diabetes). In 1997, the American Diabetes Association recommended modifications to this classification system that eliminated the terms "insulin-dependent diabetes mellitus" and "non-insulin-dependent diabetes mellitus" and their acronyms. The terms "type 1" and "type 2" were retained, with Arabic numerals replacing the Roman numerals. Other specific types of diabetes were also recognized.

Type 1 diabetes is caused by pancreatic beta cell (B-cell) destruction. Immune-mediated type 1 diabetes results from cell-mediated autoimmune destruction of the B-cells of the pancreatic islets. This type of diabetes also has strong genetic or human leukocyte antigen (HLA) associations that can be either predisposing or protective. Another form of type 1 diabetes, termed "idiopathic" type 1 diabetes, is strongly inherited but lacks immunologic evidence for B-cell autoimmunity and is not HLA-associated. Most patients with

Table 2

Incidence of Diagnosed Diabetes per 1,000 Population by Age, United States, 1994.			
Age Group			Total
0 - 4	45 - 64	65+	
1.59	7.20	8.84	3.61

SOURCE: Centers for Disease Control and Prevention (1997). *Diabetes Surveillance, 1997*. Atlanta, GA: CDC.

idiopathic type 1 diabetes are of African or Asian descent.

Type 1 diabetes accounts for approximately 5 percent of diagnosed diabetes in the United States—approximately 500,000 Americans have type 1 diabetes. Type 1 diabetes commonly occurs in childhood and adolescence, but it can occur at any age. Patients with type 1 diabetes are prone to ketoacidosis (decompensated diabetes with hyperglycemia and presence of abnormal acids [ketones] in the blood). Many affected patients have no family history of diabetes. Although most patients with type 1 diabetes are lean when they are diagnosed, the presence of obesity is not incompatible with the diagnosis.

Type 2 diabetes is characterized by both impairment of insulin secretion and defects in insulin action. It is often unclear which abnormality is the primary cause of hyperglycemia. Although patients with this type of diabetes may have insulin levels that appear normal or elevated, insulin levels are always low relative to the elevated plasma glucose levels. Thus, insulin secretion is defective in these patients and insufficient to compensate for the degree of insulin resistance. Although the specific origin of type 2 diabetes is not known, autoimmune destruction of B-cells does not occur. Although type 2 diabetes is associated with a strong genetic predisposition, the genetics of this form of diabetes are complex and not clearly defined.

Type 2 diabetes accounts for approximately 95 percent of diagnosed diabetes in the United States (9.8 million cases), and for the vast majority of the cases of undiagnosed diabetes. The risk of type 2 diabetes increases with age, obesity, and physical inactivity. As such, it is often regarded as a disease associated with a modern Western lifestyle. Type 2 diabetes occurs more frequently in

women with prior gestational diabetes and in individuals with hypertension and dyslipidemia. Affected patients often have a family history of diabetes. Type 2 diabetes is more common in African Americans, Hispanic Americans, and Native Americans than in non-Hispanic white Americans. Ketoacidosis seldom occurs spontaneously in type 2 diabetes, but it may arise in association with the stress of another illness. Approximately 70 percent of patients with type 2 diabetes are obese.

TREATMENT

Large, prospective, randomized, controlled clinical trials in both type 1 and type 2 diabetes have demonstrated that normal or near-normal blood glucose control can delay or prevent the development of major birth defects and the development and progression of complications affecting the eyes, kidneys, and nerves. Accordingly, the goals for management for both type 1 and type 2 diabetes are to achieve glucose levels as close to the nondiabetic range as possible while minimizing the side-effects of treatment (hypoglycemia and weight gain).

In nondiabetic subjects, blood glucose levels are between 70 and 90 mg/dl (milligrams per deciliter) in the fasting state and rise to 120 to 140 mg/dl one to two hours after meals. These values reflect normal glucose tolerance. Average glucose levels may be assessed by measurement of glycosylated hemoglobin (hemoglobin A1c), is a measure of the average blood glucose level over the previous two to four months. In nondiabetic subjects, hemoglobin A1c is generally less than 6.1 percent, and in poorly controlled diabetic subjects, it may rise to 12 percent or higher.

In general, the goals of treatment are to achieve blood glucose and hemoglobin A1c levels as close to the nondiabetic range as possible with diet, physical activity, and medications.

Diet. In type 1 diabetes, diet is designed to provide adequate nutrients for growth and development and for the maintenance of ideal body weight. The recommended diet includes approximately 20 percent of daily calories from protein, 30 percent from fat, and 50 percent from complex carbohydrates. Simple sugars are limited to prevent excessive glucose excursions, and carbohydrate content is distributed into regular meals and

Table 3

Population	Age Group				Total
	0 – 44	45 – 64	65 – 74	75+	
white males	7.8	57.7	96.0	106.8	28.4
black males	10.6	120.8	171.8	120.6	35.9
white females	7.9	51.9	97.2	89.2	30.5
black females	12.1	134.5	171.8	173.5	47.9
Total	8.3	62.2	101.5	103.3	30.8

From Centers for Disease Control and Prevention. Diabetes Surveillance, 1997. Atlanta, GA. U.S. Department of Health and Human Services, 1997.

snacks so that a similar quantity of carbohydrate is consumed at approximately the same time each day.

In type 2 diabetes, caloric content is adjusted to achieve and maintain an ideal body weight or, in those who are obese, to produce gradual weight loss or at least weight maintenance. Dietary composition may also be adjusted in light of intercurrent conditions. For example, sodium may be restricted for patients with hypertension, and both total fat and saturated fat may be restricted for those with high cholesterol.

Exercise. Exercise lowers blood glucose and improves glucose tolerance in diabetics. Other benefits of exercise are reductions in LDL cholesterol and triglycerides levels, and improvements in HDL cholesterol, improvements in blood pressure, improved cardiovascular fitness, and an increased sense of well-being and quality of life. Because exercise may potentiate the hypoglycemic effect of injected insulin and may, paradoxically, result in elevated blood glucose levels and the rapid development of ketosis in type 1 diabetic patients in poor metabolic control, the goal of management in type 1 diabetes is to permit people to enjoy and participate safely in physical and sport activities. In type 2 diabetes, exercise is frequently prescribed as an adjunct to reduced-calorie diets for weight reduction and to improve insulin resistance.

Medications. Because patients with type 1 diabetes are absolutely insulin deficient, treatment requires insulin injections. Although one or two

injections per day are often adequate to prevent symptoms of hyperglycemia, intensive therapy employing three or four insulin injections per day, or continuous subcutaneous insulin infusion, may be necessary to achieve near-normal glucose control.

Both oral medications and injected insulin are used for the treatment of type 2 diabetes. Four groups of oral agents are currently available: insulin secretagogues, which enhance nutrient-stimulated insulin secretion; the biguanides, which suppress abnormal glucose production by the liver; the thiazolidinediones, which reduce insulin resistance at the level of muscle and fat; and the alpha-glucosidase inhibitors, which slow the breakdown and absorption of carbohydrates and reduce postprandial glucose excursions. To the extent that these four groups of oral medications have different mechanisms of action, they can be used clinically in combination. When oral agents are ineffective in controlling hyperglycemia or achieving glycemic goals, insulin is added or substituted.

MONITORING

Self-monitoring of blood glucose is integral to modern diabetes therapy. A lancet is used to obtain a small drop of blood, which is placed on a reagent strip and inserted in a small battery-powered meter. The meter reports the blood glucose level in less than a minute. Results of self-monitoring of blood glucose are used to guide adjustments in diet, exercise, and medications, for the monitoring and treatment of hypoglycemia, and in the home management of intercurrent illness.

INCIDENCE AND PREVALENCE

The number of people developing diabetes and the number of people with diabetes are increasing worldwide. In 2000, it was estimated that 154 million persons, or 4.2 percent of the world's population, twenty years of age and older had diabetes. By the year 2025, it is estimated that nearly 300 million persons, or 5.4 percent of the world's population, twenty years of age and older will have diabetes. The major part of this increase will occur in developing countries due to the aging of the population and increasing urbanization (associated with increased body weight and decreased physical activity).

In 1994, there were 939,000 Americans newly diagnosed with diabetes, with a disproportionate number among the elderly and minority populations. The incidence of diagnosed diabetes was 3.61 cases per 1,000 persons per year in 1994 (see Table 2).

In 1994, about 8 million persons in the United States (3.1 percent of the population) reported that they had diabetes. The prevalence of diagnosed diabetes increases with age (see Table 3).

MORTALITY

Diabetes is the seventh leading cause of deaths in the United States. The highest death rates due to diabetes are observed in older Americans and in minority populations. Death certificates underestimate diabetes mortality because of underreporting of diabetes. Only about 10 percent of people with diabetes who die have diabetes listed as the underlying cause of death on their death certificates, and only about 40 percent have it listed anywhere on their death certificates. Diabetes was the underlying cause of death for approximately 57,000 Americans in 1994, and diabetes was recorded on the death certificate of approximately 182,000 Americans. In 1994, black women had the highest death rates due to diabetes, followed by white women and men. That same year, 44 percent of all diabetes-related deaths (80,000 deaths) had cardiovascular disease listed as the underlying cause. Of these deaths, approximately 60 percent were caused by ischemic heart disease and 15 percent by stroke.

COMPLICATIONS AND COMORBIDITIES ASSOCIATED WITH DIABETES

Diabetic Ketoacidosis (DKA). Ketoacidosis is an acute metabolic complication of diabetes associated with hyperglycemia, nausea, vomiting, abdominal pain, dehydration, ketonemia, and acidosis. In 1994, DKA was the primary diagnosis for 89,000 hospital discharges and a listed diagnosis for 113,000 hospital discharges. Clinical trials have demonstrated that improved education in self-management and improved access to care can prevent up to 70 percent of DKA hospitalizations.

Adverse Outcomes of Pregnancy. Each year in the United States, type 1 diabetes complicates

approximately 7,000 pregnancies and type 2 diabetes complicates approximately 12,000 pregnancies. Up to 1,700 infants (9%) of mothers with pregnancies complicated by diabetes (in the U.S.) are born with birth defects affecting the brain, spinal cord, heart, kidneys, and skeleton. Clinical trials have demonstrated that with intensive glycemic control before conception and during the first trimester, the incidence of major birth defects may be reduced to 2 percent, the rate that occurs in infants of nondiabetic mothers.

Diabetic Eye Disease. Diabetes is the leading cause of new cases of legal blindness in Americans between twenty and seventy-four years of age. As many as 40,000 Americans become blind each year as a result of diabetes. In type 1 diabetes, most legal blindness is due at least in part to diabetic retinopathy. Timely diagnosis and appropriate laser treatment can prevent up to 90 percent of blindness due to diabetic retinopathy. In type 2 diabetes, cataract, glaucoma, and senile macular degeneration are more frequent causes of blindness.

Diabetic Kidney Disease. Diabetic nephropathy is characterized by hypertension, proteinuria, and progressive renal insufficiency. Diabetes is now the leading cause of end-stage renal disease (kidney failure requiring dialysis or kidney transplant for survival). In 1997, over 33,000 Americans developed end-stage renal disease due to diabetes. Early detection, aggressive blood pressure control, and treatment with angiotensin-converting enzyme inhibitors can reduce the progression of diabetic nephropathy by about 60 percent.

Amputations. Diabetic neuropathy, peripheral vascular disease, and infection predispose people with diabetes to gangrene and amputations. More than half of all nontraumatic lower extremity amputations (LEAs) occur in people with diabetes. In 1994, there were approximately 67,000 diabetes-related hospital discharges with LEA reported as a procedure in the United States. Clinical trials have demonstrated that early detection of insensitve and deformed feet and multidisciplinary foot-care programs can reduce the rate of amputation by more than 50 percent.

Cardiovascular Disease Cardiovascular disease (CVD) is the leading cause of morbidity and

Table 4

Population	Age Group				Total
	0 - 44	45 - 64	65 - 74	75+	
males	34.3	110.6	228.3	264.9	146.3
females	18.3	101.0	191.3	245.8	139.6
Total	26.1	105.8	207.4	253.0	142.7

From Centers for Disease Control and Prevention. Diabetes Surveillance, 1997. Atlanta, GA. U.S. Department of Health and Human Services, 1997.

mortality in people with diabetes. Stroke, heart attack, and peripheral vascular disease are two to four times more common in people with diabetes than in people without diabetes. In 1994, there were 1,144,000 diabetes-related hospital discharges that had CVD listed as the primary discharge diagnosis (see Table 4). Part of the increased incidence of cardiovascular disease in people with diabetes is due to the greater prevalence of cardiovascular risk factors, including hypertension, dyslipidemia, and cigarette smoking. Clinical trials have demonstrated that pharmacologic treatments for hypertension and dyslipidemia are as effective, if not more effective, in people with diabetes compared to people without diabetes.

COSTS OF DIABETES

Health care costs incurred by people with diabetes include non-diabetes-related and diabetes-related costs. In the United States, in 1992, the direct cost of non-diabetes-related and diabetes-related medical care incurred by people with diabetes was estimated to be \$105.2 billion. The direct cost of medical care attributable to diabetes was estimated to be \$45.2 billion and the indirect cost of diabetes was estimated to be \$46.6 million (see Table 5).

In 1992, per capita health care expenditures for people with diabetes averaged \$9,493, compared to \$2,604 for people without diabetes. When adjusted for age, per capita health care expenditures for people with diabetes were approximately

Table 5

Type of Cost	Setting	Attributable to diabetes*	Among People with diabetes**	
Direct	Hospital	37.2	65.2	
	Nursing home	1.8	—	
	Office	1.1	11.0	
	Outpatient	2.9	12.5	
	Emergency room	0.2	1.3	
	Drugs	1.7	9.9	
	Home health	0.0	4.0	
	Dental	—	1.4	
	Total		45.2	105.2
	Indirect	Illness	8.5	—
Disability		11.2	—	
Death		27.0	—	
Total			46.6	

*From Fox-Ray N, Wills S, Thamer M: Direct and Indirect Costs of Diabetes in the United States in 1992. Alexandria, VA: American Diabetes Association, pp. 1-27, 1993.

**From Rubin RJ, Altman WM, Mendelson DN: Health care expenditures for people with diabetes mellitus, 1992. J Clin Endocrinol Metab 78:809A-809F, 1994.

\$3,800 higher for people with diabetes than for people without diabetes (\$6,425 versus \$2,604).

The fact that 62 percent of direct health care costs among people with diabetes and 82 percent of costs directly attributable to diabetes are incurred in the hospital setting suggests that the majority of costs are associated with the treatment of the late, chronic complications of diabetes.

SCREENING FOR TYPE 2 DIABETES

One-third of diabetes in the United States is undiagnosed, and one-third to one-half of all diabetes worldwide is undiagnosed. This finding, combined with the fact that glycemic management can prevent or delay the development of complications, and the fact that diabetic patients may already have complications at clinical diagnosis, have lead some to call for public health screening for type 2 diabetes. In general, screening is appropriate in asymptomatic populations when six specific conditions are met (see Table 6).

Table 6

Characteristics of Diseases that Warrant Diabetes Screening

- The disease represents an important health problem
- The natural history of the disease is understood
- The disease has a recognizable preclinical stage during which it may be diagnosed
- Early treatment confers greater benefit than later treatment
- Reliable and acceptable tests exist which can detect the preclinical disease
- The costs of case-finding and treatment are reasonable

SOURCE: Engelgau, M. M.; Venkat Narayan, K. M.; and Herman, W. H. (2000). "Screening for Type 2 Diabetes." *Diabetes Care* 23:1563–1580.

Diabetes imposes substantial morbidity and mortality on the population. The natural history of type 2 diabetes is well understood, and with systematic testing, diabetes can be diagnosed in asymptomatic, preclinical, subjects. Unfortunately, although it is clear that intensified management can improve outcomes, no studies have demonstrated the effectiveness or safety of early treatment. Likewise, there is no consensus as to the optimal approach to screening for type 2 diabetes. Ideally, a screening test should be both sensitive and specific. Generally, however, trade-offs must be made between sensitivity and specificity (increasing sensitivity reduces specificity, and increasing specificity reduces sensitivity). In some health systems, the costs of screening and treatment are reasonable, but in others they are simply unaffordable. Finally, although it is recognized that screening must be an ongoing process, no empirical data exist to indicate the optimal screening frequency.

Questionnaires that use self-reported demographic, behavioral, and past medical history to assign a person to a higher or lower risk group; fasting, random, and postprandial urine glucose tests; fasting, random, and postprandial capillary whole blood and capillary plasma glucose tests; fasting, random, and postprandial venous whole blood and plasma glucose tests; and hemoglobin A1c have all been evaluated as screening tests for diabetes. In general, questionnaires perform rather poorly as screening tests for diabetes. Measurement of glycosuria using a cut-off point greater than or equal to a trace value generally has a low sensitivity and a high specificity. Capillary or venous whole blood or plasma glucose determinations have generally performed better than urine

glucose testing. With both urine and blood testing, random, postprandial, and glucose-loaded tests perform better than fasting tests. There is little consensus, however, as to optimal cut-points for defining positive tests. Screening with hemoglobin A1c has suffered from lack of standardization of the assay. Even as this problem has been addressed, the test has generally been found to be specific but less sensitive than glucose measurements.

Accordingly, the American Diabetes Association has recommended that clinicians should be vigilant and recognize clinical histories and signs suggestive of diabetes that warrant testing. Generally, screening of high-risk individuals for type 2 diabetes should be performed only as part of ongoing medical care, understanding that the evidence is incomplete and questions remain as to the benefits and risks of early treatment, the optimal screening methods and cut-points, and screening frequency. Community-based screening for diabetes is generally associated with a low yield and poor follow-up, and it probably does not represent a good use of resources.

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(SEE ALSO: *Cardiovascular Diseases; Glycosylated Hemoglobin; Noncommunicable Disease Control; Nutrition; Screening*)

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DIAGNOSTIC SONOGRAPHY

The use of ultrasound to obtain diagnostic images is referred to as diagnostic sonography. Since diagnostic sonography utilizes a nonionizing form of energy, there are no known bioeffects. Thus, diagnostic sonography is applied to a large spectrum of clinical disorders, including obstetrical, gynecological, abdominal, urologic, pediatric, and vascular applications. Sonographic images are displayed in real time, which allows the study of dynamic processes. In addition, a method called Doppler interrogation, which uses ultrasound, can provide important information regarding blood flow.

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(SEE ALSO: *Maternal and Child Health; Pregnancy; Prenatal Care*)

DIAGNOSTIC TESTING FOR COMMUNICABLE DISEASE

Dorland's Illustrated Medical Dictionary (24th edition, 1965) defines "diagnosis" as the determination of the nature of a case of a disease. In practice, diagnosis is a process of observation, examination, and consideration of the pertinent medical and personal history of the patient. Conclusions as to the cause of disease are drawn from those observations. For many infectious or communicable diseases, the recovery and isolation by a laboratory of the disease agent from a patient exhibiting signs

and symptoms associated with that disease agent is considered to be diagnostic. Also, since patients make specific antibodies to disease agents they are exposed to, the measurement of significant amounts of antibodies in a patient that are specific to a disease agent may also be considered diagnostic.

The use of laboratory data and information becomes increasingly important when the symptoms of a particular disease are not unique, or are nonspecific in early stages of the disease. For example, coughing, sneezing, chills, fever, and headaches are characteristics of a number of respiratory diseases caused by viruses and bacteria. In circumstances such as these, the recovery, isolation, and identification of the disease agent, or the demonstration of specific antibodies to a disease agent by a laboratory, is the only means by which a final diagnosis can be made.

A major activity of public health agencies is the identification of a disease outbreak in a community and the implementation of appropriate disease control measures. Disease outbreak control measures, such as the administration of antibiotics, immune globulin, and vaccines; the temporary closure of public facilities; or the suspension of public activities are based on knowing what specific disease agent is affecting the community. In these cases the rapid and definitive identification of the disease agent by a laboratory is necessary for health officials to apply the appropriate control measures.

While public health agencies are principally concerned with the assessment of the health status of the community, diagnostic testing of an individual with a communicable disease is an essential part of that assessment. This is the basis for reporting certain important infectious diseases to the health department, and is a form of disease surveillance, another important public health activity.

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(SEE ALSO: *Assurance of Laboratory Testing Quality; Laboratory Services; Laboratory Technician; Practice Standards; Reference Laboratory*)

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DIARRHEA

See Food-Borne Diseases *and* Waterborne Diseases

DIET

See Nutrition

DIFFUSION AND ADOPTION OF INNOVATIONS

Diffusion is the process by which an innovation is communicated through certain channels, over time, among the members of a social system. It is a special type of communication concerned with the spread of messages that are perceived as new ideas and which will necessarily be received with some degree of uncertainty. The four main elements in the diffusion of new ideas are: (1) innovation, (2) communication channels, (3) time, and (4) the social system.

THE INNOVATION

An innovation is an idea, practice, or object that is perceived as new. The characteristics of an innovation, as perceived by members of a social system, determine its rate of adoption. Some innovations diffuse relatively slowly, while other innovations diffuse rapidly. The characteristics that determine an innovation's rate of adoption are its relative advantage, compatibility, complexity, trialability, and observability.

The relative advantage of an innovation reflects the degree to which it is perceived as better than the idea it supercedes. The degree of relative advantage may be measured in economic terms, but social prestige, convenience, and satisfaction are also important factors. It does not matter so much if an innovation has a great deal of objective advantage. What does matter is whether individuals perceive the innovation as advantageous. The greater the perceived relative advantage of an innovation, the more rapid its rate of adoption will be.

Compatibility is the degree to which an innovation is perceived as being consistent with the existing values, past experiences, and needs of potential uses. An idea that is incompatible with the values and norms of a social system will not be adopted as rapidly as an innovation that is compatible. The adoption of an incompatible innovation often requires the prior adoption of a new value system, which is a relatively slow process. Technological compatibility may be involved in cases where a particular software program cannot be used because it will not work with a computer's operation system.

Complexity refers to the degree to which an innovation is perceived as difficult to understand and use. Some innovations are readily understood by most members of a social system; others are more complicated and will be adopted more slowly. New ideas that are simpler to understand are adopted more rapidly than innovations that require people to develop new skills and understandings.

Trialability is the degree to which an innovation may be experimented with on a limited basis. New ideas that can be tried on an installment plan will generally be adopted more quickly than innovations that are not divisible. An innovation that is trialable represents less uncertainty to the individual considering using it and who can learn by doing.

Observability is the degree to which the results of an innovation are visible. The easier it is for individuals to see the results of an innovation, the more likely they are to adopt it. Such visibility stimulates peer discussion of a new idea, as friends and neighbors of a user of a product often request information about it.

Overall, innovations that are perceived by individuals as having greater relative advantage, compatibility, trialability, and observability, and as less complex, will be adopted more rapidly than other innovations.

COMMUNICATION CHANNELS

The second main element in the diffusion of new ideas is the communication channel. Communication is the process by which participants create and

share information with one another to reach a mutual understanding. A communication channel is the means by which messages get from one individual to another. Mass media channels are more effective in creating knowledge of innovations, whereas interpersonal channels are more effective in forming and changing attitudes toward a new idea, and thus in influencing the decision to adopt or reject a new idea.

Most individuals evaluate an innovation, not on the basis of scientific research by experts, but through the subjective evaluations of peers who have adopted the innovation. So the diffusion process is essentially social in nature, driven by individuals talking to others and giving meaning to an innovation through a process of social construction.

TIME

The third element in the diffusion of new ideas is time. The time dimension is involved in three ways.

First, time is involved in the innovation-decision process. This is the mental process through which an individual (or other decision-making unit) passes from first knowledge of an innovation to forming an attitude toward the innovation; then to a decision to adopt or reject it; then to implementation of the new idea; and finally to confirmation of the decision to adopt the innovation. An individual seeks information at various stages in the innovation-decision process in order to decrease uncertainty about an innovation's expected consequences.

The second way in which time is involved in diffusion is in the innovativeness of an individual or other unit of adoption. Innovativeness is the degree to which an individual or other unit of adoption is relatively earlier in adopting the new ideas than other members of a social system. There are five adopter categories, or classifications of the members of a social system on the basis of their innovativeness. These categories are: (1) innovators, (2) early adopters, (3) early majority, (4) late majority, and (5) laggards.

Innovators are defined as the first 2.5 percent of the individuals in a system to adopt an innovation. Venturesomeness is almost an obsession with

innovators. This interest in new ideas leads them out of a local circle of peer networks and into more cosmopolitan social relationships. Control of substantial financial resources is helpful to absorb possible losses from an unprofitable innovation. The ability to understand and apply complex technical knowledge is also needed. The innovator must be able to cope with a high degree of uncertainty about an innovation at the time of adoption. While an innovator may not always be respected by the other members of a social system, the innovator plays an important role in the diffusion process.

Early adopters are the next 13.5 percent of the individuals in a system to adopt an innovation. Early adopters are a more integrated part of a social system than are innovators. Whereas innovators are cosmopolites, early adopters are localites. This adopter category, more than any other, has the greatest degree of opinion leadership in most systems. Potential adopters look to early adopters for advice and information about an innovation. Early adopters are the embodiment of the successful use of new ideas, and they know that to continue to earn the esteem of colleagues and to maintain a central position as an opinion leader they must make judicious innovation decisions.

The early majority category contains the next 34 percent of individuals in a system to adopt an innovation. The early majority adopt new ideas just before the average member of a system. They interact frequently with their peers, but seldom hold positions of opinion leadership in a system. The early majority's unique position between the very early and the relatively late to adopt makes them an important link in the diffusion process.

The late majority is the next 34 percent of the individuals in a system to adopt an innovation. The late majority adopt new ideas just after the average member of a system. Like the early majority, the late majority make up one-third of the members of a system. Adoption may be the result of increasing network pressures from peers. Innovations are approached with a skeptical and cautious air, and the late majority do not adopt until most others in their system have done so. The weight of system norms must definitely favor an innovation before the late majority are convinced. The pressure of peers is necessary to motivate adoption.

Laggards are the last 16 percent of the individuals in a system to adopt an innovation. They possess almost no opinion leadership. Laggards are the most local in their outlook of all adopter categories; many are near isolates in the social networks of their system.

The third dimension in which time is involved in diffusion is in rate of adoption. This is the relative speed with which an innovation is adopted by members of a social system. The rate of adoption is usually measured as the number of members of the system that adopt the innovation in a given time period.

THE SOCIAL SYSTEM

The fourth main element in the diffusion of new ideas is the social system. A social system is defined as a set of interrelated units that are engaged in joint problem solving to accomplish common goals. The members or units of a social system may be individuals, informal groups, organizations, and/or subsystems. The social system constitutes a boundary within which an innovation diffuses. Diffusion is affected by norms, which are the established behavior patterns for the members of a social system, and by opinion leadership, which is the degree to which an individual is able to influence the attitudes or overt behavior of other individuals in a desired way with relative frequency.

A key concept in understanding the nature of the diffusion process is the critical mass, which occurs at the point at which enough individuals have adopted an innovation so that the innovation's further rate of adoption becomes self-sustaining. The concept of the critical mass implies that outreach activities should be concentrated on getting the use of the innovation to the point of critical mass. These efforts should be focused on the early adopters, who are often opinion leaders and serve as role models for many other members of the social system. Early adopters are instrumental in getting an innovation to the point of critical mass, and, therefore, they are instrumental in the successful diffusion and adoption of an innovation.

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(SEE ALSO: *Communication for Health; Communication Theory; Diffusion Theory; Health Promotion*)

and Education; Social Cognitive Theory; Social Networks and Social Support; Sociology in Public Health; Transtheoretical Model of Stages of Change)

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DIFFUSION THEORY

Research on the diffusion of innovations model began with the Bryce Ryan and Neal C. Gross investigation (1943) of the diffusion of hybrid seed corn among Iowa farmers. By 1941, about thirteen years after its release by agricultural researchers, this innovation was adopted by almost 100 percent of Iowa farmers. Ryan and Gross studied the relatively rapid diffusion of hybrid corn in two Iowa communities in order to understand this phenomenon so that it might be applied to the diffusion of other farm innovations. However the intellectual influence of the hybrid corn study reached far beyond the study of agricultural innovations and outside the rural sociology tradition of diffusion research that Ryan and Gross represented.

While there are examples of applications of diffusion theory in public health prior to 1960, particularly in immunization campaigns, it is mainly since the 1960s that the diffusion model has been applied in a wide variety of disciplines, including public health, education, communication, marketing, geography, sociology, and economics. From these diffusion studies in various disciplines have come a series of generalizations about the process through which an innovation (defined as an idea perceived by individuals) spreads through certain communication channels over time among the members of a social system. The innovations studied range from the rapid diffusion of the Internet to the nondiffusion of the Dvorak keyboard (to replace the less efficient QWERTY keyboard in typewriters and computers). The innovations that have been studied in diffusion have mainly been technological innovations.

In the 1960s the field of public health adapted the diffusion paradigm to speed the rate of adoption of family planning methods in Latin America,

Africa, and Asia. At about the same time, public health professionals in the United States and other nations began to use the diffusion model for health education and other health promotion programs. Public health researchers began to conduct inquiries on how preventive health innovations spread among members of target audiences, and on the process through which new health programs and practices spread among organizations like public health or among health professionals.

Through these efforts, public health scholarship began to make more important contributions to an improved understanding of the diffusion model. Many of the public health innovations studied are preventive in nature—an individual had to adopt a new idea at a certain time in order to avoid the likely occurrence of some unwanted health event at a later date. In most cases, this future outcome could not be predicted with certainty. Some heavy cigarette smokers, for instance, will not get lung cancer in future years. Also, the health consequences often lag behind the time of adoption of the preventive health innovation by many years. Adoption of “safe sex” practices at the time might have positive consequences (e.g., not becoming HIV [human immunodeficiency virus] positive) years later. Compared to an innovation like hybrid seed corn among Iowa farmers, preventive health innovations generally diffuse much more slowly and require much greater promotion to reach a comparable level of adoption.

Preventive innovations are perceived by their potential adopters as having a lower degree of relative advantage over current ideas and practices. One strategy sometimes utilized to overcome this problem is to stress other advantages of the preventive health innovation. For example, some family planning programs emphasize the improved sexual pleasure of a couple who does not have to worry about unwanted births. Nevertheless, from a diffusion viewpoint, preventive health innovations generally have a slower rate of adoption than do new ideas that are not preventive in nature.

A further distinctive aspect of some health innovations is that they are taboo; that is, they are perceived as extremely private and personal in nature because they deal with proscribed behavior. For example, in the first years of the AIDS

(acquired immunodeficiency syndrome) epidemic in the United States, the broadcast media refused to carry advertisements for condoms, and newspapers would not print news stories in which expressions like “anal intercourse” were used. The means of HIV transmission was referred to euphemistically as “the transfer of bodily fluids.” Communication about birth, death, sexual intercourse, and other bodily functions are considered taboo in many societies. Thus the communication of health innovations that deal with taboo topics face special difficulties.

Despite the preventive and taboo nature of many health innovations, the diffusion of health innovations has been found to share many common qualities with nonhealth innovations. For example, the five characteristics of innovations predict their rate of adoption, the adopters of health innovations can be usefully classified into adopter categories, and most individuals pass through the five stages in the innovation-decision process (knowledge, persuasion or attitude change, decision, implementation, and confirmation). And as with other innovations, mass media channels are more important in creating knowledge of an innovation than are interpersonal channels, which are relatively more important at the persuasion stage.

Further, as in the case of other innovations, most health innovations diffuse over time in the shape of a cumulative S-shaped curve. The crucial mechanism in this S-shaped diffusion process occurs at the point at which critical mass occurs, when enough individuals have adopted the innovation and its further rate of adoption becomes self-sustaining. Essentially, the diffusion process for all innovations consists of individuals talking to one another about the new idea, thus decreasing the perceived uncertainty of the innovation and giving it meaning through a process of social construction.

A number of investigations elevated the effectiveness of interventions designed to speed up the rate of adoption of a health innovation. For example, opinion leaders in a target audience may be given special training about an innovation, in order to speed up the diffusion process. An example of this process is the well-known North Karelia heart disease prevention project undertaken in

England in the 1980s and early 1990s. The project identified and trained opinion leaders in the target audience in order to encourage others to discontinue smoking, begin exercising, and change their nutritional intake in order to lower their risk of heart disease.

EVERETT M. ROGERS

(SEE ALSO: *Communication Theory; Diffusion and Adoption of Innovations; Family Planning Behavior; Health Promotion and Education*)

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DIGITAL RECTAL EXAM

See *Colorectal Cancer and Prostate Cancer*

DIOXINS

Dioxins are a class of halogenated aryl hydrocarbons, formed during chemical synthesis when chlorophenols are used in the starting material. The three most widely studied sources of dioxins are the manufacturing of the herbicide Agent Orange, the manufacturing of the microbicide hexachlorophene, and the chlorine bleaching of wood pulp. Other sources include combustion of wastes that contain chlorine residues in plastics,

and combustion in engines where a chlorinated product has been used as a fuel additive.

2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) is the prototype for the toxicity of this chemical class, which also includes chlorinated dibenzofurans. TCDD is one of the most highly toxic chemicals tested in several laboratory animal species. The acute LD50 (the lethal dose that will kill 50 percent of test animals) in guinea pigs (the most susceptible species) is in the microgram per kilogram range; the toxicity in rodents varies by species and strain of animal. The reason for this variation is that TCDD operates through a specific protein called the aryl hydrocarbon receptor (AhR), and the level of this protein and its ancillary proteins varies across species. TCDD is teratogenic in mice and carcinogenic in rats and mice, and is classified as a probable human carcinogen based on animal data and epidemiological studies. The most common human finding observed in high level occupational and accidental exposures is chloracne, a skin disorder. Several epidemiology studies have been conducted in worker cohorts, and in veterans and residents of Vietnam, with inconsistent results. However, it is generally accepted that TCDD has the potential to be a human carcinogen and teratogen, and exposures should be reduced to an absolute minimum.

The controversy surrounding this class of compounds stems from five areas. First, TCDD is highly toxic having carcinogenic, teratogenic, immunotoxic, and endocrine modulation properties. Second, there are over 200 analogs and congeners of the dioxins and benzofurans, with varying qualitative and/or quantitative toxicity. Toxic Equivalent Factors (TEFs) have been developed based on the ability of the analogs and congeners to bind to the AhR and induce a family of enzymes in a manner similar to TCDD. Third, TCDD is very persistent in soil and in animal tissues (including humans). Half-life estimates range from months to several years. Dioxins also bioaccumulate in the food chain. Hence, the potential is there for the compounds to accumulate in human tissue. Fourth, the extent of toxicity in humans has not been well defined. Fifth, dioxins are produced as combustion products when chlorine is available in the burning process. This area is of particular importance because of the incineration of municipal waste that contains bottles made from chlorinated plastics.

A great deal of research has gone into the generation and control of dioxin emissions from incinerators. One confounding factor is that incinerators may not be the only point source for dioxins, and fewer chemical plants are using starting materials that will lead to major releases of dioxins as in the past. Wood pulp and paper bleaching in the United States and Canada has minimized or eliminated the use of chlorine bleaches, but the contamination that exists is very persistent. The search for other sources of dioxins continues.

Some polychlorinated biphenyls (PCBs), another class of chlorinated hydrocarbons, mimic the biological activity of dioxins.

MICHAEL GALLO

(SEE ALSO: *Carcinogen; Carcinogenesis; Endocrine Disrupters; PCBs; Persistent Organic Pollutants [POPs]; Pollution; Toxicology*)

DIPHThERIA

Diphtheria is a communicable disease caused by infection with *Corynebacterium diphtheriae*, typically presenting as respiratory tract infection in temperate climates and as cutaneous infection in the tropics. Clinical manifestations include pseudomembrane formation in the respiratory tract and soft tissue swelling of the neck ("bull neck"). Serious complications, primarily damage to the heart muscle and certain nerves that activate muscles, are due to diphtheria toxin, a potent toxin. Nontoxicogenic strains can produce respiratory tract illness with pseudomembrane. Clusters of cases of invasive disease due to nontoxicogenic strains, predominantly among persons with antecedent injection use, have been reported recently from several countries.

Vaccines composed of inactivated diphtheria toxin–diphtheria toxic–were developed in the early twentieth century and have been widely used in most developed countries since the middle of the twentieth century. Prior to introduction of vaccination, diphtheria was a major cause of childhood mortality in the United States, but by the 1990s respiratory diphtheria has been virtually eliminated in the United States and in other countries with high levels of childhood vaccination for

diphtheria. Nonetheless, the infection remains endemic in much of the developing world. In the 1990s, a massive resurgence of diphtheria occurred in the countries of the former Soviet Union. Factors contributing to the epidemic included low vaccination coverage among children, lack of routine adult booster vaccination, population movements, and multiple introductions from areas where diphtheria remained endemic.

In the World Health Organization's Expanded Programme on Immunization, diphtheria toxic is administered with tetanus toxic and pertussis vaccine (DTP) at 6, 10, and 14 weeks of age. Recommendations for subsequent doses vary among countries. In the United States, diphtheria toxic is routinely administered with tetanus toxic and acellular pertussis vaccine at 2, 4, and 6 months of age, with booster doses at 15 to 18 months and 4 to 6 years of age.

Diphtheria antitoxin is the mainstay of treatment of diphtheria. Outcome improves with early diagnosis and treatment. Antimicrobial therapy with penicillin or erythromycin hastens elimination of the organism. Antimicrobial prophylaxis is recommended for those in close contact with diphtheria cases.

MELINDA WHARTON
CHARLES VITEK

(SEE ALSO: *Communicable Disease Control; Diphtheria Vaccine; Immunizations*)

DIPHThERIA VACCINE

Diphtheria vaccine is a toxoid prepared by inactivating (with formaldehyde) the externally released toxin produced by *Corynebacterium diphtheriae*, the causative agent of diphtheria. Administration of three or more doses of diphtheria toxoid at intervals of six weeks or longer induces circulating antibodies that will protect against the toxic effects of diphtheria for several years. These toxic effects include damage to the nervous system or to the heart. Booster doses at intervals of ten years will maintain protective levels of circulating antibodies. Because the vaccine does not contain antigens from the bacterium itself, it will not prevent colonization or infection by *C. diphtheriae*. Diphtheria

toxoid is commonly combined with tetanus toxoid and pertussis vaccine as the “DTP” vaccine. All countries in the world recommend vaccination of all infants with diphtheria toxoid. The primary adverse effects associated with diphtheria toxoid are local reactions at the site of injection.

ALAN R. HINMAN

(SEE ALSO: *Child Health Services; Communicable Disease Control; Diphtheria; Immunizations*)

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DIRECTOR OF HEALTH

“Director of Health” is a term characteristically used to describe the chief executive officer of a local or state health department. Sometimes the title “Health Commissioner” is used in local agencies. Approximately one-third of local agency top executives hold medical doctoral degrees, and fewer than twenty percent have graduate public health degrees. Doctoral degrees are most common in local agency executives serving populations of 500,000 or more. Almost sixty percent of current local agency directors have been in their positions more than five years. Qualifications are highly variable for state health directors and turnover is typically rapid.

C. WILLIAM KECK

(SEE ALSO: *Association of State and Territorial Health Officials; National Association of County and City Health Officials; National Association of Local Boards of Health; State and Local Health Departments*)

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DISASTERS

See *Famine; Genocide; Natural Disasters; and Refugee Communities*

DISEASE PREVENTION

Disease prevention is the deferral or elimination of specific illnesses and conditions by one or more interventions of proven efficacy. While the term is generally applied to human health, the principles apply to other plant and animal species.

It is useful to distinguish among three levels of prevention—primary, secondary, and tertiary—although the boundaries between these levels are not always perfectly understood. “Primary prevention” refers to the prevention of diseases before their biological onset. For example, pasteurizing milk essentially eliminates bacterial pathogens that could cause illnesses, and measles immunization prevents clinical illness before it can get started. Another kind of primary prevention occurs when older persons with osteoporosis wear hip protectors, which absorb the shock of a fall and are capable of preventing hip fracture. Behavioral interventions such as smoking cessation, preventive dental care, and maintaining physical exercise are also examples of primary prevention, as are the provision of uncontaminated food and water. Routine searching for genetic abnormalities is usually a form of primary prevention, in that abnormal genes that are associated with various diseases can often be detected before any disease occurs. An example is newborn screening for phenylketonuria, a metabolic disease that can be subverted with an appropriate diet. There are many logistical and ethical difficulties in routine searching for genetic abnormalities, however, and appropriate approaches are still being developed.

A term sometimes used, related to primary prevention, is “primordial prevention,” which refers to creating an environment where certain challenges to health are eliminated, and thus no other preventive interventions are necessary. Two

examples of primordial prevention are the global elimination of smallpox, so that no immunization is necessary; and the potential for eliminating added salt from all foods, which would, if achieved, be quite effective in preventing hypertension.

“Secondary prevention” refers to the prevention of clinical illness through the early and asymptomatic detection and remediation of certain diseases and conditions that, if left undetected, would likely become clinically apparent and harmful. This is often referred to as “screening.” There are many examples of secondary disease prevention, including routine bacteriological culturing for sexually transmitted organisms in asymptomatic persons; routine serological testing for preclinical infections such as syphilis; screening for high blood pressure, which may indicate clinical hypertension; screening for early breast cancer using mammography or for early cancers or precancerous lesions of the colon using sigmoidoscopy or colonoscopy. An example of a form of screening that is actually a primary prevention is to routinely examine the paint on walls of older homes, where lead contamination and its exposure to children may be a problem. One variation of secondary prevention is to screen for conditions that might be clinically overt but have gone undetected, such as clinical depression or other mental illnesses. This is also quite useful because such conditions are often quite treatable. Sometimes it may be possible to apply primary preventive interventions to diseases that are already developing: smoking cessation and increasing exercise may prevent the emergence of heart attack or stroke, even though some atherosclerotic lesions (hardening of the arteries) are already developing.

“Tertiary prevention” refers to the prevention of disease progression and additional disease complications after overt clinical diseases are manifest. This is generally the province of physicians and other health professionals, who manage acute and chronic conditions. While the distinction between disease treatment and tertiary prevention may be sometimes uncertain, many examples exist—lowering a high blood cholesterol level after a heart attack can prevent the occurrence of further heart attacks and related conditions such as stroke and angina pectoris (chest pain with activity). Similarly, treating high blood pressure after a stroke

may decrease the risk of subsequent strokes. For persons with diabetes mellitus, eye examinations to detect diabetic retinal disease, and steps taken to prevent its progression, are routinely undertaken. Routine podiatric care can deter the effects of diabetic vascular disease on the feet. Among persons who are severely disabled, provision of special mattresses and other interventions can prevent some chronic skin ulceration. Providing handrails in the homes of persons at high likelihood of repeated falling can prevent fractures and other injuries. Tertiary prevention is perhaps the least well developed of the three domains, and is ripe for considerable prevention research.

The construct of primary, secondary, and tertiary prevention considers preventive intervention in the context of the onset and natural history of specific human diseases and their outcomes. Another way to view disease prevention is to consider where particular preventive interventions are carried out. Some of the most important disease prevention is carried out by *environmental modification*. This includes all sanitary services, such as the provision of safe food and water; adequate housing; and a general environment free of disease-causing physiochemical and biological pollutants. Many work environments require substantial environmental protections, since they would otherwise be extremely hazardous. There are countless other environmental modifications that yield disease prevention, such as highway engineering to control speeds and dangerous road segments, the elimination of overhanging building cornices, and the removal of sharp edges or provision of shielding devices on consumer products.

Another general source of disease prevention is through appropriate individual and group behavior. Part of the disease-prevention burden lies with the individual, who must practice behaviors that minimize disease risk and occurrence, and maximize health states. Some obvious examples are maintaining an appropriate weight, never taking up or ceasing the use of tobacco products, avoiding exposures that may lead to unwanted pregnancy or passage of sexually transmitted diseases, avoiding carcinogenic sun exposure, maintaining active exercise habits appropriate for one’s health status, appropriately using prescription drugs or other substances, refusing to drive a vehicle after consuming alcohol, and discouraging participation in social behaviors that may lead to disease

or injury. Some persons are more prone to risk-taking behaviors in general, but there are currently not many interventions for these situations. It is clearly important that individuals have sufficient and accurate information in order to assist in initiating and maintaining disease-preventing behaviors. Thus, a related source of appropriate disease prevention is wherever health education and behavioral training takes place. This may include educational institutions, medical care sites, the Internet, and all other venues where health information and knowledge are offered, including the media and marketing activities.

Another important source of disease prevention lies largely with health-professional practice. In general, only health professionals can conduct and interpret many screening procedures, administer immunizations, or prescribe chemopreventive interventions and provide tertiary preventive services for persons with existing medical conditions. A substantial amount of health counseling and education is done by health professionals. Thus, it is important that health professionals provide clinically appropriate and comprehensive preventive services in the practice setting—as well as at other community locales, where the entire population can acquire access to them. In recent years, the extent of clinical preventive services provision has served as a key indicator of the general quality of health professional practice.

Underlying preventive-intervention delivery, no matter the source, is the need for political action. The citizens of every community or jurisdiction must provide the political impetus and the resources to assure that modern prevention is available, whether in regulating and policing the general or workplace environment, assuring high-quality sanitary procedures, furnishing effective educational programs and services, or providing fiscal and geographical access to clinical services. Provision of suitable research programs and prevention professionals is also critical. Prevention interventions may vary considerably in the evidence of their efficacy, the proportion of the population that will be positively affected by the intervention, and intervention delivery costs. Thus, some prioritization of the universe of potential interventions will often be necessary; methods to conduct such prioritization are often lacking, however, and more research is needed in this area.

Disease prevention may not be equally applied to all persons in the community. While many clinical and environmental interventions, such as routine childhood immunizations, air pollution control, and public health sanitary measures, are appropriately intended for all persons, individuals may differ dramatically in their risk of various diseases for genetic, behavioral, or environmental reasons. If groups with varying risks can be effectively discerned and efficiently identified, then some disease prevention activities may be differentially targeted for high-risk groups, both for reasons of efficacy and cost. For example, screening for blood-lead levels in children may only be useful for those who reside in older housing, where lead paint exposure is much more likely. Persons with a clear family history of some chronic conditions, such as coronary heart disease and cancer, may benefit from more intensive screening and intervention programs.

Applying disease-preventing interventions requires the same care and consideration as any clinical treatment, for several reasons. There should be evidence of efficacy—that the intervention has sufficient scientific basis to know that it works. Some interventions proffered under the guise of prevention have insufficient evidence of benefit, and more systems to monitor and provide evidence summaries are needed—existing systems include the United States Preventive Task Force, the Task Force on Community Preventive Services, and the Cochrane Collaboration. Also, it is important to note that most direct preventive interventions, even when appropriately applied, do not prevent disease in all persons. Thus, routine mammographic testing results in only a 20 to 30 percent reduction in breast cancer mortality, and physician counseling for smoking cessation has only a small effect on the smoking behavior of patients. The effect of these interventions will only be enhanced by new research and more efficient delivery programs. On the other hand, some preventive interventions are highly effective, such as many vaccines, food safety procedures, and other public health environmental activities. A related problem for some disease-prevention interventions is that long-term efficacy may be uncertain.

As in the case of clinical treatments, preventive interventions may have actual or potential

adverse effects, some of which may be undetected. It is often pointed out that disease prevention has a greater moral burden to be free of adverse effects than do treatments, since they target individuals who are generally healthy. Some adverse effects are clearly and immediately identifiable, such as acute allergic reaction to a vaccine or a perforated colon during an endoscopic procedure. Others require longer term surveillance. For example, a long-term randomized trial of an early cholesterol-lowering drug revealed that the drug caused lower rates of nonfatal heart attacks but higher overall mortality rates. Similarly, a particular intervention may have an effect in a definitive randomized trial that was not predicted from epidemiological studies. For example, while consuming beta-carotene-containing vegetables has been associated with lower cancer incidence rates, randomized trials of beta-carotene in smokers have been associated in some studies with higher incident lung cancer rates. Also an intervention may have varied effects on different disease outcomes. A recent clinical trial for stroke prevention using a newer cholesterol-lowering agent found that overall strokes were prevented, but hemorrhagic strokes were significantly more frequent in the intervention group.

Behavioral and psychological adverse effects of the disease-prevention activities may be more subtle, but they are still important. An individual who has undergone a screening test may conceivably abandon health-promoting behaviors, incorrectly feeling that he or she is disease-free. Since most screening tests are not 100 percent sensitive in detecting the presence of the target disease, a false sense of security may occur. Similarly, an individual may not understand that many screening interventions must be done repeatedly to be effective, and thus may fail to participate at appropriate intervals. Some individuals may not be emotionally or educationally prepared for dealing with a disease that might be detected by screening, and this poses additional challenges for health professionals and health systems.

ROBERT B. WALLACE

(SEE ALSO: *Behavior, Health-Related; Behavioral Change; Environmental Determinants of Health; Prevention; Preventive Medicine; Primary Prevention, Risk Assessment, Risk Management; Secondary*

Prevention; Social Determinants; Tertiary Prevention; and articles on specific diseases mentioned herein)

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DISINFECTION

See Antisepsis and Sterilization

DISINFECTION BY-PRODUCTS IN DRINKING WATER

Disinfection is the most important step in the water treatment process to destroy pathogenic bacteria and other harmful agents. Because chlorination is a very common and effective method for such disinfection, most drinking water is treated with chlorine. This has been the single most important process for assuring the bacteriological safety of potable water supplies. As a result of water treatment, waterborne epidemics have virtually disappeared in the industrialized world. When waterborne disease outbreaks have occurred, they have generally been traced back to a failure of the chlorination system. An important advantage in using chlorine is that a residual in the water continues to provide germ-killing potential as the water travels from the distribution point to end-users.

Trihalomethanes (THMs) are the major synthetic organic pollutants that are by-products of disinfection. THMs are formed at the water treatment plant when the chlorine is added to water that contains humic substances. Humic substances are naturally occurring leaves and other organic matter, and the dissolved compounds derived from organic matter, and they are found in all water. Among the THMs is chloroform, which is a carcinogen, along with other potential carcinogens. Chloroform has been detected in many water supplies, causing a number of individuals to call for the end of drinking water chlorination. The current consensus is that while there is a risk associated with chlorination, this risk is small compared to the risk of waterborne diseases in untreated water.

Some water suppliers have switched to alternatives to chlorination to eliminate the formation of THMs. Other methods for disinfection include ozone, bromine, iodine, or ultraviolet light. However, chlorine is a cost-effective disinfection process.

MARK G. ROBSON

(SEE ALSO: *Chlorination; Drinking Water; Sanitation; Water Quality; Water Treatment*)

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DISPARITIES IN HEALTH

See *Inequalities in Health*

DISSOLVED OXYGEN

Dissolved oxygen is the amount of oxygen present in fresh water, such as a stream, or freshwater lake. A certain amount of dissolved oxygen is required to sustain fish, animals, and other aquatic life. Any decrease in dissolved oxygen can cause changes, usually negative, in an aquatic system. These include fish kills and loss of aquatic ecosystems. Changing aerobic conditions to anaerobic conditions can cause putrefactive decomposition, which creates sulfides, mercaptanes, and amines. In liquid wastes, the level of dissolved oxygen determines whether the biological changes are brought about by aerobic or by anaerobic organisms. Anaerobic conditions are generally considered undesirable because of the foul odors produced, such as that caused by hydrogen sulfide. Since both aerobic and anaerobic organisms exist in nature, it is important to maintain aerobic conditions in water.

Maintaining aerobic conditions is also important in natural bodies of water that receive potential pollutants. The transformation and decomposition of organic matter in water occur best under aerobic conditions due to the consumption and oxidation of organic substrates by aerobic microbes. The oxygen is replenished through several mechanisms, one being the simple diffusion of the oxygen from the atmosphere into the water. Additionally, aquatic plants and algae produce oxygen through photosynthesis and the natural movement of water.

The level of dissolved oxygen can decrease in several ways, primarily through increased aerobic

microbial action. It can also decrease from increases in water temperature.

Dissolved oxygen determination serves many purposes. For example, it serves as the basis of the biological oxygen demand (BOD) test. These tests are used in the evaluation of domestic and industrial waste's capacity to pollute. Determining the residual dissolved-oxygen in a stream at various time intervals aids in the measurement of biochemical oxidation.

MARK G. ROBSON

(SEE ALSO: *Ambient Water Quality; Biological Oxygen Demand; Water Quality*)

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DISSOLVED SOLIDS

Dissolved solids in surface water come from the natural dissolution of rocks and minerals or from discharges from municipal or industrial sources. Dissolved solids are mainly composed of cations such as calcium, magnesium, sodium, and potassium; and the anions bicarbonate, carbonate, sulfate, and chloride. Excessively large concentrations of dissolved minerals in drinking water may result in physiological effects, unpalatable mineral tastes, and increased costs due to corrosion or the necessity for additional treatment.

Dissolved solids occur naturally in all surface water at varying concentrations. This variation is due to factors such as the chemical properties of drainage-basin soils and the minerals in deeper geologic strata. Groundwater may dissolve salts from marine sediments containing large salt deposits and then discharge them into surface water. The concentration of dissolved solids in surface water may also increase due to point-surface discharge. The total solids content of water can be determined indirectly by measuring both the suspended and the dissolved solids. The sum of the

dissolved solids plus the suspended solids equals the total solids. The presence of solids in water can increase turbidity. Dissolved minerals such as magnesium and calcium contribute to the hardness of water.

MARK G. ROBSON

(SEE ALSO: *Sanitation; Water Quality; Water Treatment*)

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DIX, DOROTHEA

Dorothea Dix was born in 1802 in a rural section of Maine. After moving to Boston at the age of fourteen to live with her wealthy but austere grandmother, Dix became a schoolteacher and writer. In 1835, however, she suffered a physical and psychological collapse. She traveled to England, where under the care of philanthropists William and Elizabeth Rathbone, Dix regained her health. In England, she also came into contact with new ideas about social reform and government responsibility.

After returning to the United States, she initiated a public health movement to reform the treatment of the indigent mentally ill. At the time, paupers who were mentally ill were incarcerated alongside convicted criminals and often housed in unheated, unfurnished, and squalid quarters. After conducting an extensive investigation throughout Massachusetts, Dix wrote her most influential tract, *Memorial to the Legislature of Massachusetts* (1843). Dix's thirty-two page report humanized the plight of the mentally ill residing in state institutions, and Massachusetts responded with legislation.

As an antisuffragist and antiabolitionist, Dix appealed for her causes to male politicians as well

as southerners, and she prompted cities and states throughout the nation to create better facilities for the mentally ill. Motivated by her success, Dix proposed placing a large land grant in the custodial care of the federal government to provide perpetual funding for the care of the indigent mentally ill of America. Her plan, however, fell to a presidential veto in 1851. Dix took on a new challenge during the Civil War, accepting the position of Superintendent of Women Nurses, but her personality was ill suited for this administrative position. Towards the end of her life, Dix chose to reside in Trenton, New Jersey, at the first complete hospital built through her efforts, where she died in 1887.

JENNIFER KOSLOW

(SEE ALSO: *Homelessness; Mental Health*)

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DOMESTIC VIOLENCE

Societies have made important gains in addressing the problem of domestic violence, particularly in the area of service delivery to its victims. However, millions of women are battered by their intimate partners every year in countries around the globe.

HISTORY AND OUTRAGE

During the 1960s, the women's liberation movement began drawing attention to violence committed against women, and the battered women's movement began to form. At its core was the outrage of women who argued that individual cases of violence against women in the home added up to an enormous and unacceptable social problem. By the end of the 1970s, statistics proved that isolated cases of abuse were part of a shocking national problem. Victims became more visible; so, too, did the inadequacy of society's response. The battered women's movement emerged, becoming one of the most powerful social justice and service movements in United States history.

Shelters and hotlines began to spring up around the country. What began as a social, service-based response to crisis began to take on political urgency. The staggering numbers of women and children turning to shelters perpetually outpaced the growth of the movement. The shelter work uncovered endless horror stories: law enforcement officials who mislabeled domestic disturbances, judges who ruled in favor of perpetrators, and health care providers who mishandled violence-related injuries. At every turn, women seeking help could expect indifference, hostility, and endangerment. It became clear that helping women in crisis required more than front-line emergency services. It required changing the established social institutions and creating or changing the laws that affected them. During the 1980s, a vibrant network of nearly two thousand domestic violence programs in the United States organized into state coalitions, formed to take on the challenge of pressuring social institutions to adequately respond to victims.

The 1990s proved to be a watershed decade. The Violence Against Women Act (VAWA, 1994) was passed, a major federal bill that provided more than \$1 billion to assist shelters, train law enforcement personnel and judges, and support other crime-prevention efforts addressing violence against women. The decade also saw, via live television, the trial of football legend O. J. Simpson for allegedly murdering his former wife, Nicole, and her friend. Though he was eventually acquitted of criminal charges, Simpson's case prompted unprecedented media coverage of the issue of domestic violence.

DILEMMAS AND OPPORTUNITIES

The domestic violence movement clearly has a rich history of achievement. The critical front-line service provision crisis response, while central to saving some women's and children's lives, can never realize its mission: to reach out to all victims. Despite its rapid growth, the service system is unable to keep pace with widespread need. Prevalence statistics and anecdotal evidence all point to the epidemic nature of domestic violence: Nearly one-third of American women (31%) report being physically or sexually abused by a husband or boyfriend at some point in their lives. Yet only a

small fraction of abused women ever go to a shelter.

The domestic violence movement's agenda remains predominantly shaped by the quest to improve services for, and to make laws accountable to, domestic violence victims. As a result, the notion of domestic violence prevention in North America and most of Europe relies heavily on punitive criminal intervention. Although the movement has consistently educated policymakers and other institutions, the advocacy community has not focused collective attention on developing an agenda for preventing domestic violence at its earliest stages.

The criminalization of domestic violence and the sensitizing of criminal justice agents should by no means be abandoned. However, emphasis must also be given to other sectors of society, including communities of faith, health delivery systems, and workplaces. Preachers, doctors, employers, coworkers, friends, and family members are all in a prime position to reach out to help women facing abuse, as well as to let batterers know—perhaps for the first time—that their behavior is simply unacceptable. Evidence suggests that many battered women are actually more comfortable talking with friends and family members about the violence in their lives than with trained domestic violence professionals whom they do not know. Developing leadership within each of these arenas, then, represents a huge potential for disseminating more broadly messages that can begin to change the social norms.

Unfortunately, pervasive cultural acceptance of domestic violence at all levels of society helps to explain how the justice system has historically responded to domestic violence. Typically, police have not taken the problem seriously, rarely arresting perpetrators. When battered women persevered and tried to press charges, district attorneys often refused to support their cases, and the cases that did make it to court were likely to be dismissed.

While laws have strengthened the ability to respond to domestic violence cases, covert attitudes that condone battering explain why inaction is the norm rather than the exception. According to a 1996 public opinion survey, almost half of Americans (47%) currently believe that men sometimes physically abuse women because they are

stressed out or drunk, not because they intend to hurt them. Clearly the domestic violence movement has yet to cultivate widespread attitudes that condemn violent abuse of women.

RECREATING A SENSE OF OUTRAGE

One of the greatest challenges facing the domestic violence movement is the widespread perception that spousal abuse is a “private matter.” Domestic violence is often perceived as private business between two individuals that requires therapy rather than intervention. Creative approaches are needed in order to move a private matter into the sphere of public concern and to translate that public concern into a widespread social consensus for action. A successful strategy would include the following: a comprehensible institutional change approach to empower individuals to make contributions through the institutional structures that touch their daily lives; an emphasis on prevention that is partnered with an ongoing commitment to victims; a multifaceted media campaign that begins to change the collective social consciousness; and a reigniting of the community-based, political activism that spawned the movement in the first place.

For example, in the early 1990s, The Family Violence Prevention Fund (FVPPF) began to explore ways to strategically inject the politics of outrage back into the domestic violence movement in the United States, combining media and community-based activism into an overall approach. In 1994, the FVPPF launched a nationwide media and grassroots organizing campaign called “There’s No Excuse for Domestic Violence.” It targets the friends, family, and coworkers of victims of abuse who sanction the violence with their silence and whose actions can help change social norms. The campaign includes public service announcements that trumpet the campaign’s key messages that “domestic violence is everybody’s business” and “there’s no excuse for it.” In one powerful print ad, viewers are confronted with the image of a man brutally beating his cowering wife, under the words: “If the noise coming from next door were loud music, you’d do something about it.” These public service announcements provide a toll-free number individuals can call for a free action kit, which details concrete ways people can address abuse in their workplaces and communities.

These and other programs that generate and communicate this kind of collective sense of indignation about the problem of domestic violence work toward a broader, more comprehensive approach that involves ever more components of society. Their aim is to proactively affect public policy and wide-ranging institutional policies, community responsibility, and individual action, and to move a “private issue” into a public space in which domestic violence is forbidden.

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(SEE ALSO: *Alcohol Use and Abuse; Antisocial Behavior; Gun Control; Homicide; Violence*)

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DOSE-RESPONSE RELATIONSHIPS

See Toxicology

DOUBLING TIME

The average time it takes for a particular population to double in size is known as its “doubling

time.” This statistic is a rough indicator of the fertility of a population. Factors responsible for variation in reproductive rates are complex and imperfectly understood, but the world's doubling times have become progressively briefer throughout recorded history. It took several hundred years for the world's population to double from 1 million to 2 billion, less than one hundred years for doubling from 2 billion to 4 billion, and less than fifty years for doubling from 3 billion to 6 billion. It is believed that improvements in public health are the main cause of these shorter doubling times. Within individual nations, doubling times relate closely to total fertility rate, and they can vary considerably. As of 2000, several European countries had doubling times of hundreds of years, while in Kenya, the doubling time was less than twenty years.

JOHN M. LAST

(SEE ALSO: *Demography; Fecundity and Fertility; Population Growth*)

DOWN SYNDROME

See Medical Genetics

DRACUNCULOSIS

Guinea worm, or dracunculosis, is a helminth infection. The adult female worm is about a meter in length and a millimeter in diameter. It lives in subcutaneous tissue, often embracing a male worm. Males are about 2.5 centimeters long. The female consists almost entirely of a uterus to produce eggs that are disgorged into fresh water through an ulcer on the skin, usually on the lower legs of infected individuals. The eggs are ingested by fresh water crustaceans that are small enough to be swallowed when humans drink the water. The larvae mature and migrate through soft tissue to reach their final destination just under the skin.

Until the 1980s, guinea worm infection affected about 125 million people all across equatorial Africa, the Arabian peninsula, Iran, Afghanistan, and the Indian subcontinent. Prevention

campaigns based on water filtration, education, and treatment of affected people have succeeded in eradicating dracunculosis from India, which was declared free of infection early in 2000 after zero case reports since 1996, and have reduced the total number of cases worldwide to an estimated 100,000, mostly in West Africa and Yemen, by late 1999.

The worm can survive in subcutaneous tissue for years. The traditional method of removing it by winding it laboriously around a stick, withdrawing it gradually a little more each day, is still an effective way to get rid of worms, although surgical removal is also an option.

JOHN M. LAST

DRINKING WATER

In the United States, the rate of consumption of drinking water is almost 100 gallons per person per day. Only a small portion of the “drinking water” supplied by public water systems is actually used for drinking; other uses include toilet flushing, bathing, cooking, cleaning, and lawn watering. Drinking-water supplies in large cities come from surface-water sources such as lakes, rivers, and reservoirs. In rural areas, groundwater is more likely to be the source of drinking water. In this case, groundwater is pumped from a well that taps into aquifers. Rain and snow precipitation are also collected and used for this purpose.

Groundwater, which is the main source of drinking water for almost half of the population of the United States, is normally free of suspended solids, bacteria, and other disease-causing organisms. Due to agricultural runoff or disposal of liquid waste, however, groundwater is being contaminated. Groundwater is relatively inexpensive and easy to access, but it is limited in volume and thus irreplaceable if depleted. To avoid such an occurrence, many states are creating ways for rainfall to move into holding ponds so that water can recharge aquifers by entering the ground again.

Another potential source of drinking water is runoff from rainfall, which can be used to supply large municipalities. This water is collected and treated before being distributed for human consumption.

Surface water requires extensive treatment before it can be distributed for human consumption. Sources of surface water include lakes, streams, and rivers.

The 1974 Safe Drinking Water Act was used by the Environmental Protection Agency (EPA) to set a series of primary standards to protect human health, as well as secondary standards that deal with the temperature, color, taste, and odor of drinking water. The primary standards consist of maximum contaminant levels (MCLs) for specific inorganic contaminants, volatile organic chemicals, and radioactive materials, as well as limits for turbidity and coliform organisms. The EPA also identified the following treatment processes as being effective in removing or reducing the levels of contaminants: conventional coagulation, sedimentation, and filtration; or lime softening treatment.

Societal concerns for the quality of water resources continue as many of the streams and coastal waters do not meet water-quality goals. States report that 40 percent of the waters surveyed are too contaminated for drinking, fishing, or swimming. Since the signing of the Clean Water Act in 1972, public and private sectors have spent more than \$500 billion on water pollution control.

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(SEE ALSO: *Ambient Water Quality; Clean Water Act; Environmental Protection Agency; Groundwater; Groundwater Contamination; Water Quality; Water Treatment*)

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DRUG ABUSE RESISTANCE EDUCATION (DARE)

Drug Abuse Resistance Education (DARE) is the most widely adopted drug education program in the United States today. The DARE program is designed to give young people skills to resist pressures to use drugs. It originated as a collaborative effort between the Los Angeles Unified School District and the Los Angeles Police Department in 1983. The original curriculum consisted of seventeen weekly lessons for fifth- and sixth-grade students taught by specially trained uniformed police officers. Since its origin, a nine- to ten-week middle school curriculum and a six-week high school curriculum have been added. DARE school police officers make regular visits to lower elementary classrooms. DARE-PLUS, a later addition to the DARE program, consists of two ten-week "Play and Learn Under Supervision" programs of after-school activities. DARE programs have received widespread support from parents and community leaders. Careful evaluations suggest modest short-term changes in young people's knowledge, attitudes, and beliefs about drugs, and some effect on cigarette smoking. DARE appears to be less effective in delaying drug use than other more interactive programs. Strong public support for DARE and limited evidence of its effectiveness have created controversy about DARE's role and value.

IAN M. NEWMAN

DRUG RESISTANCE

Drug resistance is the inability of a drug to bring about an effect on a disease-causing agent that occurred previously in the presence of that same medication. Resistance to an antibiotic, for example, occurs when bacteria that were previously killed by one antibiotic will now grow in the presence of that same antibiotic (i.e., the bacteria have developed a way to avoid or prevent cell death). In the United States, *Streptococcus pneumoniae*, a common cause of pneumonia, bronchitis, ear infections, and other conditions, was universally sensitive to penicillin prior to 1990. As of June 1999, however, penicillin was either no longer effective or was required in higher than previously effective doses to treat about 25–35 percent of all *S. pneumoniae* isolates. This decrease in the effectiveness of penicillin is attributed to an acquired drug resistance to penicillin by the bacteria.

MEGANNE S. KANATANI

(SEE ALSO: *Antibiotics; Communicable Disease Control; Multi-Drug Resistance; Pathogenic Organisms; Penicillin*)

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E

E. COLI

The primary bacterial indicator used for assessment of microbial contamination of water consists of the coliform group. Coliform bacteria are universally present in high numbers in the feces of warm-blooded animals, including humans, and can be detected even after considerable dilution.

Escherichia coli (*E. coli*), is one of the most common coliform bacteria types. Detection of *E. coli* is definite evidence of fecal pollution. *E. coli* are facultatively anaerobic gram-negative rods that live in the intestinal tracts of animals. They can grow in the presence or the absence of oxygen. Under anaerobic conditions, *E. coli* grow by fermentation, producing mixed acids and gases as end products. They can also grow by anaerobic respiration, utilizing NO_3^- , NO_2^- , or fumarate. This versatility is what gives *E. coli* its ability to adapt to its intestinal (anaerobic) and its extraintestinal (aerobic or anaerobic) habitats.

As a pathogen, *E. coli* is best known for its ability to cause intestinal diseases. Five classes of *E. coli* can result in diarrheal diseases, but three specific pathogenic strains—enterotoxigenic, enteropathogenic, and enteroinvasive—cause problems when present in the water supply. All three of these types can cause acute diarrhea. An outbreak of *E. coli*-induced diarrhea can have a fatality rate as high as 40 percent in newborn children.

Enterotoxigenic *E. coli* (ETEC) are an important cause of diarrhea in infants (e.g., in nurseries and institutions), and in travelers to areas with poor sanitation. ETEC are acquired by ingestion

of contaminated food and water. Adults in endemic areas develop immunity. In developing countries, children under the age of three experience multiple ETEC infections. The primary symptom of ETEC infection is diarrhea without fever.

Enteroinvasive *E. coli* (EIEC) penetrate and multiply within epithelial cells of the colon and cause widespread cell destruction. EIEC are very similar to *Shigella* in their pathogenic mechanisms and the type of clinical symptoms they cause—diarrhea with fever. EIEC infections are endemic in developing countries and are the cause of 1 to 5 percent of diarrheal episodes among people seeking treatment.

Enteropathogenic *E. coli* (EPEC) are an important cause of traveler's diarrhea in Mexico and in North America. This class of *E. coli* produces watery diarrhea similar to that of ETEC, probably due to the bacterial invasion of host cells and modification of cellular signals. Diarrheal episodes among children caused by EPEC in endemic populations are normally limited to children under the age of one. In this age group, EPEC causes watery diarrhea with mucus, fever, and dehydration. EPEC is no longer an important cause of infant diarrhea in North America and Europe, but is still a major cause in many developing countries in South America, southern Africa, and Asia.

Escherichia coli 0157:H7 is classified by the Centers for Disease Control and Prevention as the cause of one of the emerging infections diseases. *E. coli* 0157:H7 is one of the more virulent of the many strains of *E. coli* found in the environment.

(The CDC reports that 20,000 cases of 0157:H7 infection may occur annually.) *E. coli* 0157:H7 is found in the intestinal tract and feces of animals and humans. Infection often causes severe, bloody diarrhea and abdominal cramps. In children, the elderly, and immune-compromised individuals, the infection can lead to kidney failure and possible death. Undercooked ground beef (due to its handling and preparation) represents one of the greatest risks of *E. coli* 0157:H7 infections.

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EARTHQUAKES

See Natural Disasters

EASTERN EQUINE ENCEPHALITIS

See Arboviral Encephalitides

EATING DISORDERS

The term "eating disorders" encompasses a group of problems that fall into two broad categories—overeating (binging), and undereating (anorexia)—sometimes referred to as "starving or stuffing." Eating disorders are most commonly found in young females during early adolescence. However, eating disorders affect both males and females at many stages in the life cycle. Although the conditions create physical problems, the causes are usually psychological.

Eating disorders have been recognized by health experts for many years. Bulimia symptoms were described by the Egyptians, Hebrews, and Greeks; and anorexia nervosa was first described in the 1600s. However, it was not until 1980 that these conditions were categorized as psychiatric disturbances.

Eating disorders are marked by extreme dissatisfaction and preoccupation with body size and shape. People with these disorders may see themselves as overweight when their weight is actually lower than normal, or they may measure their self-worth by their weight. Emotional disturbance accompanies disordered eating, including self-loathing over amounts eaten or panic about possible weight gain. In addition to overeating or undereating, individuals with eating disorders engage in "compensatory behaviors," such as purging (self-induced vomiting or inappropriate use of laxatives, enemas, or diuretics), fasting, excessive exercise, and restricting (overly strict limiting of calories or food types).

Eating disorders can be distinguished from dieting by the psychological distress that accompanies the concern about weight; by the interference with everyday responsibilities and pleasures; and by the danger of causing medical problems, possibly even death.

Shame and secrecy often accompany eating disorders, and the problem may go undetected for years. Recognition of these disorders is necessary to begin the long process of treatment. Unlike other addictive or habit problems, food cannot be avoided, and recovery requires developing a healthier relationship to food and to one's own body, as well as improved coping skills.

TYPES OF EATING DISORDERS

Mental health professionals recognize three main types of eating disorders, anorexia nervosa, bulimia nervosa, and binge eating.

Anorexia. Although the word "anorexia" literally means "without appetite," the condition is better described as "restricted eating" or "self-starvation." The person with anorexia has an appetite, and food tastes good; however, food is seen as "the enemy." One authority terms anorexia "food phobia." The disorder is characterized by a refusal to maintain a minimal normal body weight, an intense fear of gaining weight, a disturbance in the self-perception of body size and shape, and (in women) an absence of menstrual periods for three or more consecutive months. Anorexia may be further classified as a restricting type or binge-eating/purging type.

Bulimia. Bulimia (Greek for “ox hunger”) is characterized by recurrent episodes of binge eating. Binging (eating an extreme amount of food) is accompanied by a sense of lack of control over amounts eaten, and a feeling of being unable to stop. The disorder is further classified as either purging or nonpurging bulimia depending on whether the individual uses fasting or exercise instead of purging to “compensate” for binging.

Binge Eating. Binge eating is sometimes termed “stress eating” or “emotional overeating.” It is characterized by compulsive overeating, usually in secret and without purging, followed by guilt or remorse for the episode. It has been estimated that up to 40 percent of people with obesity may be binge eaters. The term “binge eating disorder” was officially introduced in 1992. Unlike nonpurging bulimia, there is no attempt to “compensate” for the binge by fasting or overexercising.

CAUSATION

Eating disorders can be considered biologically based alterations filtered through cultural pressures and individual psychology. The psychological aspects of anorexia are frequently thought to include conflicts between mothers and adolescent daughters over perfection. Bulimia is often thought to involve conflicts over dependence and loneliness. Binging may share causal factors with obsessive-compulsive behavior.

PREVALENCE AND RISK FACTORS

Since people commonly deny or try to hide their disordered eating behaviors, it is difficult to accurately estimate the number of people affected by these problems. Nonetheless, experts report approximately 1.2 million women in the United States are affected by anorexia or bulimia.

Anorexia is more present in developed societies, especially in societies where being attractive is linked to being thin. The prevalence of anorexia has been estimated to be 0.5 to 1 percent of the population, and rates appear to be increasing. The condition usually begins in early adolescence (13–18 years) and 90 percent of the cases are female. Occasionally, but rarely, the disorder may begin in someone over age forty. Stressful life events (e.g., leaving home for college) occasionally trigger the onset of the problem. Long-term death rates from

anorexia approach 10 percent, with death usually resulting from starvation, suicide, or electrolyte imbalance.

The chances of developing an eating disorder are higher among females (female cases outnumber male cases 10 to 1), among those pressured by society or family to be thin, and among athletes. Athletes for whom weight control and/or thinness provides an advantage (e.g., gymnastics, wrestling) are particularly susceptible to eating disorders. Psychological factors that put a person at risk for disordered eating include low self-esteem, poor coping ability, perfectionism, and body image distortion. Genetics may also play a role. Risk increases among those with a close relative (a parent or sibling) with an eating disorder, especially with binging/purging.

IMPACT

Eating disorders cause an array of medical problems ranging from fatigue to illness, and occasionally death. Even when eating disorders do not reach this level of severity they can be significant sources of suffering for the patient and family members. Mild complications include lack of energy, cavities, cold intolerance, irregular periods, constipation and diarrhea, and difficulty with concentration. Serious complications include electrolyte instability, irregular heartbeat, suicidal tendencies, and death. Between 5 to 18 percent of those with anorexia or bulimia will die from complications of the disorder.

Malnourishment and self-starvation affect the heart, thyroid, and the digestive and reproductive systems, as well as seriously decreasing bone density. Specific problems seen in athletes with eating disorders include impaired athletic performance and an increased risk of injuries and stress fractures. Female athletes with an eating disorder may be considered to have the “female athlete triad” if they manifest symptoms of: (1) disordered eating (which leads to decreased body fat causing a lower estrogen level); (2) amenorrhea (not having a period for three consecutive cycles because of low estrogen); and (3) osteoporosis (fragile bones because of low estrogen).

Although eating disorders are not contagious, the culture in which the person lives can contribute to the spread of an eating disorder, particularly

in cultures that glorify thinness. Although obesity may be a consequence of binge eating, it does not typically result from the major eating disorders. Prevention efforts may help, and early detection efforts are essential as patients do not typically request treatment for themselves. Psychological consequences of semistarvation include depressed mood, social withdrawal, insomnia, irritability, and loss of libido, as well as obsessive thoughts about food.

TREATMENT

The most important factor in treating people with eating disorders is the recognition of the disorder. Disordered eating is usually not self-diagnosed because of associated denial and embarrassment. Anorexics usually do not even realize there is a problem with their behavior, and bulimics usually realize the problem but try to hide their behavior. Family, friends, or health care professionals are often the people who recognize the problem. A team treatment approach is frequently employed, consisting of a physician, a nutritionist, and a psychologist. Medically, antidepressants may be needed, and complications may require treatment or hospitalization if the situation is severe enough. Nutritionally, people with disordered eating need to learn how to eat in a healthful way. Psychologically, modification of inappropriate food-related behavior and development of improved coping mechanisms are necessary. In addition, changes in body image and ideal body image may be necessary.

Treatment, especially for anorexia, can be a long drawn-out affair, and it can take a big toll on family resources and on the social productivity of the person. Recovery from these disorders is difficult, and estimates of 50 percent relapse rates for anorexia and 33 percent for bulimia are common. A difficulty in the control of disordered eating behaviors is the need to continue to eat. This it is in contrast to other disorders of habit or addiction in which treatment involves total avoidance of the abused substance.

RESOURCES

The Academy of Eating Disorders (<http://www.acadeatdis.org>) is a multidisciplinary professional group devoted to the improved detection and

treatment of these conditions. Efforts to expand screening are promoted through eating disorders awareness week on U.S. college campuses, and this has now been expanded to high school and the general public (<http://www.nmisp.org/eat.htm>).

Other valuable resources include the following:

- American Anorexia/Bulimia Association, 165 West 46th Street #1108, New York, New York 10036; (212) 575-6200, <http://www.aabainc.org/>
- National Eating Disorders Organization (formerly the National Anorexic Aid Society), 6655 South Yale Avenue, Tulsa, Oklahoma 74136; (918) 481-4044, <http://www.kidsource.com/nedo/>
- Overeaters Anonymous Headquarters, World Service Office, 6075 Zenith Court NE, Rio Rancho, New Mexico 87124; (505) 891-2664, <http://www.overeatersanonymous.org/>

LEONARD J. HAAS
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(SEE ALSO: *Anorexia; Menstrual Cycle; Mental Health; Nutrition; Social Determinants*)

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ECOLOGICAL FALLACY

The ecological fallacy is the logical fallacy of interpreting general data too particularly or minutely. An example would be projecting to the level of individuals the generalizations that apply to a population. This fallacy, and the opposite fallacy of generalizing from the particular, have been responsible for some misguided health policies. For example, many epidemiological studies have demonstrated an increased risk of heart disease associated with high-fat diets, cigarette smoking, and lack of exercise; but not everyone who exhibits these behaviors necessarily dies of a heart attack—and it is a mistake to blame such people if they experience a heart attack because many other factors could precipitate such an event. When a relationship was found between drinking water hardness and a reduced risk of dying from heart disease, some public health authorities suggested that municipal water supplies should be artificially hardened by adding calcium or magnesium sulfate, although there was no direct evidence whatever that this would have any real health effect. It is important for those implementing public health policies to guard against this fallacy when transforming theoretical models and scientifically gathered data into real-world policy.

JOHN M. LAST

(SEE ALSO: *Data Sources and Collection Methods; Planning for Public Health; Policy for Public Health*)

ECOLOGICAL FOOTPRINT

In the past two hundred years, economic growth fueled by industrialization has vastly increased the standard of living in industrialized nations and has

contributed significantly to improved health status. But at the same time, the combination of economic growth and population growth has resulted in a dramatic increase in the consumption of natural resources, the production of wastes, and the pollution of the environment. In 1998 the Worldwatch Institute reported that globally between 1950 and 1997 lumber use tripled, paper use increased sixfold, fish catch increased nearly fivefold, grain consumption almost tripled, and fossil fuel consumption almost quadrupled. The scale of this impact is so large that human consumption is beginning to affect the global climate, global ecosystems, global resources, and the web of life itself. These constitute a global life-support system; in effect, they provide free “eco-services” to humankind.

The massive impact on the natural environment of the urban and industrialized way of life has been graphically described by Mathis Wackernagel and William Rees (1996) as the “ecological footprint.” The concept is a simple one, although complex in its implementation. An attempt is made to calculate the area of biologically productive space required per person in order to maintain the person’s current lifestyle through the “provision” of resources and eco-services. This requires calculating such issues as how much land is required for food production, housing, transportation, consumer goods, and services. Land categories that are included in the calculation include forest, pasture, arable land, sea space, fossil-energy land, and built-up land. However, the largest single component of the ecological footprint (roughly half) is attributable to energy consumption.

The ecological footprint can be calculated for individual households; for facilities such as hospitals, schools or businesses; for infrastructure projects such as highways, bridges or dams; for particular products (e.g., hothouse tomatoes); and for communities, for nations, and at a global level. The impacts of different lifestyles and economic choices can be apparent. For example:

- The ecological footprint of a typical North American detached single family dwelling is estimated to be roughly 1.5 hectares (3.7 acres) per person, while for a high-rise apartment it is approximately 0.9 hectares (2.2 acres) per person.

- A 5-kilometer commute by bicycle has a footprint of only 122 m², but 300 m² by bus and 1,530 m² if driving in a car alone.
- The footprint of a low-income Canadian is estimated to be less than 3 hectares (7.4 acres) per person, compared to more than 12 hectares (29 acres) for a high-income Canadian.

Based on 1993 data, the United States had a footprint of 10.3 hectares per capita, compared to 7.7 hectares per capita in Canada, 5.9 hectares per capita in Sweden, 5.2 hectares in the United Kingdom, and 4.3 hectares in Japan. On the other hand, developing countries had much smaller ecological footprints: 2.5 hectares per capita in Costa Rica; 0.8 hectares in India; and 0.5 hectares in Bangladesh, for example.

Globally, however, there are only 2.0 hectares of biologically productive land and sea space available per person. If around 12 percent (0.25 hectares) is reserved for biodiversity protection, as recommended by the World Commission on Environment and Development, this leaves 1.75 hectares per person. Yet humans already use 2.3 hectares per person, on average, or 35 percent more than is available.

Thus, the “ecological footprint” on the earth has become so large that were everyone to achieve the U.S. standard of living, to which many aspire, using current technologies, human beings would need five more planets to sustain them today! If world population increases to 10 billion by the year 2030 or so—only one generation—as is currently predicted, the amount of biologically productive space will fall to 1 hectare per capita, and less than that if humans continue to degrade land and sea space. Reaching the current U.S. standard of living for everyone will then require an additional nine planets.

Clearly this standard of living is not sustainable, even in the short term, and certainly not if countries aim to increase their gross domestic product and concomitant resource use at a “modest” 3.5 percent per annum, which results in a doubling time of some twenty years, or a thirty-two-fold increase in one century. Reducing the ecological footprint must become a priority concern for communities and nations if the health of

both humans and the ecosystem are to be maintained in the future.

THE RELEVANCE FOR PUBLIC HEALTH

The relevance of the ecological footprint for public health is that the current level of health is due primarily to high levels of social and economic development, rather than the provision of quality health care services. In Europe and North America, there has been an astonishing rate of development since the 1850s. Life expectancy for women in Canada, for example, increased from 39.8 years in 1831 to 76.4 years in 1971. According to the World Health Organization, globally, life expectancy at birth has increased from 48 years in 1955 to 56.7 years in 1970–1975 and more than 65 years in 1995, and is projected to increase to 73 years by 2025. But as Thomas McKeown demonstrated many years ago, and others—notably the Canadian Institute for Advanced Research’s Population Health Research Group—have confirmed, it has been the social and human development purchased by economic development that has been the principal factor underlying this improvement in health. This social and economic development has in turn been based upon the exploitation of the earth’s resources—notably energy, forests, soils, minerals, and the oceans—and the accompanying widespread pollution of the planet. Thus, in a very real sense, the current high level of health and long lives have been “purchased” at the expense of the environment. How long can health be sustained if humans are depleting the resources and disrupting the ecosystems and global life-support systems upon which health and well-being are ultimately based?

A key public health priority for the twenty-first century—indeed a key human priority and a key global priority—must be to reduce the human impact on the planet in order to ensure that future generations will lead long and healthy lives, not just in the “developed” world, but globally. Creating more sustainable communities thus becomes an important public health strategy. By highlighting the absurdities of the current situation with respect to resource use and the degradation of ecosystems, and by doing so in a way that makes it possible to highlight the inequities within and between people and nations, the ecological footprint provides a useful tool that can help to raise

public awareness and shape a healthier and more sustainable future.

TREVOR HANCOCK

(SEE ALSO: *Healthy Communities; Urban Transport*)

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ECOLOGY

See Ecosystems

ECONOMICS OF HEALTH

Health is fundamental to living, but are the choices people make regarding their health fundamentally different from the choices they make in other areas of their life? The economics of health adapts the general study of how people make choices to issues involving health. Much of the focus is on the interaction among individuals, the health care system, and government policy. However, the boundaries of health economics also include topics linking individuals with other parts of the economy, topics such as lifestyle choices, the effect of air and water pollution, and the provision of public services such as drinking water and sewage water treatment.

SCARCITY AND ECONOMIC EFFICIENCY

Economics is built on scarcity. People have many desires, among them good health, but there is a lack of resources to provide all things to all people. In the presence of this scarcity, someone, or some process, must decide what mixture of goods and services to produce, what quantity of each is to be produced, and how to allocate the production to participants in the economy. If the world is such that people are well informed, there are many buyers and sellers, there are no barriers to moving resources from one use to another, and one consumer's or producer's choice does not affect another's outside the market place; economic analysis indicates that a market (or price) system will function well. The market will decide what to produce, including various kinds of medical care; decide the quantity to be produced; and allocate what is produced in a way that no one individual can be made better off without making someone else worse off. This is the economist's notion of an efficient outcome. Economists recognize that many efficient production and allocation combinations are possible, although the results may not always be viewed as equitable. But efficiency, not equity, is the focus of economists.

When the situation differs from the criteria for efficiency, then markets can yield an inefficient outcome. This means that if a change can be made that leaves one person better off without leaving another person worse off, there can be a winning situation for everyone. Consequently, economists advise leaving situations alone where the criteria are met, and changing the situation where the criteria for efficiency are not met.

HEALTH ECONOMICS

The economics of health focuses on real or perceived differences between the economically idealized setting for efficiency and the setting for decisions about health. Such differences would not be important if health-related economic activity were a small part of the economy. However, the health care system in the United States has grown from 5 percent of gross national product (GNP) in 1960 to 13.5 percent in the late 1990s. This figure excludes numerous expenditures not directly related to the health care system, such as the control

and treatment of water and air pollution. Expenditures on water and air pollution control and treatment were approximately 2.5 percent of GNP in the late 1990s. Consequently, these two components alone involved over 1.2 trillion dollars in 1997, an amount over three times the amount spent on national defense or almost twice the amount spent by consumers on durable goods such as cars and furniture. In short, if economic behavior differs from the conditions for efficiency, the effects can be enormous.

There are many conditions that may be different for health-related goods and services compared to other products. These include:

- *Information:* Consumers may not be informed about the nature and quality of health care being purchased.
- *Uncertainty:* Randomness in the cause and timing of ill health.
- *Barriers to competition:* Limitations may be placed on health care labor, the use of hospitals, or other resources.
- *Externalities:* One person's or firm's action can affect those of a third party separately from financial effects in the marketplace.

Furthermore, economists' concern with efficiency ignores a concern for fairness regarding what obligation a society owes to provide health treatment for the poor, the disadvantaged, or other groups.

INFORMATION

Health, for an individual, is a state of being. Economists often think of health as an asset of the individual that is produced through the use of various inputs. This asset can depreciate, improve through investment, or just be maintained. Individuals can undertake a variety of actions to achieve their desired level of health, which is constrained by physical factors and is subject to various risks. People's choices about living location, work, diet, recreation, over-the-counter medication, and formal health care can all affect their health status. Perhaps startlingly, studies of factors that determine health in affluent societies indicate that changes in lifestyle choice and status—such as

environment, income, education, and cigarette consumption—outweigh the contribution of changes in health care services.

To the extent that information is public knowledge, a market with costly information can still be efficient. However, if there are barriers to knowledge about health-improving opportunities, then markets may not be efficient. The debate in health economics relates primarily to health care information and the role of the physician, and secondarily to the quality of hospital and other services. For example, most individuals purchase over-the-counter drugs for mild, repetitive problems, such as headaches or a common cold. With such purchases there is little financial loss for a wrong decision. If a consumer is not satisfied with Brand X, he or she can switch to Brand Y. In contrast, when an individual seeks professional health care for serious problems, a wrong choice could be costly, and the specialized knowledge required for resolution may be beyond the reach of the typical consumer at the time that information is needed.

This nonstandard form of economic service is one type of what is called a *merit good* in economics. A merit good leads to a situation where an agent, say a physician, is working on the consumer's behalf to choose the appropriate remedy. In that sense, physicians are *asymmetrically informed* compared to patients. Doctors are high on a scale of expertise that can also include services such as those of automobile mechanics, plumbers, carpenters, teachers, travel agents, lawyers, and so on. Each has expertise whose quality is difficult for a consumer to evaluate in advance, and each involves a skill that the consumer may purchase infrequently. Several difficulties exist for the efficient working of a health care market in such a situation. The consumer has difficulty choosing, and the agent can have incentives to add unnecessary services that may not be in the consumer's best interests—a problem called “supplier-induced demand” in the health literature. While research tends to reject a large impact for this problem, it can be exacerbated or reduced depending on the financial terms of the contract between patient and physician. Professional certification is one method used to signal a minimum level of quality to patients, while malpractice suits are an after-the-fact quality-reinforcing mechanism. Professional certifications are typically necessary to work in medicine in the developed world. Finally, some

argue that a tradition of medical ethics serves as a counterbalance to these information asymmetries.

A relatively new topic in this discussion is the role of quality information for medical care providers. Important differences in frequency and outcome of treatment, called “small area variations,” have led to suggestions that either patients or physicians, or both, are relatively uninformed. One method to improve the functioning of health care markets is to make information more available. In particular, various ranking methods for hospitals and doctors have been developed to identify those of apparently lower (and higher) quality, while restrictions on advertising have been struck down as illegal. There is economic incentive in providing the rational consumer, whether an individual or organization providing insurance, with information to improve the efficiency of economic choices in the medical marketplace.

Information also plays a key role in government programs related to health risks from food and drugs. From meat and other food inspection to the certification of drugs, government certification programs are targeted at overcoming consumer difficulties in evaluating product quality. While some certifications could be handled by market processes, as through a credible third-party seal of approval or the threat of litigation, the safety of food and drugs is an established part of government regulation. The debate regarding genetically altered food products is only one example that combines both information issues and the potential for indirect, third-party effects, discussed as externalities later in this section.

UNCERTAINTY AND HEALTH INSURANCE

While the search for information can reduce some aspects of uncertainty about quality or price, the random aspect of illness is another type of uncertainty. From an individual’s viewpoint, one’s health state may change due to a large variety of health problems related to aging, accidents, disease, and so on. Individuals can “take their chances” and, if an accident or illness occurs, obtain what treatment is available within their budgets. This “self-insurance” option is risky, however, since individuals would not be able to afford care for serious health problems. In the early 1990s about 15 percent of the U.S. population was self-insured,

or, more accurately, uninsured. If such individuals choose to access the health care system, they must either pay for services directly or seek free treatment.

In fact, various types of medical insurance are widespread in developed countries. In the United States, employer-provided medical insurance expanded rapidly during World War II, while Medicaid and Medicare (both begun in 1966) provide a form of medical insurance for the poor and the elderly, respectively. Insurance works as a market concept because health uncertainty is large for an individual but can become quite stable across a large population, a statistical result of the law of large numbers. Thus, the number of cardiovascular problems in a large population may be similar year to year, although to an individual it is a very uncertain event. By pooling resources through insurance, each person at risk pays a smaller guaranteed payment in exchange for more expensive conditional coverage if a health problem occurs. While individuals can, and often do, pay for their own health insurance, the tax-free status of employer-provided health benefits in the United States provides an incentive to businesses to expand coverage in place of wage or salary increases.

As with the potential problem of asymmetric information between physician and patient, various asymmetry problems arise with regard to insurance. Those individuals with potentially more health demands have an incentive not to reveal such information, a problem known as “moral hazard” or “adverse selection.” If this occurs too frequently, insurance premiums are incorrectly charged or insufficient. A second problem can occur if medical care is free to those insured. In such cases the care may be overused in comparison to the benefit received.

Insurance plans in the United States, including Blue Cross/Blue Shield and Medicare and Medicaid, focused for many years on administering bill-paying systems that implemented fee-for-service types of contracts to reimburse the health care provider. This contractual form places all the financial risk with the insurance company or government and is thought to be a significant contributor to rapid increases in health care costs. In contrast, health maintenance organizations (HMOs) combine the three roles of insurer, administrator, and health care provider. Consequently, they are

potential competitors in both the insurance market and in the provider market. HMOs receive income through a steady stream of periodic payments per enrollee, a form of revenue called "capitation." As HMOs, which are increasingly for-profit organizations, retain any cost savings from improved case management, they are said to internalize the incentive to reduce cost. A variety of other types of organizations mix and match the roles of insurer, plan administrator, and health care provider, with the result of increasing competition in both the insurance and provider markets. Other details of insurance, including deductibles (a fixed amount paid before insurance coverage begins), co-payments (a monetary fee paid by the patient per service), co-insurance (a fixed percentage paid by the patient), and coverage of in-patient (hospital) or out-patient claims, have all been studied for their economic incentives on various parties. For example, some form of consumer payment reduces the number of small claims, which require more administrative effort, or transaction costs, and also provides some impetus to search for low-cost providers.

BARRIERS TO COMPETITION

A bewildering array of policies have evolved over the years that both encourage and retard competition in health care. Many of these policies involve barriers to entry for those who provide health care services. When these barriers are lowered the number of health care providers tends to increase, encouraging competition. Also important has been the role of large buyers of health care services, such as governments and large employers. Such buyers have been able to change the market conditions where there are organized sellers of health services.

The economic analysis of competition requires the definition of closely related markets. The broad health care market can be identified as producing goods or services using inputs such as specialized labor services like doctors and nurses, medical equipment and drugs, and buildings and facilities. In 1997, hospitals received 34 percent of health expenditures and physicians received just under 20 percent, with smaller fractions going to other providers. Major subjects for the economic analysis of competition have included the impact of

barriers to entry in the labor markets for physicians and nurses, the institutional structure of health insurance and provider markets, and research and development for medicinal drugs.

The economic analysis of medical labor markets has generally been one of analyzing barriers to entry. These restrictions, first taking the form of state licensing of physicians, can be a response to concerns about quality that are based on the lack of information of the consumer. However, economists have also analyzed the various restrictive practices promoted by medical organizations as serving primarily to increase the income of physicians, and less consistently to preserve or improve quality. Among these restrictive practices were apparent limits on the number of U.S. medical schools and increasingly long training or "residency" times after graduation. This appeared to restrict the supply of new physicians without retraining existing physicians, which could also address concern for quality. Government policy linking funding to expanded medical school enrollment started in 1965 and seems to have reduced the shortage of physicians.

In addition to direct barriers to entry for labor, various practices contributed to limitations on competition. These include collusive behavior among physicians—including boycotting specific insurers, the denial of hospital privileges to physicians joining competitive organizations, and restrictions on advertising. While similar actions in industry would be considered anticompetitive and illegal based on federal anti-trust laws, it was not until the mid-1970s that these laws were applied to professionals such as doctors, lawyers, and engineers. A series of anti-trust cases on these topics reduced barriers to entry and increased information, thus opening the way to increased competition.

The fee-for-service form of health care financing has been much studied as a system that does not minimize costs. While federal expenditures do not dominate the system, providing about one-third of health care expenditures in 1997, increases in government health care costs have led to various efforts at reform. In 1973 the federal government passed the Health Maintenance Organization Act, which opened another door to increased competition. Through various amendments and related legislation, the government

changed hospital planning requirements (certificates of need); changed hospital payments under Medicare to diagnostic-related groupings in order to establish fixed prospective payments; and eliminated a requirement that Medicaid provide “free choice” of medical provider to its constituents. Simultaneously, large employers became increasingly concerned with the cost of health insurance and undertook actions to modify contracts and provide incentives to providers to reduce costs, often under the umbrella of managed care. These changes, taken together, appear to have increased the competitiveness of the health care system and slowed down cost increases.

An important part of improved health, both in the United States and worldwide, is attributed to medical advances in the pharmaceutical industry. The research and development emphasis of this industry is another important issue in competitiveness. When research and development provides a new treatment, economic efficiency would dictate that such advances be distributed at the cost of production. However, the large sunk (precommitted) costs of research and development cannot be recovered at production-based prices, and profit-seeking firms will not invest in such efforts. Patents, which provide a monopoly or sole right to produce for a limited period of time, are a compromise between providing an incentive for research and development and the long-term economic interest of providing new treatments at low prices. In addition to providing patents, the federal government, through the Food and Drug Administration, also reviews new drugs for safety and effectiveness. This review adds time and expense, which in turn affects the incentives to conduct research and development. This problem was addressed in 1984 by providing an extension of the effective life of drug patents by taking into account part of the time taken for research and development and clinical trials. Issues about dynamic efficiency (efficiency over time), such as the role of research and development, remain at the forefront of economic research.

EXTERNALITIES

What constitutes public health has evolved over the years. In the nineteenth century it was more focused on sanitation projects, and later on medical science. The economics of health provides a

common thread for why “public” health is seldom left to a free market. When a market transaction between two parties affects another that is unconsidered in the transaction, this indirect or external effect causes a market to fail to achieve economic efficiency. The concept of “public goods” is based on the concept of “externalities.” Whatever the historical failings of sanitary engineers and public health officials in understanding the exact science of diseases, the indirect effects caused by people disposing of personal and industrial wastes in a detrimental manner is one justification for some form of government action, although not necessarily government provision of the specific goods or service. Government action can, and has, taken a variety of specific forms, including publicly owned water supply and treatment works, technological requirements, taxes, or numerically limited but tradable rights to pollute.

The concept of externalities opens a wide range of topics, some solidly within the economics of health, others at its boundary. There is little ambiguity about the presence of health-related externalities in the diffusion of gastrointestinal diseases such as typhoid fever, which caused an average of 53.5 deaths per 100,000 people in 1900 for fifteen large cities located on U.S. waterways. Its diffusion largely depends on the method of disposal of human and animal waste, and on the interaction of that disposal with sources of drinking water—a link broken in the United States with the advent of drinking water treatment or source control. Industrial pollution can have similar indirect impacts through the disposal of waste into the air, land, or water. Some programs of the Environmental Protection Agency are entirely or partially justified on health grounds. Finally, social problems such as violence and drug use have implications for the economics of health. Crime victims are, by definition, unwilling participants, and the causes of crime are therefore causes of “external effects.” The impacts of this are not only health related but extend to a variety of defensive economic activities.

The economic analysis of external effects, and of health programs in general, typically involve identifying and quantifying the cause and size of the problem and designing institutional responses, often involving government action, to restore the efficiency of the marketplace or to provide for the public good. Identifying the externality typically

involves some form of risk analysis, followed by economic valuation of that risk. As many risks are not bought and sold in the marketplace, a variety of indirect estimation tools have been developed. Efforts to put a value on a statistical life, a quality-adjusted life year, or even direct health endpoints, such as an asthma attack, are challenging and controversial. Policy design and evaluation are the next steps, with economic concerns about designs that are cost-effective (providing a given level of service at the minimum cost) or efficient (balancing the additional costs with the additional benefits). Benefit–cost analysis is one tool by which economists formally evaluate alternative policies, taking into account risk, valuation, program costs, and timing.

EQUITY

Issues of fairness, or equity, receive only modest attention in economics. Economists associate equity with the distribution of income—who gains and who loses in particular actions. In a market exchange between two individuals, each person believes he or she will be better off after the exchange or else the transaction would never take place. Each transaction depends not only on the preferences of the individual but also on each individual’s available income. In the standard economic view, if society does not like the result of voluntary transactions between individuals, then society should redistribute wealth in some way and then let the individual transactions take place. Either market solution—before or after redistributing wealth—would be viewed as efficient according to economists. Since economists have no particular expertise in what is the right or wrong distribution of wealth, they have generally focused on efficiency and ignored equity.

This hands-off approach stumbles in the face of numerous demands to provide advice on what actions are better or worse for the economy, technically called “welfare economics.” Such advice requires adding up the welfare of all the individuals in the economy, and there is no objective method for knowing if the economy is better off so long as an action increases the welfare of someone at the expense of another. The economist’s standard solution to this, exemplified in benefit–cost analysis, is to add up the value of benefits and costs

no matter who receives them. If the benefits outweigh the costs (appropriately adjusted for time) then the winners can potentially compensate the losers and society is judged to be (potentially) better off.

Such prescriptions are criticized on equity grounds, with critics often pointing to the poor or to minority groups as the losers in this system. While various suggestions have been made to weigh the impacts of such groups differently, or to require actual instead of potential compensation to those who lose, such approaches were not widespread as of the 1990s.

In practice, health care is an area importantly influenced by equity concerns. The Medicare and Medicaid programs effectively insure large parts of the elderly and poor populations. In addition, free or reduced price treatment for the poor or otherwise disadvantaged is another long-standing feature of the ethics and practice of the health care system and was, in fact, the original basis for the development of hospitals. These applications of community values to provide in-kind services and to achieve distributional objectives are another version of a merit good, which is considered by some economists as sufficient justification for government involvement. Concerns for equitable access to health care continue to prompt reviews of who has and who does not have health insurance coverage. Economists contribute to this debate by estimating the costs and implications of extended coverage and by evaluating alternative policy designs.

Each society must answer the economic questions of how much health care is to be produced and how health care will be distributed. The way in which these allocations are made in practice in the United States mixes market forces with a large influence of direct and indirect government intervention. The work of economists is to highlight the efficiency aspects of this marriage of the marketplace and the statehouse.

SCOTT FARROW

(SEE ALSO: *Benefits, Ethics, and Risks; Cost-Effectiveness; Equity and Resource Allocation; Ethics of Public Health; Inequalities in Health; Urban Social Disparities*)

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ECOSYSTEMS

The health of humans, like all living organisms, is dependent on an ecosystem that sustains life. Healthy ecosystems are the sine qua non for healthy organisms. Yet there is abundant evidence that many life-support systems are far from healthy, placing an increased burden on human health. In some areas of the world, gains in life expectancy and quality of life made during the twentieth century are at risk of being reversed in the twenty-first century. The consequences of ecosystem degradation to human health are numerous, and include health risks from unsafe drinking water, polluted air, climate change, emerging new diseases, and the resurgence of old diseases owing to ecological imbalances. Reversing this damage is

possible in some cases, but not in others. Prevention of ecological damage is by far the most efficient strategy.

DEFINING ECOSYSTEMS

An ecological system may be defined as a community of plants and animals interacting with each other and their abiotic, or natural, environment. Typically, ecosystems are differentiated on the basis of dominant vegetation, topography, climate, or some other criteria. Boreal forests, for example, are characterized by the predominance of coniferous trees; prairies are characterized by the predominance of grasses; the Arctic tundra is determined partly by the harsh climatic zone. In most areas of the world, the human community is an important and often dominant component of the ecosystem. Ecosystems include not only natural areas (e.g., forests, lakes, marine coastal systems) but also human-constructed systems (e.g., urban ecosystems, agroecosystems, impoundments). Human populations are increasingly concentrated in urban ecosystems, and it is estimated that, by the year 2010, 50 percent of the world's population will be living in urban areas.

A landscape comprises a mosaic of ecosystems, including towns, rivers, lakes, agricultural systems, and so on. Precise boundaries between ecosystems are often difficult to establish. Often regions slide into one another gradually, over a protracted "transition" zone, as for example between the boreal forest and the Taiga regions of Canada.

ECOSYSTEM HEALTH

It is important to recognize the inherent difficulties in defining "health," whether at the level of the individual, population, or ecosystem. The concept of health is somewhat of an enigma, being easier to define in its absence (sickness) than in its presence. Perhaps partially for that reason, ecologists have resisted applying the notion of "health" to ecosystems. Yet, ecosystems can become dysfunctional, particularly under chronic stress from human activity. For example, the discharge of nutrients from sewage, industrial waste, or agricultural runoff into lakes or rivers affects the normal functioning of the ecosystem, and can

result in severe impairment. Excessive nutrient inputs from human activity was one of the major factors that severely compromised the health of the lower Laurentian Great Lakes (Lake Erie and Lake Ontario) and regions of the upper Great Lakes (Lake Michigan). Unfortunately, degraded ecosystems are becoming more the rule than the exception.

The study of the features of degraded systems, and comparisons with systems that have not been altered by human activity, makes it possible to identify the characteristics of healthy ecosystems. Healthy ecosystems may be characterized not only by the absence of signs of pathology, but also by signs of health, including measures of vigor (productivity), organization, and resilience.

Vigor can be assessed in terms of the metabolism (activity and productivity) of the system. Ecosystems differ greatly in their normal ranges of productivity. Estuaries are far more productive than open oceans, and marshes have higher productivity than deserts. Health is not evaluated by applying one standard to all systems. Organization can be assessed by the structure of the biotic community that forms an ecosystem and by the nature of the interactions between the species (both plants and animals). Invariably, healthy ecosystems have more diversity of biota than ecologically compromised systems. Resilience is the capacity of an ecosystem to maintain its structure and functions in the face of natural disturbances. Systems with a history of chronic stress are less likely to recover from normal perturbations such as drought than those systems that have been relatively less stressed.

Healthy ecosystems can also be characterized in economic, social, and human health terms. Healthy ecosystems support a certain level of economic activity. This is not to say that the ecosystem is necessarily self-sufficient, but rather that it supports economic productivity to enable the human community to meet reasonable needs. Inevitably, ecosystem degradation impinges on the long-term sustainability of the human economy that is associated with it, although in the short-term this may not be evident, as natural capital (e.g., soils, renewable resources) may be overexploited and temporarily enhance economic returns. Similarly, with respect to social well-being, healthy ecosystems provide a basis for and encourage community

integration. Historically, for example, native Hawaiian groups managed their ecosystem through a well-developed social cohesiveness that provided a high degree of cooperation in fishing and farming activity.

Another reflection of ecosystem health lies directly in the public health domain. In spring 2000, a deadly strain of the bacterium *E-coli* (0157:H7) entered the public water supply in Walkerton, Ontario, Canada, causing seven deaths and making thousands sick. This small town, with a population of five thousand, is in a farming community. Inadequate manure management from cattle operations was the likely source of this tragedy.

HOW HEALTHY ECOSYSTEMS BECOME PATHOLOGICAL

Stress from human activity is a major factor in transforming healthy ecosystems to sick ecosystems. Chronic stress from human activity differs from natural disturbances. Natural disturbances (fires, floods, periodic insect infestations) are part of the dynamics of most ecosystems. These processes help to “reset” ecosystems by recycling nutrients and clearing space for recolonization by biota that may be better adapted to changing environments. Thus, natural perturbations help keep ecosystems healthy. In contrast, chronic and acute stress on ecosystems resulting from human activity (e.g., construction of large dams, release of nutrients and toxic substances into the air, water, and land) generally results in long-term ecological dysfunction.

Five major sources of human-induced (anthropogenic) stresses have been identified by D. J. Rapport and A. M. Friend (1979): physical restructuring, overharvesting, waste residuals, introduction of exotic species, and global change.

Physical Restructuring. Activities such as wetland drainage, removal of shoals in lakes, damming of rivers, and road construction fragment the landscape and alter and damage critical habitat. These activities also disrupt nutrient cycling, and cause the loss of biodiversity.

Overharvesting. Overexploitation is commonplace when it comes to harvesting of wildlife, fisheries, and forests. Over long periods of time,

stocks of preferred species are reduced. For example, the giant redwoods that once thrived along the California coast now exist only in remnant patches because of overharvesting. When dominant species like the giant redwoods (arguably the world's tallest tree—one specimen was recorded at 110 meters tall with a circumference of 13.4 meters) are lost, the entire ecosystem becomes transformed. Overharvesting often results in reduced biodiversity of endemic species, while facilitating the invasion of opportunistic species.

Waste Residuals. Discharges from municipal, industrial, and agricultural sources into the air, water, and land have severely compromised many of the earth's ecosystems. The effects are particularly apparent in aquatic ecosystems. In some lakes that lack a natural buffering capacity, acid precipitation has eliminated most of the fish and other organisms. While the visual effect appears beneficial (water clarity goes up) the impact on ecosystem health is devastating. Systems that once contained a variety of organisms and were highly productive (biologically) become devoid of most lifeforms except for a few acid-tolerant bacteria and sediment-dwelling organisms.

Introduction of Exotic Species. The spread of exotics has become a problem in almost every ecosystem of the world. Transporting species from their native habitat to entirely new ecosystems can wreck havoc, as the new environments are often without natural checks and balances for the new species. In the Great Lakes Basin, the accidental introduction of two small pelagic fishes, the alewife and the rainbow smelt, combined with the simultaneous overharvesting of natural predators, such as the lake trout, led to a significant decline in native fish species. The introduction of the sea lamprey, an eel-like predacious fish that attacks larger fish, into Lake Erie and the upper Great Lakes further destabilized the native fish community. The sea lamprey contributed to the demise of the deepwater benthic fish community by preying on lake trout, whitefish, and burbot. This contributed to a shift in the fish community from one that had been dominated by large benthics to one dominated by small pelagics (fish found in the upper layers of the lake profile). This shift from bottom-dwelling fish (benthic) to surface-dwelling fish (pelagic) has now been partially reversed by yet another accidental introduction of an exotic: the zebra mussel. As the zebra mussel is

a highly efficient filter of both phytoplankton and zooplankton, its presence has reduced the available food in the surface waters for pelagic fish. However, while the benthic fish community has gained back its dominance, the preferred benthic fish species have not yet recovered owing to the degree of initial degradation. Overall, the increasing dominance by exotics not only altered the ecology, but also reduced significantly the commercial value of the fisheries.

Global Change. Rapid climate change (or climate warming) is an emerging potential global stress on all of the earth's ecosystems. In evolutionary time, there have of course been large fluctuations in climate. However, for the most part these fluctuations have occurred gradually over long periods of time. Rapid climate change is an entirely different matter. By altering both averages and extremes in precipitation, temperature, and storm events, and by destabilizing the El Niño Southern Oscillation (ENSO), which controls weather patterns over much of the southern Pacific region, many ecosystem processes can become significantly altered. Excessive periods of drought or unusually heavy rains and flooding will exceed the tolerance for many species, thus changing the biotic composition. Flooding and unusually high winds contribute to soil erosion, and at the same time add to nutrient load in rivers and coastal waters.

These anthropogenic stresses have compromised ecosystem function in most regions of the world, resulting in ecosystem distress syndrome (EDS). EDS is characterized by a group of signs, including abnormalities in nutrient cycling, productivity, species diversity and richness, biotic structure, disease prevalence, soil fertility, and so on. The consequences of these changes for human health are not inconsiderable. Impoverished biotic communities are natural harbors for pathogens that affect humans and other species.

ECOSYSTEM HEALTH AND HUMAN HEALTH

An important aspect of ecosystem degradation is the associated increased risk to human health. Traditionally, the concern has been with contaminants, particularly industrial chemicals that can have adverse impacts on human development, neurological functions, reproductive functions, and

that appear to be causative agents in a variety of carcinomas. In addition to these serious environmental concerns (where the remedies are often technological, including engineering solutions to reduce the release of contaminants), there are a large number of other risks to human health stemming from ecological imbalance.

Ecosystem distress syndrome results in the loss of valued ecosystem services, including flood control, water quality, air quality, fish and wildlife diversity, and recreation. One of the major signs of EDS is increased disease incidence, both in humans and other species. Human population health should thus be viewed within an ecological context as an expression of the integrity and health of the life-supporting capacity of the environment.

Ecological imbalances triggered by global climate change and other causes are responsible for increased human health risks.

Climate Change and Vector-Borne Diseases.

The global infectious disease burden is on the order of several hundred million cases per year. Many vector-borne diseases are climate sensitive. Malaria, dengue fever, hantavirus pulmonary syndrome, and various forms of viral encephalitis are all in this category. All these diseases are the result of arthropod-borne viruses (arboviruses) which are transmitted to humans as a result of bites from blood-sucking arthropods.

Global climate change—particularly as it impacts both temperatures and precipitation—is highly correlated with the prevalence of vector-borne diseases. For example, viruses carried by mosquitoes, ticks, and other blood-sucking arthropods generally have increased transmission rates with rising temperatures. St. Louis encephalitis (SLE) serves as an example. The mosquito *Culex tarsalis* carries this virus. The percentage of bites that results in transmission of SLE is dependent on temperature, with greater transmission at higher temperatures.

The temperature dependence of vector-borne diseases is also well illustrated with malaria. Malaria is endemic throughout the tropics, with a high prevalence in Africa, the Indian subcontinent, Southeast Asia, and parts of South and Central America and Mexico. Approximately 2.4 billion people live in areas of risk, with some 350 million new infections occurring annually, resulting in

approximately 2 million deaths, predominantly in young children. Untreated malaria can become a life-long affliction—general symptoms include fever, headache, and malaise.

The climate sensitivity of malaria arises owing to the nature of the interactions of parasites, vectors, and hosts, all of which impact the ultimate transmission rates to humans. The gestation time required for the parasite to become fully developed within the mosquito host (a process termed sporogony) is from eight to thirty-five days. When temperatures are in the range of 20°C to 27°C, the gestation time is reduced. Rainfall and humidity also have an influence. Both drought and heavy rains tend to reduce the population of mosquitoes that serve as vectors for malaria. In drier regions of the tropics, low rainfall and humidity restricts the survival of mosquitoes. Severe flooding can result in scouring of rivers and destruction of the breeding habitats for the mosquito vector, while intermediate rainfall enhances vector production.

Ecological Imbalances. Cholera is a serious and potentially fatal disease that is caused by the bacterium *Vibrio cholerae*. While not nearly so prevalent as malaria, cases are nonetheless numerous. In 1993, there were 296,206 new cases of cholera reported in South America; 9,280 cases were reported in Mexico; 62,964 cases in Africa; and 64,599 cases in Asia. Most outbreaks in Asia, Africa, and South America have originated in coastal areas. Symptoms of cholera include explosive watery diarrhea, vomiting, and abdominal pain. The most recent pandemic of cholera involved more regions than at any previous time in the twentieth century. The disease remains endemic in India, Bangladesh, and Africa. *Vibrio cholerae* has also been found in the United States—in the Gulf Coast region of Texas, Louisiana, and Florida; the Chesapeake Bay area; and the California coast.

The increase in prevalence of *V. cholerae* has been strongly linked to degraded coastal marine environments. Nutrient-enriched warmer coastal waters, resulting from a combination of climate change and the use of fertilizers, provides an ideal environment for reproduction and dissemination of *V. cholerae*. Recent outbreaks of cholera in Bangladesh, for example, are closely correlated with higher sea surface temperatures. *V. cholerae* attach to the surface of both freshwater and marine copepods (crustaceans), as well as to roots and

exposed surfaces of macrophytes (aquatic plants) such as the water hyacinth, the most abundant aquatic plant in Bangladesh. Nutrient enrichment and warmer temperatures give rise to algae blooms and an abundance of macrophytes. The algae blooms provide abundant food for copepods, and the increasing copepod and macrophyte populations provide *V. cholerae* with habitat. Subsequent dispersal of *V. cholerae* into estuaries and fresh water bodies allows contact with humans who use these waters for drinking and bathing. Global distribution of marine pathogens such as *V. cholerae* is further facilitated by ballast water discharged from vessels. Ballast water contains a virtual cocktail of pathogens, including *V. cholerae*.

Two other examples of how ecological imbalances lead to human health burdens concern the increased prevalence of Lyme disease and hantavirus pulmonary disease. Lyme disease, so-named because it was first positively identified in Lyme, Connecticut, is a crippling arthritic-type disease that is transmitted by spirochete-infected Ixodes ticks (deer ticks). Ticks acquire the infection from rodents, and spend part of their life cycle on deer. Three factors have combined to increase the risk to humans of contracting Lyme disease, particularly in North America: (1) the elimination of natural deer predators, particularly wolves; (2) reforestation of abandoned farmland has created more favorable habitat for deer; and (3) the creation of suburban estates, which the deer find ideal habitat for browsing. The net result is a rising deer population, which increases the chances of humans coming into more contact with ticks.

By 1995, in the southwestern United States, hantavirus infection was confirmed in ninety-four persons in twenty states, with 48 percent mortality. Variants of the strain that causes hantavirus pulmonary syndrome have also been found in other areas of the country, as well as in Asia and Europe. The virus is apparently asymptomatic in rodents, and it is transmitted in their saliva and excreta. In humans it has a flu-like presentation, which is followed by acute respiratory distress syndrome. The primary reservoir in the Four Corners area of the southwestern United States is the deer mouse. Climatic disturbances, which in recent years are thought to be exacerbated by human activity (e.g., global warming), appear to set up conditions that trigger outbreaks. In the early 1990s, ENSO events

initially caused drought conditions to develop in the southwestern United States. This led to a decline in plant and animal populations, including natural predators of the deer mouse. Heavy rains followed the drought in 1993, resulting in a bumper crop of piñon nuts, a major food supply for the deer mouse. Subsequently the deer mouse population greatly increased, bringing about increased contact with humans and triggering the outbreak of hantavirus.

Antibiotic Resistance and Agricultural Practice Antibiotic resistance is a growing threat to public health. Antibiotic resistant strains of *Streptococcus pneumoniae*, a common bacterial pathogen in humans and a leading cause of many infections, including chronic bronchitis, pneumonia, and meningitis, have greatly increased in prevalence since the mid-1970s. In some regions of the world, up to 70 percent of bacterial isolates taken from patients proved resistant to penicillin and other b-lactam antibiotics. The use of large quantities of antibiotics in agriculture and aquaculture appears to have been a key factor in the development of antibiotic resistance by pathogens in farm animals that subsequently may also infect humans. One of the most serious risks to human health from such practices is vancomycin-resistant enterococci. The use of avoparcin, an animal growth promoter, appears to have compromised the utility of vancomycin, the last antibiotic effective against multi-drug-resistant bacteria. In areas where avoparcin has been used, such as on farms in Denmark and Germany, vancomycin-resistant bacteria have been detected in meat sold in supermarkets. Avoparcin was subsequently banned by the European Union. Another example is the use of ofloxacin to protect chickens from infection and thereby enhance their growth. This drug is closely related to ciprofloxacin, one of the most widely used antibiotics in the year 2000. There have been cases of resistance to ciprofloxacin directly related to its veterinary use. In the United Kingdom, ciprofloxacin resistance developed in strains of campylobacter, a common cause of diarrhea. Multi-drug-resistant strains of salmonella have been traced to European egg production.

Food and Water Security. Agricultural practices are also responsible for a growing number of threats to public health. Some of these are related to inadequate waste management, which has resulted in parasites and bacteria entering water

supplies. Others are of entirely different origins and involve apparent transfer across species of pathogens that affect both animals and humans. The most recent and spectacular example is mad cow disease, known as variant Creutzfeldt-Jakob disease in humans, a neuro-degenerative condition that, in humans, is ultimately fatal. The first case of Bovine Spongiform Encephalopathy (BSE), the animal form of the disease, was identified in Southern England in November 1981. By the fall of 2000, an outbreak had also occurred in France, and isolated cases appeared in Germany, Switzerland, and Spain. More than one hundred deaths in Europe were attributed to what has come to be commonly called mad cow disease.

Improper manure management was the likely source of the outbreak of *E. coli* 0157:H7 in Walkerton, Ontario, Canada. Other health risks associated with malfunctioning agroecosystems include periodic outbreaks of cryptosporidiosis, a parasitic disease that is spread by surface runoff contaminated by feces of infected cattle. This parasite causes fever and diarrhea in immunocompetent individuals and severe diarrhea and even death in immunocompromised individuals.

ECOSYSTEM RESTORATION

Ecosystem pathology in some cases can be reversed simply by removing the source of stress. In cases, for example, where ecosystem degradation is the result of point-source additions of nutrients or toxic chemicals, removal of these stresses may result in considerable recovery of ecosystem health. A classic case is Lake Washington (near Seattle, Washington). This lake had become highly anoxic (oxygen-depleted) owing to a sewage outfall entering the lake. Redirecting the sewage outfall away from the lake reversed many of the signs of pathology.

In cases where it is not feasible to remove the source of stress, more innovative engineering solutions have been tried. For example, in the Kyrönjoki and Lestijoki Rivers in western Finland, spring and fall runoff leads to sharp pulses of acidity. Spring runoff from snowmelt, which releases acid from tilled or dug soils, has been particularly damaging to fish, during the critical time of year for spawning. Fish reproduction is severely curtailed, if not all together eliminated in highly acidic water. Further there have been massive fish kills resulting from

the highly acidic waters. One possible remedy is to replace the original drains which take runoff from the land to the rivers with new limed drains that can neutralize the acidity. This solution has been implemented on an experimental basis and appears to substantially reduce acidic runoff.

More radical treatments for damaged ecosystems involve "ecosystem surgery." In some cases, invading exotic vegetation (such as mangroves in Hawaii) have been removed from regions, and native vegetation has been replanted. In areas of North America where wetlands have been severely depleted owing to farming, urbanization, and industrial activity, efforts have been made to establish new wetlands.

More often than not, however, reversing ecosystem pathology is not possible. Efforts to restore the indigenous grasslands in the Jornada Experimental Range in the southwestern United States provide an example. Overgrazing by cattle has severely degraded the landscape and has led to replacement of the native grasses by largely inedible shrubs, dominated by mesquite. Erosion by wind and episodic heavy rains have left areas between shrubs largely bare, and subsequently underlying sands have developed in dune-like fashion over a large part of the area. The resulting mesquite dunes have proven highly resistant to efforts to restore the native grasslands, although almost every intervention has been tried, including highly toxic defoliant (Agent Orange), fire, and bulldozing.

Even where it has been possible to restore some of the ecological functions of degraded ecosystems, and thus improve ecosystem health, the restoration seldom results in reestablishment of the pristine biotic community. The best that can be achieved in most cases is reestablishment of the key ecological functions that provide the required ecosystem services, such as the regulation of water, primary and secondary productivity, nutrient cycling, and pollination. In all such efforts, key indicators of ecosystem health (vigor, productivity, and resilience) are essential to monitor progress. Standard ecological indicators can be used for this purpose (e.g., measures of productivity, species composition, nutrient flows, soil fertility) along with socioeconomic and human health indicators.

Experience in efforts to restore highly damaged ecosystems suggests that ecosystem-health

prevention is far more effective than restoration. For marine ecosystems, setting aside protective zones that afford a sanctuary for fish and wildlife has considerable promise. Many countries are adopting policies to establish such areas with the prospect that these healthy regions can serve as a reservoir for biota that have become depleted in the unprotected areas. Yet this remedy is not without its limits. Restoring ecosystem health is not simply a matter of replenishing lost or damaged biota. It is also a matter of reestablishing the complex interactions among ecosystem lifeforms. Having a ready source of healthy biota that could potentially recolonize damaged ecosystems is important, but it is only part of the solution.

PREVENTION OF ECOSYSTEM DISRUPTIONS

Given the difficulties in reversing ecosystem degradation, and the many associated human health risks that arise with the loss of ecosystem health, the most effective approach is simply the prevention of ecosystem disruption. However, like many common-sense approaches, this is easier said than done. In both developed and developing countries there is a strong inclination to continue economic growth, even at the cost of severe environmental damage. Apart from selfish motivations, the argument is made that economic growth has many obvious health benefits, such as providing more efficient means of distributing food supplies, providing more plentiful food, and providing better health services and funding for research to improve standards of living. These are indeed benefits of economic development, and have led to substantial increases in health status worldwide.

However, at the dawn of the twenty-first century, the past is not necessarily the best guide to the future. The human population is at an all-time high, and associated pressures of human activity have led to increasing degradation of the earth's ecosystems. As ultimately healthy ecosystems are essential for life of all biota, including humans, current global and regional trends are ominous. Under these circumstances, a tradeoff between immediate material gains and long-term sustainability of humans on the planet may be the only option. If so, the solution to sustaining human health and ecosystem health becomes one of

devising a new politic that places sustaining life-support systems as a precondition for betterment of the human condition.

DAVID J. RAPPORT

(SEE ALSO: *Acid Rain; Ambient Air Quality [Air Pollution]; Ambient Water Quality; Biodiversity; Cholera; Ecological Footprint; Emerging Infectious Diseases; Global Burden of Disease; PCBs; Pesticides; Pollution; Vector-Borne Diseases*)

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EDENTULISM

Edentulism is defined as the absence or complete loss of all natural dentition (teeth). While tooth loss has long been considered an inevitable part of the aging process, significant changes in oral disease patterns have occurred in the twentieth century relative to the rate of edentulism in the United States. Until the mid-twentieth century, much of dental care was devoted to tooth extraction. Prevention of dental decay was unknown, and attempts to restore cavities were often painful. However, data from the third National Health and Nutrition Examination Survey (NHANES III) in

1996 reported that just 10.5 percent of adults aged 18 or older were completely edentulous. There are significant age-cohort differences in edentulism rates that continue to reflect changes in treatment patterns from the early twentieth century. As of 1996, just 1 percent of 25- to 34-year-olds are were edentulous, compared to 44 percent of those aged 75 or over. It has been estimated that by 2024, 10 percent of Americans between 65 and 74 will be edentulous, compared to nearly 28 percent edentulous in this age group in 1988 to 1991.

Tooth loss results from dental decay, gum disease (periodontitis), or accident. It can also reflect attitudes of the patient or provider, accessibility to dental care, or prevailing societal attitudes regarding oral health care. Edentulism is considerably less prevalent in higher than lower socioeconomic segments of the population. In the United States, whites have demonstrated higher rates of edentulism than African Americans. This difference may be attributed to better access to dental care among whites, who then are at greater risk for tooth extraction. Women have consistently displayed higher rates of edentulism and become edentulous at earlier ages than men. This difference, while difficult to explain, may be representative of differences in the dentist-patient relationship, rather than differences in disease patterns. The dentally uninsured have consistently shown higher levels of edentulism, which may be a result of limited use of preventive and restorative dental services. Within the United States, dental insurance is employment based, and Medicare does not cover routine or preventive services for adults over the age of 65, those most likely to be completely edentulous.

Risk factors for edentulism include socioeconomic status, income, education level, and smoking. Edentulous individuals have been identified as being at greater risk for cardiovascular disease than are dentate individuals. Retention of fewer teeth in older adults has been correlated with poorer health, in contrast to greater tooth retention among people of the same age who report better general health. Replacement of missing teeth has historically focused on the fabrication of complete dentures. Materials used in the earliest dentures ranged from carved ivory to animal bones. Often the results were only slightly better than

being completely edentulous from a functional and an aesthetic view. Since the 1980s, the use of dental implants has begun to show promise for improving the retention of artificial teeth among those individuals healthy enough to be considered viable candidates.

As the trend for retention of teeth increases, more natural teeth are at risk for dental caries (decay) and periodontal (gum) disease. Public health preventive strategies aimed at preventing tooth loss include the continuation of optimal levels of water fluoridation; expansion of dental insurance, particularly for older adults; and the appropriate use of fluoride-containing or antibacterial agents, such as dentifrices, topical gels, and mouth rinses. Increased tobacco-control educational activities, expanded access to affordable oral health care, more positive attitudes toward tooth retention, and more conservative dental treatment decisions are additional strategies for decreasing total tooth loss.

MICHAEL S. STRAYER

(SEE ALSO: *Caries Prevention; Community Dental Preventive Programs; Community Water Fluoridation*)

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EHRlich, PAUL

Paul Ehrlich (1854–1915), a German chemist, was a pioneer in the field of applied organic chemistry. He worked initially on dyestuffs and staining methods for microscopic study of bacteria; and then, beginning in 1891, at the Koch Institute in Berlin,

on the search for drugs that would be effective against some of the bacteria that had by then been identified as the specific causes of many diseases. Ehrlich's early work on antitoxins evolved into a systematic examination of many candidate chemicals that might be effective against *Treponema pallidum*, the spirochaete responsible for syphilis. At that time, syphilis was a common disease and a serious public health problem. This work was based on the observation that many chemicals exhibited selective affinity for specific organisms and tissues. In 1909, in collaboration with Sakahiro Hata, a Japanese colleague at the Koch Institute, he developed Salvarsan, an arsenical that killed the spirochaete without killing the patient—although it did have some toxic side effects. Ehrlich was awarded the Nobel Prize for medicine in 1908.

JOHN M. LAST

(SEE ALSO: *Syphilis*)

ELDERLY

See Gerontology

ELECTROCARDIOGRAPHY

The electrocardiogram (ECG) displays important information about the heart, including the occurrence of a heart attack or lack of oxygen, whether conduction of the heartbeat is disturbed, or its rate or rhythm altered. It is useful as a rapid indicator of the diagnosis and it is easy, painless, and inexpensive to record. The record made in healthy people at rest, or undergoing an exercise test, helps predict risk of future heart problems. It is also used to monitor severely ill patients.

The electrocardiograph was invented by Wilhelm Einthoven in Leiden, the Netherlands, around 1900. Einthoven measured the small differences in electrical potential between the arms and legs by amplifying the tiny current passing through the body with each heartbeat. In the twenty-first century, data about heart function are recorded from the chest wall and the limbs with the electrocardiograph and displayed on paper or TV screens as the

ECG, an electrical recording, or tracing, of the heartbeat. This tracing is interpreted by physicians or technicians and, in digital form, is analyzed automatically with computers.

HENRY BLACKBURN

(SEE ALSO: *Atherosclerosis; Cardiovascular Diseases; Coronary Artery Disease*)

ELECTROMAGNETIC FIELDS

Technically, the term “electromagnetic field” (EMF) refers to all fields throughout the electromagnetic spectrum. In common usage, however, the term usually refers to so-called extremely low-frequency nonionizing radiation fields—those fields below 300 Hertz (Hz)—and often only to those fields in the 50 to 60 Hz range, which are also known as power-frequency EMFs. As a type of nonionizing radiation, EMFs in this range do not have sufficient energy to remove an electron from an atom or molecule, but generally transfer thermal energy to other particles. Power-frequency EMFs are those generated by electric power delivery systems—those for which there has been the greatest public concern and research about possible adverse human health effects.

Power-frequency EMFs have two components: electric fields and magnetic fields. The electric fields are generated from potential energy, or the presence of voltage on a power line. The magnetic fields, on the other hand, are generated from the actual electrical current, or the flow of electricity. Thus, when a standard household electric light is plugged into a live electrical socket, but turned off, it generates only an electric field. Once turned on, it generates both electric and magnetic fields, since the voltage is still present but current is now flowing. The size of a magnetic field increases as the amount of current flow increases, as the size of the source increases, and as one gets nearer to the source. Adverse health effects from acute exposures include shocks, burns, and death (by electrocution). Generally, from chronic exposures, only magnetic fields have shown associations with adverse human health effects in epidemiologic studies.

Until the late 1970s, it had been assumed that power frequency EMFs were too weak, or had too

little energy, to cause biologic effects. Then, in 1979, Nancy Wertheimer and Ed Leeper published an epidemiologic study that showed that children in Denver, Colorado, who died of cancer, particularly leukemia, were more likely to live in houses with higher EMF exposures than children of similar ages living in the same neighborhoods. This set off a flurry of research seeking to determine whether those with high exposures to magnetic fields at home or in the workplace might be at greater risk of getting and/or dying of cancer than those with lower exposures. In general, the most consistent and compelling cancer data are found in the studies of children exposed to EMFs in their homes. While there is still much controversy, the most well-conducted studies suggest a slight excess of childhood leukemia, particularly among those most highly exposed. In workers, the data show weaker support for excess leukemia and brain cancers. A variety of other adverse effects have also been investigated, including adverse reproductive outcomes, neurodegenerative diseases, and cardiac abnormalities. However, there are fewer of these studies, the studies have more methodologic limitations, and the results are more uncertain.

There are some methods for reducing exposure to magnetic fields. For large sources, such as outdoor power lines, sometimes similar strength currents can be set up to run in opposite direction to each other so that they cancel out most of the magnetic fields. For smaller sources, such as appliances (e.g., electric blankets, hair dryers, televisions), the magnetic fields fall off rapidly with distance, so increasing the distance from a source rapidly reduces exposure.

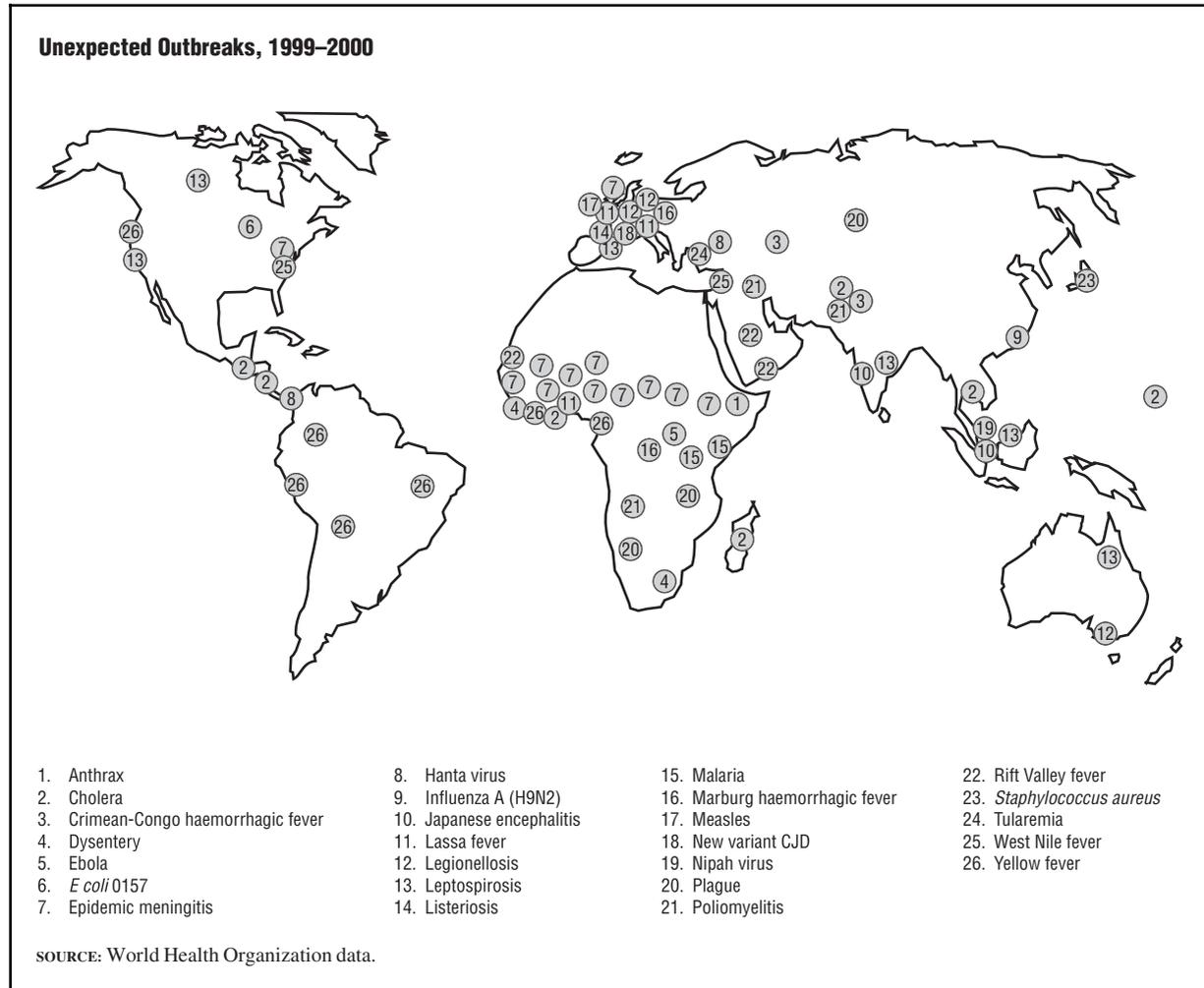
DANIEL WARTENBERG

(SEE ALSO: *Nonionizing Radiation; Radiation, Ionizing*)

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Figure 1



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EMERGING INFECTIOUS DISEASES

The term “emerging infection,” first widely used in the early 1990s, refers to newly identified and previously unknown infectious agents that cause public health problems either locally or internationally. Their impact, in terms of economic repercussions, goes well beyond the immediate costs

to health systems. They may impede trade or travel or cause disproportionate alarm, especially if rumors of intentional use become widespread. During the last three decades of the twentieth century, over thirty emerging infections were identified in humans. They range from the Ebola, Marburg, and Nipah viruses to the more common hepatitis C virus and HIV (human immunodeficiency virus). Emergence of infectious agents has occurred throughout the world, causing many unexpected outbreaks (see Figure 1). Contributing factors for these outbreaks include widening development gaps, collapse of public health infrastructures, poverty, urbanization, civil strife, environmental change and degradation, and globalization of travel and trade.

NEWLY IDENTIFIED INFECTIOUS AGENTS

In 1976, the Ebola virus was identified for the first time during simultaneous outbreaks in Zaire (now the Democratic Republic of the Congo) and southern Sudan. It has since come to symbolize emerging diseases and their potential impact on populations without previous immunological experience. Ebola has caused at least four severe epidemics and numerous smaller outbreaks. In an outbreak that took place in Zaire in 1995 there were 315 cases, with a case-fatality rate of 77 percent. Approximately one-third of those infected were health care workers who came into contact with the blood or body fluids of infected patients. In a smaller outbreak in Gabon two years later, 61 cases occurred, with a case-fatality rate of 78 percent. During a recent outbreak, which was reported in Uganda in October 2000, nearly 425 cases and over 224 deaths had been reported by the end of the epidemic in February 2001.

The Marburg virus, a member of the same family of filoviruses as Ebola, was first recognized in 1967 when laboratory workers in Germany were infected by handling monkeys imported from Uganda. Since then, there have been reports of sporadic cases in 1975, 1980, and 1987. A recent outbreak took place in 1999 among gold miners in the Democratic Republic of the Congo.

In 1996, the occurrence in the United Kingdom of 10 cases of an apparently new variant of Creutzfeldt-Jakob disease (vCJD) was linked to an epidemic of bovine spongiform encephalopathy (BSE), also known as mad cow disease, among cattle. By September 2000, at least 84 people in the United Kingdom, 1 in Ireland, and 3 in France had contracted vCJD. Accurate prediction of the future number of vCJD cases is not possible, but the possibility of a significant and perhaps geographically diverse epidemic occurring over the next two decades cannot be excluded. The economic impact of this unexpected disease is being felt throughout the agricultural sector of all European countries, and costs continue to escalate.

Since first being recognized as a human pathogen in 1982, enterohaemorrhagic *Escherichia coli* has gained increasing importance as a human pathogen. The best known serotype, *E. coli* 0157:H7, has been responsible for recent large food-borne

outbreaks in Japan, Scotland, and the United States, placing heavy demands on medical and public health response systems, while also causing major political concern about food safety.

In 1997, the World Health Organization global surveillance system for human influenza virus (FluNet) received reports of an isolated and fatal influenza infection in a three-year-old child in Hong Kong. The virus was identified as influenza A (H5N1), and was associated with epidemics of avian influenza with high fatality rates in live poultry markets. By the end of 1997, a total of 18 human infections had been confirmed, 6 of which were fatal. Thanks to prompt action on the part of public health authorities, the outbreak did not spread further. In 1999, FluNet received reports of another new influenza virus, A (H9N2), isolated from 2 human cases in Hong Kong, but no further spread is known to have occurred.

In the United States, *Legionella* infection was first identified in 1976 in an outbreak of fatal respiratory illness among war veterans. Legionellosis (Legionnaire's disease) is now known to occur worldwide and is a threat to travelers and others exposed to poorly maintained air-conditioning systems. Cases of the disease contracted by European residents anywhere in the world are tracked by a specialized network. This has revealed that the number of cases reported in 1999 in Europe was the highest ever, with 2,136 cases in European residents, almost 700 more than were reported in 1998. One outbreak in Belgium and one in the Netherlands, both linked to trade shows, collectively gave rise to about 300 cases. At both trade fairs, whirlpool spas were on display and people became infected by breathing in contaminated aerosols after walking past them.

Although Rift Valley fever (RVF) had already been recognized in 1930 as the agent for a zoonotic disease in Kenya, outbreaks outside sub-Saharan Africa were first described in Egypt from 1977 to 1978 and in 1993. A large outbreak occurred in East Africa in 1998, and the disease has now extended its reach outside Africa. RVF virus transmission on the Arabian peninsula was documented for the first time in 2000, during a vast outbreak which has encompassed the border area between Saudi Arabia and Yemen. The disease, which affects both animals and humans, causes severe

hardship in populations whose subsistence depends on their herds.

Hepatitis C, first identified in 1989, had already spread worldwide with an estimated global prevalence of at least 3 percent in the mid-1990s. Meanwhile Hepatitis B, identified several decades earlier, continues an upward trend in many countries, reaching a prevalence exceeding 90 percent in populations at high risk, in countries ranging from the tropics to Eastern Europe.

Other newly identified viruses include *Sin Nombre*, which caused an outbreak of hantavirus pulmonary syndrome in the United States in 1993 (50 cases with a case-fatality rate over 75%); Hendra virus, which affects humans and horses, first identified in Australia in 1994; and Nipah virus (causing febrile encephalitis), first identified in 1999 in Malaysia, where it caused a severe epidemic in those that had close contact with pigs, leading to grave economic losses owing to the destruction of around 900,000 pigs.

One of the most important emerging infection is HIV. First identified in the early 1980s, it has rapidly spread worldwide, affecting over 36 million people by the end of 2000. Because working-age adults are the group most directly affected, it has become a significant impediment to economic development, especially in sub-Saharan Africa.

THE PUBLIC HEALTH THREAT

Emerging infectious diseases pose an international threat that can be countered through well-coordinated global surveillance and response. Whereas traditional approaches to containing outbreaks are defensive—trying to secure borders from the entry of infectious diseases—modern solutions are built on a combination of early warning, surveillance systems, speedy communications, and information sharing through networks to facilitate action.

DAVID HEYMANN

(SEE ALSO: *Bovine Spongiform Encephalopathy; Communicable Disease Control; Epidemics; Epidemiologic Surveillance; Epidemiology; HIV/AIDS*)

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EMISSIONS TRADING

Emissions trading is a means of achieving environmental objectives at potentially lower cost than the more traditional use of uniform standards on emissions sources. Properly designed emissions trading systems can also encourage innovation.

A number of different types of emissions trading approaches have been used in the United States and elsewhere. The least structured, termed emissions “offsets,” involves a reduction of emissions at one place to compensate for increased emissions somewhere else. Such offsets can be between different plants or different sources within the same plant. Offsets can be particularly useful in allowing new or expanded sources of pollution to exist in a region already failing to meet its environmental objectives.

A more ambitious approach, which requires additional governmental infrastructure, is the open-market trading system. This approach allows a pollution source to earn marketable emission rights by reducing its emissions to levels below a regulatory standard or by making reductions in advance of a prescribed deadline. The credits earned may be sold to other sources and used to offset an equal amount of excess emissions. The credits may also be resold or (where allowed) banked for future use. Open-market trading has not been formally implemented in the United States.

Still more ambitious, flexible, and demanding in terms of government infrastructure is a cap-and-trade system, where sources in an area may trade pollution reduction responsibilities among themselves to meet an aggregate emissions cap for a given region. Under this system, the regulatory authorities decide on the aggregate level of allowable emissions for all the parties participating in the program (the “cap”) and then it allocates to

each party a portion of this amount in the form of “allowances,” which are tradable rights to pollute. Once allowances are allocated, parties are prohibited from emitting more pollution than their allocation, unless they purchase additional allowances from another party.

The Environmental Protection Agency’s (EPA) acid rain program, widely hailed a success from both environmental and economic perspectives, is the most prominent example of the cap-and-trade type of emissions trading. Emission reductions are ahead of schedule and the costs are considerably lower than anticipated.

Emissions trading has several potential advantages compared to traditional regulatory approaches. Firms are free to use the options they believe to be most cost-effective, and they do not need to seek approval from government authorities or engage in lengthy negotiations about the “appropriateness” of their actions. At the same time, some remain skeptical of emissions trading, on both ethical and technical grounds. One thing that is widely agreed upon is that credible monitoring systems are essential to ensure the environmental integrity of emissions trading regimes.

RICHARD D. MORGENSTERN

(SEE ALSO: *Acid Rain*; *Ambient Air Quality [Air Pollution]*; *Environmental Protection Agency*; *Hazardous Air Pollutants*; *Pollution*; *Sulfur-Containing Air Pollutants [Particulates]*)

EMPHYSEMA

Emphysema is a lung disease that, along with chronic bronchitis, represents a type of chronic obstructive pulmonary disease (COPD). Medical scientists have defined emphysema as “a condition of the lung characterized by abnormal, permanent enlargement of airspaces distal to the terminal bronchioles, accompanied by the destruction of their walls, and without obvious fibrosis” (Snider 1985).

COPD is the fourth leading cause of death in the United States, accounting for about 113,000 deaths annually. About 14 million Americans have

symptoms of COPD. Among these, 1.65 million have emphysema. Millions more likely have undiagnosed or incipient COPD. The prevalence of COPD peaks in the sixty-five to seventy-four age range, and men are affected more than women.

Pathologists recognize three major types of emphysema: localized (distal acinar, paraseptal), centrilobular (centriacinar), and panlobular (panacinar). Centrilobular emphysema, the most common of the three, is usually caused by cigarette smoking. Cigarette smoke is thought to cause chronic inflammation in the walls of the air sacs (alveoli) of the lung, leading to an imbalance between destructive proteases and protective protease inhibitors. The proteases, such as elastase, gradually destroy the structural proteins (elastin, collagen) in the alveolar walls. Substantial variation in individual susceptibility to cigarette smoke exists, as only about one in seven cigarette smokers develops symptoms of COPD. Other than cigarette smoking, the only condition clearly linked to emphysema is a hereditary disorder called alpha₁-antitrypsin deficiency (AAT). This rare condition, which is found in less than one percent of patients with COPD, occurs because the blood level of a glycoprotein (protease inhibitor) is not sufficient to counteract the activity of the proteases. Coal miners and workers chronically exposed to cadmium fumes are at risk to develop emphysema. The effects of other occupational agents, air pollution, and familial factors in the pathogenesis of emphysema are not clear.

Destruction of alveolar walls in emphysema reduces the lung’s elasticity, which results in obstruction to airflow in small airways, trapping air in the lung. Other pathophysiologic findings in emphysema include increased lung compliance, elevation of the pressure in the pulmonary arteries (pulmonary hypertension), and abnormal matching of air flow and blood flow (ventilation/perfusion imbalance), which causes hypoxemia (low oxygen level in the blood).

Patients with emphysema suffer from shortness of breath (dyspnea), which typically appears between the ages of fifty and sixty. Initially, the dyspnea is noted only with heavy exertion, but it progresses over time to a persistent, daily symptom that may eventually limit simple activities and even be present at rest. If the patient also has

chronic bronchitis, daily cough and sputum production are present. Physical examination in emphysema reveals chest hyperinflation (overdistention) and reduced breath sounds on auscultation (listening to breathing noises with a stethoscope). In severe cases, there may be signs of respiratory failure and failure of the right side of the heart (cor pulmonale).

The clinical diagnosis of emphysema is suggested by the presence of a risk factor for emphysema (smoking and/or AAT), the clinical findings described above, the absence of alternative diagnoses to explain these findings (e.g., bronchial asthma, bronchiectasis, and central airways obstructive diseases), and evidence of airflow obstruction on spirometry (pulmonary function testing). Airflow obstruction in emphysema is usually irreversible, meaning there is no improvement in the obstruction after inhaling a bronchodilator drug. Specialized pulmonary tests may demonstrate air trapping and reduction in the gas-transfer ability of the lung. The chest radiograph in mild emphysema may be normal, but in severe cases there is hyperinflation. Sometimes large air sacs called *bullae* are seen. Computed tomographic imaging may confirm lung destruction, bullae, and hyperinflation. Arterial blood-gas analysis and transcutaneous measurement of oxyhemoglobin saturation (oximetry) reveal hypoxemia in advanced emphysema.

Emphysema is treated with a broad-based approach that includes elimination of cigarette smoking, immunization against influenza virus and *Streptococcus pneumoniae* infection, exercise, maintenance of a healthy lifestyle, and the use of bronchodilator medications (e.g., ipratropium bromide and albuterol). Supplemental oxygen is prescribed if hypoxemia is present. Continuous long-term oxygen therapy improves survival in COPD patients with hypoxemia. Anti-inflammatory drugs such as corticosteroids are helpful in a small percent of emphysema patients. COPD exacerbations, with increasing dyspnea, cough, and sputum production, are usually treated with intensification of the bronchodilator regimen, antibiotics, supplemental oxygen, and in some cases corticosteroids. Hospitalization may be necessary, and in severe cases insertion of a breathing tube into the airway (endotracheal intubation) and mechanical ventilation are necessary. Debilitated COPD patients may

benefit from comprehensive outpatient rehabilitation. Rarely, patients with advanced emphysema are treated surgically (removal of large bullae, volume reduction surgery, or lung transplantation).

With the exception of AAT, emphysema is a preventable disease. Smoking abstinence remains the best hope for reducing the morbidity and mortality associated with emphysema. Early detection of airflow limitation in young cigarette smokers may provide a strong stimulus to quit smoking. This is important because smoking cessation is known to slow the rate of decline in lung function in middle-aged smokers with mild COPD.

Survival in patients with COPD is determined by multiple factors, including age, gender, lung function, and levels of oxygen and carbon dioxide in the blood. The prognosis is worse when the airflow obstruction is irreversible. COPD patients with severe obstruction, as defined by spirometry, have a median survival of about four to five years, but there is substantial variability. Death in emphysema patients is usually a result of pneumonia, lung cancer, heart disease, or respiratory failure.

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(SEE ALSO: *Asthma; Chronic Respiratory Diseases; Pulmonary Function; Smoking Behavior; Smoking Cessation; Tobacco Control*)

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ENABLING FACTORS

In the public health arena, the term "enabling factors" is recognized most widely as part of Lawrence W. Green's PRECEDE Model and Green and Kreuter's PRECEDE-PROCEED Model of Community Health Promotion Planning and Evaluation. These models provide a series of steps to guide the assessment of the health and quality-of-life needs of individuals and populations, and the planning, implementation, and evaluation of strategies and programs designed to meet those needs. Once a particular health problem has been identified, the process of designing effective strategies to address it involves determining which behaviors lead to, or are otherwise associated with, that health problem. The next step involves ascertaining which factors have the ability to cause each of these behaviors to occur or to inhibit their occurrence. These factors are themselves grouped into three types: predisposing, reinforcing, and enabling factors.

Green originally adapted the term "enabling factor" in 1974 from the concept of "enabling resources" found in Ronald Andersen's Behavioral Model of Families' Use of Health Services (1968). Andersen's model, still used widely in the fields of health services research and health administration, suggests that among the factors that influence use of health services are two categories of enabling resources: community enabling resources (e.g., health personnel and facilities must be available), and personal/family enabling resources (e.g., people must know how to access and use the services and have the means to get to them).

Within the PRECEDE-PROCEED Model, enabling factors are defined as factors that make it possible (or easier) for individuals or populations to change their behavior or their environment. Enabling factors include resources, conditions of living, societal supports, and skills that facilitate a behavior's occurrence.

SKILLS

A person or population may need to employ a number of skills to carry out successfully all of the

tasks involved in changing behavior. Skills that people already possess may serve as predisposing factors insofar as they motivate the behavior. In contrast, any skills that still need to be developed are considered to be enabling factors.

New skills may include those involved with determining how to identify, access, and use medical care procedures, facilities, and programs. For example, women who are comfortable using the Internet may be able to follow a number of links to access information about where to receive a screening mammogram, whereas women who are not able to use the Internet may have a harder time tracking down available services. Women who have never been shown how to perform breast self-examination may feel that they would do it wrong and may therefore not try at all. Similarly, older women who have traditionally let their doctor guide the discussion during office visits may not know how to effectively ask questions about becoming involved in preventive health maneuvers related to breast cancer.

Other skills of importance are those that allow an individual or population to undertake personal action to reduce their risk of disease. For instance, women may not know how to decrease the fat content of their diet or to increase the amount of vegetables they eat so as to reduce their risk of cancer and heart disease. They may not know how to change their cooking patterns to create meals that are healthful while also being tasty enough that their families will eat them.

Finally, skills in changing the environment may be important for behavior change. As an example, women who receive training in advocacy may be effective in securing funding for comprehensive breast cancer screening programs for low-income recipients. Women who are shown how to participate in community development initiatives may gain credibility with ethnic populations and be able to share with them the importance of breast-cancer screening.

HEALTH CARE RESOURCES

A number of health care resources may be implicated if an individual or population is to make a behavior change. These include such things as

health care providers, hospitals, public health programs and classes, clinics for those who are sick, and programs for healthy people who are trying to maintain or improve their health. The relative availability, accessibility, and affordability of these resources may either enable or hinder undertaking a particular behavior.

For example, overweight people may need to reduce their risk of heart disease and diabetes by decreasing the amount of fat and sugar in their diet. Toward this end, health care providers or clinics might agree to making themselves available to people who need to be informed about, and who need periodic monitoring of their blood pressure and the levels of sugar and fat in their blood. Accessibility depends on such things as whether people can secure transportation to clinics and doctors' offices and whether the design of these facilities is user friendly for people with physical limitations. Similarly, the affordability of visits to health care providers for testing, and possibly for lifestyle counseling, is influenced by whether people have health-insurance coverage and whether preventive health care procedures such as lifestyles counseling are covered.

COMMUNITY AND OTHER ENVIRONMENTAL CONDITIONS AND RESOURCES

Changing behavior may be easier if aspects of one's environment are supportive of that change. Community resources include such things as the availability of referral services and of centers that sponsor or provide space for public health initiatives or activities. Other important conditions and resources include policy initiatives, the availability of healthful products and alternatives to unhealthful behaviors, and the existence and enforcement of legislation.

As an example, public health practitioners may want people to increase their levels of physical activity. Individuals may have a greater likelihood of becoming involved in regular exercise if such things as parks, recreation centers, and swimming pools are available in their community. They might be more likely to take up regular walking, jogging, rollerblading, or bike riding if their neighborhood is safe and relatively clean. Furthermore, user fees

for recreation centers and other sports facilities, and having to pay for child care while exercising, will influence the affordability of exercise options.

If the aim is to reduce tobacco use, people may be encouraged to quit, or at least to reduce their smoking, if there is a ban on smoking in workplaces and in other public spaces. Levying taxes on cigarettes increases their cost and acts as a disincentive to smoking, especially among youth. Laws that prohibit tobacco sales to minors and that eliminate the placing of tobacco vending machines where minors can access them can combine to decrease access to tobacco among youth, and may serve to discourage their experimentation with tobacco. Making nicotine replacement therapy and other smoking cessation aids available, accessible, and relatively low cost may also increase the likelihood that smokers will attempt to quit.

EFFECTIVE USE OF INFORMATION COLLECTED ABOUT ENABLING FACTORS

Key to the success of health-promotion and disease-prevention programs is a determination of which of the requisite skills and resources for changing behavior and the environment people already possess, and which ones are lacking. This involves an organizational assessment of resources and an educational assessment of the necessary skills. Public health practitioners should then consider adding components to their programs or tapping into other sources that teach the necessary skills or that provide the missing resources. They should further identify what organizational actions need to be taken to modify the environment.

To continue with the examples provided above, if the availability of health care providers in a geographical area is minimal or if their business hours are limited, blood pressure as well as blood lipid and sugar testing can be offered periodically during evening and weekend hours in local shopping malls or in mobile units. Providing child care while individuals undergo testing and any follow-up counseling could further increase accessibility. Follow-up counseling could include the provision of information about, and samples of, low-fat cooking, along with referrals for low-cost classes on healthful cooking. If neighborhoods are not adequately safe or clean, or during winter months,

walking clubs could be established in shopping malls before stores opened. If vendors are selling tobacco products to youth in the community, interested citizens could be trained to advocate for consistent enforcement of minors' access laws. In all cases, the aim is to render the environment more supportive of and more conducive to behavior change.

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(SEE ALSO: *Behavior, Health-Related; Community Health; Health Promotion and Education; PRECEDE-PROCEED Model; Predisposing Factors*)

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ENCEPHALITIS

See Arboviral Encephalitides

ENDANGERED SPECIES ACT

Species have evolved throughout the course of natural history, and the fossil record is filled with evidence of extinctions, some of which have been sudden and catastrophic. Ecologists believe that we are in such an era of rapid species extinctions today. The most prominent current cause is human activity, which brings about loss of habitat for species and also causes pollution and overharvesting. For example, the spotted owl is endangered by overharvesting of old growth forests in the Northwest; the bald eagle was nearly rendered extinct in the United States outside of Alaska due to poisoning with DDT and its metabolites; and many species have been hunted to extinction. Species biodiversity has a number of health benefits for people, including maintenance of stable environmental processes that support human life, provision of biological substances that may be useful in pharmaceutical and other applications, and enhancement of the enjoyment of the environment and recreational opportunities.

Enacted in 1973, the Endangered Species Act emerged as a result of concern about extinctions of "various species of fish, wildlife, and plants in the United States" and an understanding that many other species had become "so depleted in numbers that they are in danger of or threatened with extinction." In the act, an endangered species is defined as one for which there is a danger of extinction in "all or a significant portion of its range," unless the species is an insect that has been determined by the secretary of the interior to be a "pest that presents an overwhelming and overriding risk to man." A threatened species is one that is likely to become endangered in the foreseeable future. The Endangered Species Act replaced an earlier statute, the Endangered Species Conservation Act of 1969.

The Endangered Species Act was revolutionary in that it explicitly recognized that to protect species one must conserve "the ecosystems upon which endangered species and threatened species depend." Specifically, "critical habitat" is the area occupied by a species requiring protection that contains the physical or biological features that are essential to the conservation of that species. It does not include the entire potential geographic area that can be occupied by the threatened or

endangered species. The Department of the Interior (DOI) is responsible for making determinations of which species are threatened or endangered, and defining the critical habitat for these species. This activity is carried out within the department's Fish and Wildlife Service. The department is also charged with development of protective regulations, recovery plans, and monitoring efforts.

The act explicitly applies to the actions of "all departments and federal agencies" and also requires that the federal government work in concert with state and local agencies to resolve water resource issues involved with the conservation of endangered species. DOI issues "biological opinions" that set the stage for actions to protect endangered species by other agencies.

The act also incorporated provisions for implementation of a number of international agreements, including:

- Migratory bird treaties with Canada and Mexico;
- The Migratory and Endangered Bird Treaty with Japan;
- The Convention on Nature Protection and Wildlife Preservation in the Western Hemisphere;
- The International Convention for the Northwest Atlantic Fisheries;
- The International Convention for the High Seas Fisheries of the North Pacific Ocean;
- The Convention on International Trade in Endangered Species of Wild Fauna and Flora.

The protection of endangered species is very complex and involves inherent conflict and competition over the use of resources. Critical habitat may be in the hands of private owners, and there may therefore be conflicts regarding property rights. The DOI has evolved mechanisms to help minimize these conflicts. Biological opinions and listing decisions written by its biologists receive peer review by outside scientists to provide assurance of a strong scientific basis. Interior has a policy of developing "habitat conservation plans," which seek to bring all the critical players to the

table to develop and agree on plans for conserving critical habitat for endangered and threatened species.

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(SEE ALSO: *Biodiversity; Ecosystems; Environmental Justice; Environmental Movement*)

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ENDOCRINE DISRUPTORS

An endocrine disruptor is any chemical (including dietary) or physical agent that modulates one or several of the endocrine organs or the function of these organs. The endocrine system works primarily as a closed feedback loop that functions to maintain homeostasis. It is made up of a series of organs, the hormones these organs produce and release, and the organs and tissues affected by these hormones. Endocrine disruptors can modulate any segment of the endocrine system.

A simple example of this loop is the axis between the pituitary and the thyroid. The anterior pituitary gland secretes thyroid-stimulating hormone (TSH) in response to signals from the hypothalamus. The TSH travels to the thyroid gland via the circulatory system and activates pathways that lead to uptake of iodine and the synthesis and eventual secretion of thyroid hormone. The thyroid hormone is carried in the blood to end organs and tissues where it regulates metabolism. Thyroid hormone is eventually metabolized in the liver and excreted as a conjugated metabolite. The decreasing levels in the blood initiate a response in the hypothalamus that restarts the cycle in the pituitary gland. If the levels of thyroid hormone are chronically low (hypothyroidism) the anterior pituitary secretes increasing amounts of TSH that, if the thyroid cannot synthesize thyroid hormone (for example, in the absence of dietary iodine), leads to an enlarged thyroid and in some cases goiter. An endocrine disruptor can be any condition (chemical, diet, radiation, stress) that modulates any of these critical steps, or similar steps in any endocrine system.

Several chemical classes have been identified as endocrine disruptors. The compounds that affect the gonadal-pituitary axis are those that modify the metabolism and/or synthesis of estradiol and testosterone, such as the 5 α -reductase inhibitors that block production of dihydrotestosterone. These inhibitors are drugs, but are also found in herbs such as saw palmetto. Several chemicals are estrogen mimics that bind to the high-affinity estrogen-binding protein called the estrogen receptor (ER). These chemicals include drugs, natural products, and manufactured chemicals. The concern about estrogen mimics is that they may be involved in causing breast cancer, uterine cancer, and developmental defects. In addition, there is a large class of herbal remedies that are marketed for "female" and "male" health. These preparations are physiologically active and clearly modify the target endocrine system. The standard for determining if these compounds are endocrine modulators is to test them in laboratory systems that have been validated as reasonable surrogates for the intact endocrine system. Estrogen mimics that are widespread in the environment are the substituted phenols such as Bisphenol A, and the longer chain nonyl- and octyl-phenols. These are many times weaker than the active human hormone estradiol in classic assays. Several derivatives of the pesticides DDT and methoxychlor are active as estrogens and/or anti-androgens through mechanisms that involve the respective estrogen or androgen receptors. Natural products, such as genistein from soy, exhibit remarkable estrogenic activity.

There are many endocrine-disrupting chemicals in the environment. The question is what impact these agents have, and how they affect public health. In the occupational setting, if high levels of exposure occur, the risk of disease is very high. This was seen during the manufacturing of diethylstilbestrol (DES), the prototypical endocrine disruptor. The effects of environmental levels of estrogen modulators may be masked by dietary factors, natural hormones, or therapeutic agents. However, exposures of select populations, such as PCB exposures in China, may be of such magnitude as to be discernible in the clinical setting.

In the light of public health concern, the best policy is to minimize exposure and at the same time determine the mechanisms of action of each

class of chemical involved in disrupting the function of a particular organ system. It appears that for the most part environmental levels of these pollutants may be tolerated in adults (animals and humans) but there are very few data on the effects of these agents in the developing endocrine systems of the fetus or of children.

MICHAEL GALLO

(SEE ALSO: *Pollution; Toxicology*)

ENERGY

Energy means work. It refers to the effort required to move a weight for some distance. The heavier the weight or the longer the distance, the more energy is required. Energy is measured in units called "joules," or sometimes as the heat equivalent to these joules, called "calories." In nutrition, both terms are used. A calorie is the amount of heat needed to warm one gram of water by one degree centigrade. A more convenient unit is the kilocalorie (kcal), which equals one thousand calories. In physical terms, energy has several forms, all of which can be converted into heat. These include potential energy, kinetic energy, chemical energy, and heat energy.

GEORGE A. BRAY

(SEE ALSO: *Fats; Krebs Cycle; Nutrition*)

ENFORCEMENT OF RETAIL SALES OF TOBACCO

Retail stores represent the main interface between tobacco producers and customers. Other sources include home-grown and black market cigarettes that have been smuggled to avoid taxes. Governments want to regulate the distribution of tobacco, similar to other products intended for consumption such as food and alcohol. Governments are principally interested in collecting revenues and ensuring product safety. Most product safety concerns at point of purchase have focused on preventing sales of tobacco to young people.

Attitudes about tobacco are shaped at an early age. Roughly 40 percent of smokers begin experimenting prior to becoming a teenager, and 80

percent adopt the habit during their teenage years. One in three of those who begin smoking during this period eventually die of smoking-related causes. Regardless of future health problems, teenagers represent the market for replacing smokers who quit or die. It is a market that has been courted by the tobacco industry and by health groups.

Legislation has primarily been viewed as a tool to control supply rather than demand. During the early twentieth century, the temperance movement lobbied for legislation to prevent tobacco from reaching young people. By 1920, Virginia and Rhode Island were the only states that lacked age restrictions. Canada had federal and provincial legislation that restricted sales of tobacco to minors, as well as possession by minors. These laws were rarely enforced, and most were ignored or repealed. Such legislation returned to prominence, however, as evidence mounted concerning patterns of smoking and the consequences of smoking to health. Advocacy groups began to raise the issue by sending minors into stores to purchase tobacco. The initial legal remedies consisted of warnings or minor penalties, but increased media coverage added the burden of social concern and corporate disgrace. In one case, the Provincial Court of Ontario levied a \$25 fine after University of Toronto students brought charges against the Canadian pharmacy chain, Shoppers Drug Mart, a subsidiary of Imasco Ltd., which also owns Imperial Tobacco, Canada's largest tobacco company. The retailer responded with an in-house program to train employees about sales of tobacco to underage customers.

During the 1980s researchers began to publish results of studies that illustrated how young people could easily purchase tobacco products. They found that early experimental smoking often involved cigarettes obtained from parents or friends, but that retail stores quickly became the main source of tobacco. The researchers revealed the ineffectiveness of both voluntary programs sponsored by the tobacco industry and isolated educational programs provided by health agencies. A small number of surveys solicited input from tobacco retailers. In one survey, over 90 percent of the merchants surveyed stated that they thought they should not be able to sell cigarettes to underage youths. The merchants wanted government legislation that set rules for a "level playing field" applicable to all tobacco outlets. Building

upon diffusion theory, the authors of the survey categorized retailers into three groups, using the concept of early, middle, and late adopters to describe sales practices. Early adopters were the first retailers not to sell tobacco products to minors. It was hypothesized that the first two groups were amenable to educational programs, but enforcement would be necessary to help support the middle adopters and change the minority who persisted in selling tobacco to minors. The need for a combination of education and enforcement has been confirmed by several studies.

Numerous agencies have demonstrated success at working with tobacco retailers, and standard undercover procedures are evolving to assess the behaviors of vendors. These measures have variously been called *stings*, *compliance checks*, *Synar surveys*, *decoy purchases*, or *test shopping*. In such operations, minors are selected and verified to look their age. The supervised minors are then sent into stores where they attempt to purchase a tobacco product. For operations sponsored by universities, the minors are usually truthful about their age, but for purposes of enforcement the protocol may include slight deception. It is the vendor's responsibility to ask for photo identification. Cashiers and business owners share responsibility for tobacco transactions; and one or both may be charged for an infraction. Enforcement agents include the police, inspectors from health agencies, or liquor control inspectors. Penalties for illegal sales escalate from warnings and a range of monetary fines to loss of license. Losing the right to sell tobacco provides an effective deterrent for repeat offenders or when high profits smother the relative impact of fines.

In response to scientific evidence and public opinion, by the end of the twentieth century most of the government jurisdictions in North America had rewritten their laws restricting sales of tobacco to minors. They were faced with sobering statistics showing that during the last decade of the century there was a steady increase in the proportion of teenagers using tobacco. Every day approximately 7,000 North American minors experimented with tobacco, and 3,500 became daily smokers. While vigilance and enforcement were being stepped up for traditional retail outlets, young people were finding new types and sources of tobacco. The market introduced imported cigarettes, such as "bidis," with the allure of a slim profile, colorful

wrappers, and fruit flavors, and the Internet provided a faceless source of mail-order tobacco. These new elements present additional challenges in the effort to reduce teenage smoking.

RONALD A. DOVELL

(SEE ALSO: *Enabling Factors; Smoking Behavior; Smoking Cessation; Tobacco Control; Tobacco Sales to Youth, Regulation of*)

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ENGINEER, PUBLIC HEALTH CAREER

An engineering career in the public health setting centers on managing the undesirable, physical by-products of American society so as to minimize their impact on public health. The dominant role is one of oversight for health-based agencies, ensuring that various waste streams (air, water, and solid waste) from both industrial and public sources comply with local, state, and federal pollution laws and regulations. Since emission regulations are designed to protect public health and the environment, engineers are also employed by the facilities that generate regulated materials. Engineers contribute to the study of pollution on the environment, and are responsible for designing, operating, and maintaining pollution control systems and water supply systems.

FRANK J. MARKUNAS

(SEE ALSO: *Environmental Determinants of Health; Environmental Protection Agency; Sanitation; Wastewater Treatment*)

ENVIRONMENTAL DETERMINANTS OF HEALTH

An environmental determinant of health is, in general, any external agent (biological, chemical,

physical, social, or cultural) that can be causally linked to a change in health status. However, since virtually everything that is not genetically determined could be considered "environmental," this general definition is too all-encompassing to be useful. Rather, environmental epidemiologists have narrowed the term to include only those environmental influences that are involuntary. For example, breathing secondhand tobacco smoke would be an environmental hazard, whereas active tobacco smoking would be considered a behavioral determinant.

In the developed world, environmental epidemiologists are concerned about such things as gene-environment interactions, environment-environment interactions, particulate air pollution, nitrogen dioxide, ground-level ozone, environmental tobacco smoke, radiation, lead, video display terminals, cellular telephones, and persistent organic pollutants (POPs) that act as endocrine disruptors. Exposures to these types of environmental vectors are known as downstream, or proximate, determinants of health (that is, the exposures are closely related in time and space to the ill effects they produce), and they impact both health and well-being.

In the developing world, the primary environmental determinants of health are biological agents in the air, water, and soil that account for most deaths, and for most deaths in the world. Four million children die annually from diarrheal diseases acquired from contaminated food or water. Over one million people die from malaria each year. Hundreds of millions of people suffer from debilitating intestinal parasitic infestations. Hundreds of millions of people suffer from respiratory diseases caused by biological and chemical agents in the air, both indoors and outdoors. According to the World Health Organization (WHO), over one billion people are unable to meet their basic needs (i.e., adequate food, clean water, and shelter) because they lack the necessary income or land. These are environmental hazards that take a far greater toll on human life and suffering in absolute terms compared to those environmental determinants of concern in the developed world.

To understand approaches needed to address environmental health concerns, a distinction is made between infectious and chronic causes of

disease. A distinction also is made between short-term, acute exposures resulting in epidemic outbreaks of illness, and long-term, low-dose exposures resulting in chronic diseases. Such classifications are necessary to ensure appropriate methods for researching and understanding the extent of health problems in the world. The workplace often serves as a laboratory for understanding the relationship between environmental exposures and health. It serves as a laboratory because, in their occupational environment, workers tend to be exposed to measurable amounts of pollution. This fact allows occupational health researchers and epidemiologists to link adverse health outcomes to these environmental factors. If no link between a workplace pollutant and worker ill-health can be demonstrated, then that pollutant is unlikely to have measurable consequences for human health beyond the work environment owing to comparative lack of frequency and concentration of exposure experienced by those not working in that specific environment. One notable exception, however, is that class of people who are more susceptible to ill-effects even from low levels of exposure.

An emerging concern with great potential impact on public health relates to upstream, or distant, determinants of health (the exposures are far apart in time or space from the witnessed ill-effects) including as policies that drive current levels of population growth, consumption and waste issues, and the uses of technology. For example, the environmental, transboundary transport of contaminants through the food chain has resulted in global chemical contamination. Other transboundary issues include acid precipitation, ozone, greenhouse gasses, and hazardous wastes. Global ecological integrity (i.e., the ability of life-support systems to sustain themselves in the presence of polluting forces) and global change (including concerns about climate change from global warming, ozone depletion, and the loss of biodiversity) have given people reason to adopt the WHO maxim: "Think globally, act locally." Reducing wastes and consumption at the local level can have positive effects on the entire earth's ecosystems.

COLIN L. SOSKOLNE
LEE E. SIESWERDA

(SEE ALSO: *Acid Rain; Ambient Air Quality [Air Pollution]; Ambient Water Quality; Behavioral*

Determinants; Biodiversity; Chronic Illness; Climate Change and Human Health; Environmental Justice; Environmental Movement; Environmental Protection Agency; Environmental Tobacco Smoke; Global Burden of Disease; Population Growth)

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ENVIRONMENTAL IMPACT STATEMENT

The National Environmental Policy Act (NEPA) of 1969 requires that federal agencies prepare an environmental impact statement (EIS) indicating, for any legislation or action that they propose, that the agencies have investigated and considered the possible environmental consequences.

NEPA was a response to widespread concerns that the environment was being endangered by projects in which federal agencies were involved in various ways. Its passage established a precedent subsequently followed by requirements in more than forty other countries that similar environmental impact assessments be conducted. The purpose of the act was to "encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of

man; to enrich the understanding of the ecological systems and natural resources important to the nation; and to establish a Council on Environmental Quality.”

In passing NEPA, Congress declared “that each person should enjoy a healthful environment” as an aim of compliance with the NEPA. The act did not mandate any particular decision, only that the facts concerning environmental consequences of proposed actions be determined and taken into account. It did require “utiliz[ing] a systematic, interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts in planning and decision making which may have an impact on man’s environment.” The impact on human health must be included along with consideration of physical, biological, social, and economic factors.

The EIS process in the United States has significantly influenced decision making by allowing: (1) public participation in commenting on draft EISs, which permits environmental advocates, industrial groups, and others to make their voices heard, and (2) litigation originating from any of the affected parties challenging the decisions made. Thus, besides delineating the facts about potential environmental impacts and considering them in making decisions, the federal agencies must take into account public reaction and legal issues.

As many countries have joined the effort, an internationally related move toward environmental protection has been to prepare covenants among different nations on such issues. One example is the Kyoto Protocol on global warming. Even though the Kyoto Protocol is in serious jeopardy, such international moves could eventually carry substantial force for environmental protection.

LESTER BRESLOW

(SEE ALSO: *Climate Change and Human Health; Environmental Protection Agency; Environmental Movement; Pollution; Sustainable Development*)

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ENVIRONMENTAL JUSTICE

Does every income, racial, ethnic, and age group have an equal right to protection from environmental hazards? This question is central to the emotionally charged debate about the location of industrial and waste management facilities and the application of regulations and funds to protect people and neighborhoods. The environmental justice movement came to the forefront of environmental health politics during the 1980s when a landfill for PCB-contaminated waste was located in a poor, largely African-American community in Warren County, North Carolina. That controversial siting led to a study by the United Church of Christ (UCC) which found that hazardous waste management facilities in the United States were disproportionately located in areas that had minority and poor populations.

The UCC research prompted more than two dozen studies that have examined waste management and industrial facility locations, air pollution incidents, and measures of public exposure to toxins to determine whether minority and poor populations bear an unfair toxic burden. The research, which has produced contradictory results, has looked for evidence that the process used to make decisions were equitable, and that the outcomes were equitable. Differences in the findings are largely explained by differences in what populations were chosen as potentially burdened, what activity was supposedly causing the burden, what burden was measured, what the spatial scale was of the analysis, and what statistical methods were used in the analysis. Overall, the evidence proving that poor and minority populations across the United States are disproportionately at risk from environmental hazards is not conclusive.

Nevertheless, this research has made environmental equity an important policy consideration. On February 11, 1994, President Bill Clinton issued Executive Order 12898, which required all federal agencies to take steps to overcome any disproportionately adverse environmental effects on the poor and minorities. Many federal agencies now have environmental justice offices, take steps

to consider the impact of their activities on poor and minority populations, and try to increase minority representation in their agencies. Some states have followed the federal example, and citizens groups have also been active. For example, in May 1996 a citizens group in Chester, Pennsylvania, sued the Pennsylvania Department of Environmental Protection, under Title VI of the Civil Rights Act of 1964, for approving the location of a waste management facility in a largely African-American neighborhood that already had five such facilities and had high rates of morbidity and mortality among its residents. Title VI considerations have become important in the siting of new facilities.

On the other hand, mayors such as Dennis Archer of Detroit have expressed concern that a blanket application of environmental justice concerns hurts the redevelopment of inner-city neighborhoods—precluding, for example, the placement of new factories on remediated brownfield sites. Environmental injustice is also invoked as a reason to curtail suburban sprawl, which removes resources from inner cities and leaves unwanted land uses and poor people in its wake.

MICHAEL R. GREENBERG

(SEE ALSO: *African Americans; Agency for Toxic Substances and Disease Registry; Assessment of Health Status; Brownfields; Environmental Determinants of Health; Environmental Movement; Ethics of Public Health; Ethnicity and Health; Hazardous Waste; Minority Rights; Not In My Backyard [NIMBY]; Poverty and Health; Risk Assessment, Risk Management; Toxic Torts; Toxicology*)

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ENVIRONMENTAL MOVEMENT

The environmental movement in the United States is often dated to the 1962 publication of Rachel

Carson's book *Silent Spring*. This seminal description by an articulate scientist on the dangers of the chemical era to the environment and to human health struck a responsive chord with the general public and among opinion leaders. It tapped into a perhaps inbred human belief of the sanctity of air, water and soil, as well as an atavistic human concern about insidious and unknown poisons. The widespread success of the first "Earth Day," in 1969, revealed the environment to be a potent political issue as well. This led to the formation of the U.S. Environmental Protection Agency, in 1969, and to a wide range of laws to control existing and potential threats to the environment.

There are many parallels between the environmental movement and the Sanitary movement of the nineteenth century. The Sanitary movement was characterized by a broad concern among all segments of society with poor sanitary conditions and their perceived linkages to ill health, and by a recognition that advocacy was necessary to achieve societal changes. In many ways both of these movements preceded the scientific discoveries upon which effective public policy was eventually built.

The environmental movement in the United States has its roots not only in public health but also in longstanding public support for conservation that led, for example, to our National Park system. The wide range of environmental organizations reflect this duality of approach. The success of these environmental advocacy organizations also reflects the expectations of more from the environment than can be expressed solely in health or economic terms. This transcendent aspect continues to fuel the environmental movement despite highly significant gains in air and water quality and in wilderness preservation in recent decades.

BERNARD D. GOLDSTEIN

(SEE ALSO: *Ecosystems; Environmental Determinants of Health; Environmental Impact Statement; Environmental Justice*)

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ENVIRONMENTAL PROTECTION AGENCY

In response to a growing environmental movement, the United States Environmental Protection Agency (EPA) was formed in 1970 by President Richard Nixon through a Congressionally approved reorganization plan that joined together parts of existing federal agencies, including parts of the U.S. Public Health Service (USPHS). The goal was to centralize federal organizational components involved with protecting human and ecological health from environmental threats. The EPA is responsible, either alone or with other agencies, for administering over twenty federal laws, including the Clean Air Act; the Clean Water Act; the Comprehensive Environmental Response Compensation and Liability Act (Superfund Act); the Emergency Planning and Community Right-to-Know Act; the Federal Insecticide, Fungicide, and Rodenticide Act; the Resource Conservation and Recovery Act; the Safe Drinking Water Act; and the Toxic Substances Control Act. It differs from other federal agencies with health regulatory responsibilities by not having a defining legislative act (e.g., the Food and Drug Act for FDA). The administrator of EPA reports directly to the president and is sometimes unofficially accorded Cabinet status. EPA is organized into programmatic offices responsible for administering one or more of the environmental laws. There also are a number of crosscutting organizational components, including an Office of Research and Development responsible for assuring that EPA's activities are guided by sound science.

Under EPA oversight, there has been a substantial reduction in overt pollution. Urban air is visibly cleaner, the nation's rivers and beaches are

now more swimmable and fishable; there is much less illegal dumping of hazardous wastes; recycling of household and industrial products is increasing; and it is far less likely that a manufactured chemical will be toxic to humans or to ecosystems. Yet many problems remain and new ones have developed, such as global climate change, the impact of loss of wetlands, the recognition of subtle biological effects of pollutants such as endocrine disruption, and the need for international harmonization of risk assessment and management practices in a global economy.

EPA's activities often have been controversial. Its first administrator, William Ruckelshaus, was brought back in 1983 after President Ronald Reagan's initial choice became a political liability and a senior EPA official was jailed for perjury. An area of tension within EPA is its role in public health, including its relations with federal public health agencies that also have roles in environmental protection. This tension is mirrored within the many states that have environmental protection agencies separate from their health departments. The number of USPHS commissioned officers with EPA has dropped precipitously in both absolute and relative amounts. Recent administrators have attempted to move EPA from legalistic command-and-control management strategies toward more of a partnership with stakeholders, including other federal and state agencies.

Particularly challenging for the future EPA is the increasing evidence of the linkage between ecosystem and human health. Relatively low levels of fine acidic particulates are the cause both of barren lakes through acid rain and increased mortality and morbidity in humans; endocrine disruptors affect reproductive endpoints in amphibians and in humans; and alterations in ecosystems caused by global climate changes alter human disease vectors. Another major challenge will be to apply legal definitions related to protection of susceptible populations to new information about more subtle susceptibility factors obtained through the unraveling of the human genome.

BERNARD D. GOLDSTEIN

(SEE ALSO: *Acid Rain; Ambient Air Quality [Air Pollution]; Ambient Water Quality; Clean Air Act; Clean Water Act; Climate Change and Human*

Health; Ecosystems; Endocrine Disruptors; Hazardous Waste; Risk Assessment, Risk Management; Toxic Substances Control Act; United States Public Health Service [USPHS]

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ENVIRONMENTAL TOBACCO SMOKE

According to the United States Environmental Protection Agency (EPA), environmental tobacco smoke (ETS), which is also referred to as secondhand smoke, is a mixture of the smoke emanating from the burning end of a cigarette, pipe, or cigar, and the smoke exhaled from the lungs of smokers. It has also been called passive, or involuntary, smoke. Although different sources may use different terms and varied definitions, the basic focus is on the exposure of a nonsmoker to the high levels of carcinogenic and toxic fumes emitted from burning tobacco.

ETS contains over 4,700 chemicals. Of these chemicals, forty-two are known carcinogenic compounds, including benzene, arsenic, nickel, nicotine, chromium 6, and vinyl chloride. Many of these compounds are added to tobacco in order to enhance burn time, freshness, and nicotine levels.

EXPOSURE TO ETS

A 1996 study conducted by the Department of Health and Human Services' Centers for Disease Control and Prevention (CDC) documented that measurable levels of serum cotinine were found in the blood of 88 percent of American nonsmokers. The presence of cotinine, a chemical the body metabolizes from nicotine, shows that a person has been exposed to tobacco smoke in the last two to three days. In other words, nearly nine out of ten nonsmoking Americans are exposed to ETS on a regular basis. Furthermore, it is estimated that 50 to 75 percent of children under five years of age live in homes with at least one adult smoker.

HEALTH EFFECTS

R. J. Reynolds, the manufacturer of Camel, Winston, and other cigarette brands, has stated that they "do not believe that the scientific evidence concerning secondhand smoke establishes it as a risk factor for lung cancer, heart disease, or any other disease in adult nonsmokers" (R. J. Reynolds, "Tobacco Issues"). However, research indicates that exposure to ETS can contribute to serious health consequences and is the third leading cause of preventable death in the United States.

The EPA has classified ETS as a group A carcinogen and estimates that it causes about three thousand lung cancer deaths in U.S. nonsmokers per year. Legal challenges against the validity of this study have been filed, mostly by tobacco interests. However, the EPA stands behind its findings and has received confirmation and support from other health groups conducting similar and expanded studies. For instance, in 1997 a study conducted by the California Environmental Protection Agency linked secondhand smoke not only to lung cancer, but also to heart disease, nasal sinus cancer, and various other life-threatening diseases. Other studies have established a connection between ETS and breast cancer and stroke. Studies of the effects of ETS exposure on children (both prenatal and postnatal) have indicated higher instances of sudden infant death syndrome, low birthweight, problems with neurodevelopment, negative behavior, childhood cancer, cardiovascular disease, and negative respiratory effects such as asthma and reduced lung capacity. The EPA estimates that each year between 200,000 and 1 million asthmatic children have their condition aggravated by exposure to secondhand smoke. Children of adult smokers have been found to have higher instances of ear infections, nosebleeds, colds, and flu.

POLICIES AND LAWS

Tobacco interests concentrate on the issue of "accommodation" in the establishment of ETS policies. Philip Morris, producer of Marlboro, Virginia Slims, and other cigarettes brands, states, "We know that environmental tobacco smoke . . . can be unpleasant and annoying, and that many people believe that it presents a health risk to nonsmokers. That is why we strongly support—through a variety of actions and programs—options

designed to minimize unwarranted ETS, while still providing adults with pleasant and comfortable places to smoke” (Philip Morris USA, “Second Hand Smoke”). The tobacco industry focuses on using ventilation to remove the components of ETS that might “irritate” a nonsmoking patron, while the health community is more concerned with removing the carcinogenic or toxic elements of tobacco smoke altogether.

The bulk of scientific research supports the health communities’ claims that ventilation cannot create a safe indoor environment when tobacco smoke is present. Modern ventilation systems may provide a worker or patron with a perception of protection due to an apparent decrease in tobacco-smoke irritants. However, research proves that tobacco smoke does not remain within designated smoking areas, but travels easily through a building’s open doorways and ventilation system. Therefore, accommodation policies do not significantly reduce exposure to the toxins that are associated with ETS-related diseases.

Formal policies and laws restricting or banning the use of tobacco in public buildings, schools, workplaces, and places customarily utilized by the public have been enacted at the federal, state, and local levels. Early ETS policies established rules of accommodation, limiting smoking to designated locations within buildings. As information about the inadequacy of accommodation policies grows, however, public and private entities are moving toward a complete ban of tobacco use within buildings and vehicles. The ban of smoking on U.S. airplanes in 1997 was the result of the settlement of a lawsuit brought by 60,000 flight attendants who suffered the ill effects of long-term exposure to tobacco smoke while on duty.

ETS policy should also address tobacco use outside building entrances. Tobacco smoke follows the natural airflow into a building. Open doors and windows can actually attract smoke in a funneling action. Therefore, many public and private facilities are establishing a ten- to twenty-five-foot smoke-free zone around all entrances; around operating window, air conditioning, and heating intake units; and within stairwells. Some entities, such as worksites that handle flammable or hazardous chemicals, health care facilities, and schools and day-care centers, prohibit tobacco use on their

entire campus (all property, both inside and outside). In 1999 the State of Arizona passed a law banning both the use and possession of tobacco products on all school K-12 campuses (private, public, and charter). This comprehensive law was in direct response to the state’s concern about both the exposure to tobacco smoke and the influence of tobacco use around children.

While children can be protected from ETS exposure by laws prohibiting tobacco use in schools, day-care facilities, restaurants, and other public places, these laws do not protect children from tobacco smoke within their homes or automobiles. Since up to three-fourths of all children live with a smoker, public health professionals work to educate the general public on the importance of establishing smoke-free homes and automobiles for the safety and well-being of their children and nonsmoking family members.

IMPACT OF SMOKING BANS

Workplace smoking bans also have positive health affects on smokers, including a decrease in the overall number of cigarettes smoked per day and a higher rate of successful quit attempts. Employers and business owners instituting tobacco-free policies can save costs associated with fire risks, damage to property and furnishings, cleaning, worker’s compensation, disabilities, retirement, injuries, and life insurance.

The tobacco and hospitality industry has long claimed that the passage of ordinances restricting tobacco use, particularly in restaurants, would pose an economic hardship on those businesses. However, continuing community sales tax studies have shown that communities that have enacted restaurant smoking bans have not seen a decrease in restaurant revenues.

THE ETS CONTROVERSY

Regulation of smoking in an effort to curb exposure to ETS has been a controversial issue in many communities. The tobacco industry and its supporters do not acknowledge that exposure to ETS compromises health. The National Smoker’s Alliance is a smokers’ rights group that represents the industry’s interests. They contend that adults have the right to choose to smoke and that smoking

restrictions impose restraints on smokers' personal rights. They also claim that regulation of smoking in private businesses infringes on the rights of business owners to decide how to best serve their customers. Public health advocacy groups counter that the adverse health effects of ETS exposure are well documented, and that while adults have the right to choose to smoke, they also have the right to clean indoor air. They frame the regulation of smoking in public and private workplaces as a worksite safety issue, arguing that nonsmokers who work in smoking environments are constantly exposed to high levels of ETS.

Exposure to environmental tobacco smoke is the third leading cause of preventable death in the United States today. According to a report released by the U.S. Surgeon General's office in August 2000, ETS may account for as many as 62,000 deaths per year in the United States from heart disease alone. Many communities have passed laws to restrict or prohibit smoking in public places and worksites in order to protect the public from the harmful effects of ETS. Policies that restrict smoking to designated smoking areas have been found to be ineffective, as tobacco smoke circulates freely into nonsmoking areas. Instituting 100 percent smoke-free policies is the most effective way of protecting workers, children, and the public from exposure to the numerous carcinogens and toxins found in tobacco smoke.

NINA S. JONES

(SEE ALSO: *Ambient Air Quality [Air Pollution]; Cancer; Cardiovascular Disease; Clean Air Act; Clean Indoor Air Ordinances; Disease Prevention; Environmental Determinants of Health; State Programs in Tobacco Control; Tobacco Control; Workplace Smoking Policies and Programs*)

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ENZYME IMMUNOASSAY

Enzyme immunoassay (EIA) is a test used to detect and quantify specific antigen-eliciting molecules involved in biological processes, specifically processes related to cancer and autoimmune disorders. EIA can be used on most types of biological samples, such as plasma, serum, urine, and cell extracts. In the assay, a plate is coated with a primary antibody, which recognizes the antigen of the target molecule and bonds with it. The antigen-antibody complex is recognized by a secondary antibody that is joined to an enzyme that catalyzes the reaction mixture, yielding a specific color. By measuring the optical density of this color, the presence and number of a specific molecule can be determined; the density of color is proportional to the advancement of the reaction or disease being tested.

MUKESH VERMA
SUDHIR K. SRIVASTAVA

(SEE ALSO: *Antibody, Antigen*)

EPIDEMIC INTELLIGENCE SERVICE

The Epidemic Intelligence Service (EIS) of the Centers for Disease Control and Prevention (CDC) is a training program that, since 1951, has trained over two thousand public health professionals in applied epidemiology. It has had a significant impact on the practice of epidemiology throughout the world.

In the 1940s, the U.S. Public Health Service (a uniformed service of the U.S. government) developed an Office of Malaria Control in War Areas, headquartered in Atlanta, Georgia, for the purpose of developing methods to control and prevent malaria among the armed forces located both in the United States and in areas of conflict—primarily in Southeast Asia. In 1946, the office had successfully met its mission in developing appropriate control and prevention measures, and it was no longer necessary to have approximately two thousand professionals working solely on malaria. Dr. Joseph W. Mountin, assistant U.S. Surgeon General, developed the concept of a Communicable Disease Center (the original name of the CDC) dedicated to investigating communicable diseases and developing appropriate control and prevention measures. Alexander D. Langmuir, a professor at Johns Hopkins University School of Hygiene and Public Health, was recruited as the senior epidemiologist at the newly designated CDC.

Langmuir recognized the need for a cadre of epidemiologists who could conduct investigations of the causes of epidemics from which control and prevention measures could be identified. At the same time, the Korean War raised concerns about biological warfare in the United States, and a major defense would be the availability of epidemiologists who could immediately investigate potential threats. The wisdom of developing such an applied epidemiology training program was recognized, and twenty-two physicians and one sanitary engineer began their training at EIS in July 1951.

From this initial endeavor the program has grown into an exemplary applied epidemiology training program. Today, EIS officers are selected from a large number of applicants for the sixty-five to seventy-five positions available each year. Approximately 80 percent of incoming officers

are physicians, with the remaining being veterinarians, nurses, statisticians, demographers, biologists, microbiologists, dentists, sanitary engineers, behavioral social scientists, and other professionals. The incoming officers may have just completed their professional training, or they may have had one or several years of experience in their professional areas—which may have included work in public health.

The objectives of the EIS program are to train public health personnel in epidemiology, provide epidemiologic services to states and other municipalities, investigate disease and injury as they occur in communities, and develop and recommend appropriate control and prevention measures.

The two-year training course begins with a three-week course that includes discussions of the principles of epidemiology, biostatistics, public health surveillance, field investigations, and laboratory science; and of specific diseases prevalent throughout the United States and the world. A community survey is conducted and hands-on computer training is also included.

Following this classroom training, the EIS officers are assigned to a specific program either at CDC headquarters, in a field station, at another federal agency, or at a state (or large city) health department for their two-year commitment. The important criteria for an assignment is that the EIS officer will have close supervision from a trained field epidemiologist and opportunities to participate in epidemiological investigations.

The concept behind this applied, hands-on training is that epidemiology is best learned by working on epidemics in communities as they occur, initially with close supervision from an experienced epidemiologist. In addition to responsibilities for field investigations, the officers will have other ongoing responsibilities, such as working on public health surveillance, handling public inquiries, writing reports, training other personnel in epidemiology, and assisting in planning activities. During the two years in the EIS program, the officers will also participate in some specialized short training programs and in the annual one-week EIS Conference held every April.

EIS officers work on the full spectrum of public health problems, both domestically and

internationally. Initially, the emphasis was on infectious diseases, but the focus has evolved to include all health conditions. Each year EIS officers conduct hundreds of disease investigations. Major contributions have been made in portraying the epidemiology of infectious diseases and identifying appropriate control and prevention measures for hospital-acquired infections, food-borne and waterborne diseases, respiratory diseases, and emerging or reemerging infections such as Legionnaire's disease, toxic shock syndrome, HIV/AIDS (human immunodeficiency virus/acquired immunodeficiency syndrome), sexually transmitted diseases, hantavirus pulmonary syndrome, and multi-drug-resistant tuberculosis. There has also been strong epidemiological input in reproductive health, environmental and occupational health problems, nutritional problems, chronic diseases, birth defects, unintentional injury, and violence.

EIS officers are on call twenty-four hours a day, seven days a week. Depending upon the situation, a multidisciplinary team can be rapidly assembled and dispatched, and may include statisticians, laboratorians, nurses, veterinarians, physicians, administrators, public-relations personnel, and secretaries from the EIS and other CDC programs. Additionally, any laboratory or other equipment not available in the field can be assembled by the team.

In all circumstances, approval has to be received from the appropriate governmental agency or foreign government before the CDC team can travel to the area in which the epidemic is occurring. The team will then remain in the field as long as necessary in order to meet the objectives of the investigation. Before departing a verbal report is given to the appropriate authorities, following which a written report is prepared and distributed to those with a need to know.

At the present time, there are approximately 2,500 alumni of the EIS program. Approximately 75 percent of EIS graduates work for federal, state, or local governments, or for international organizations in public health. Another 15 percent are on the staff of academic institutions, while most others are in a private hospital-based practice. Though these individuals are not working directly with public health, they serve as an important group of practicing professionals who have been trained in

preventive medicine and who continue to stress prevention in their daily private practices.

The excellence of the EIS training has been recognized throughout the world, and each year several health professionals from other countries are selected to participate in the EIS program. However, the need for trained epidemiologists in other countries has been greater than can be satisfied through the EIS program. In 1979 the concept of a Field Epidemiology Training Program (FETP) was developed with strong support from the World Health Organization's Southeast Asia Regional office in Delhi, India. The first FETP was initiated in Thailand. In addition to increasing the opportunities to provide hands-on training of a country's own health professionals, the FETP makes it possible to train students in each nation using their own health problems and resources. In 2000 there were twenty FETP programs located throughout the world from which more than nine hundred individuals have graduated. These two-year training programs are patterned after the EIS program in the United States but modified to meet the epidemiologic needs of each specific country.

Another activity developed by the EIS program is an epidemiology elective for fourth-year medical and veterinary students. This is a one to two month experience in the EIS program and provides opportunities for the students to become familiar with field epidemiology. To date, 632 medical and veterinary students have rotated through this program, participating in field investigations, analyzing data, and attending meetings and conferences. Seventeen percent of the medical students have returned to join the EIS program and more than 8 percent of them have continued in a public health career after graduation.

Another aspect of the EIS program is a preventive medicine residency program. Officers who desire this additional training spend an extra year at CDC, and split their time between headquarters and field assignments.

The professional activities of EIS graduates demonstrate the significant contributions they make to the practice of public health. Approximately one hundred of them have been or are state epidemiologists, sixteen have been state health commissioners, and twelve have been deans of

schools of public health. Others have had important positions at universities and colleges, such as chancellors, deans, and department chairs.

The concept of hands-on field experiences in the training of applied epidemiologists has resulted in strengthening the practice of epidemiology and public health in the United States as well as throughout the world. As the emphasis on healthy people continues, and with the increasing recognition of the importance of disease and injury prevention, the need for trained epidemiologists experienced in applied epidemiology is apparent. The EIS program helps satisfy this need.

PHILIP S. BRACHMAN

(SEE ALSO: *Centers for Disease Control and Prevention; Epidemics; Epidemiologic Surveillance; Epidemiology; Langmuir, Alexander; Training for Public Health*)

EPIDEMIC THEORY: HERD IMMUNITY

Epidemics that strike without warning, killing and incapacitating people indiscriminately, are dramatic and terrifying natural phenomena, equaled only by floods, earthquakes, and fires in the devastation they can cause, and often exceeding them in the horror and fear they evoke. Ancient priests and physicians seized on any supernatural or natural explanation for such epidemics. They blamed the wrath of a vengeful god, evil spirits, or a convenient scapegoat—witches, the Jews, passing strangers. By the time of the Renaissance, people were blaming the climate and weather, with or without the conjunction of astrological signs. The miasma theory of disease was concordant with this view. The birth of bacteriology, the discovery of infectious pathogens, and the ascendancy of the germ theory of disease led to more rational analysis of the observed facts and development of more logical explanations. From the public health perspective, it is as important to discover what leads to the decline and disappearance of epidemics as to understand why and how they begin and continue.

William Farr (1807–1883) was the first to discern mathematical principles governing the behavior of epidemics. William Hamer, Ronald Ross, and other public health specialists in the early

twentieth century developed refined mathematical models, factoring into their equations the variables involved in determining the interactions of disease agents, human hosts, and environmental conditions. Ross's models showed the interaction of mosquitoes, malaria parasites, and humans under varying conditions. Hamer modeled common infectious fevers of childhood. Modern concepts of epidemic theory evolved from these beginnings.

EPIDEMIC THEORY

At its simplest, epidemic theory considers three variables: agent, host, and environment. Each of these has many components, however—host-agent interactions vary greatly, and variations in environmental conditions influence the interactions in innumerable ways. Epidemic theory is therefore inherently extremely complex, involving advanced stochastic mathematics. Epidemic theory has been verified by empirical observations, and by experimental epidemiology, in which infectious pathogens are introduced into colonies of mice or rats and the effects (disease and death outcomes) are observed. This enables epidemiologists to construct simple mathematical rules about the behavior of agents and hosts, while observations in the field provide data on variations in environmental conditions. Epidemic theory has also been used to study cancer, where the agent is a carcinogen, the host undergoes cellular and molecular (immunological) reactions, and the environment exposes the host to many influences, including other carcinogens. Social and behavioral scientists have applied epidemic theory to the study of the propagation and transmission of ideas, political beliefs, rumors, and behavioral epidemics. The HIV/AIDS (human immunodeficiency virus/acquired immunodeficiency syndrome) epidemic, new challenges in controlling tropical infectious diseases, and emerging infectious diseases from the 1980s onward have all aroused renewed interest in epidemic theory.

The Agent. Infectious pathogens vary in size and biological makeup from protein particles (prions) and ultramicroscopic viruses to multicellular tapeworms many meters long. They are spread by direct contact; person-to-person contact; droplet spread; through personal articles, clothing,

utensils, and other belongings (known collectively as fomites); by way of a common vehicle such as water, food, milk, or contaminated air; by insect and other vectors; from animals that are their natural hosts, and from the inanimate environment. Survival of the agent is crucial—if it cannot survive, it cannot invade and infect new hosts, and the epidemic ends. Many agents can flourish in some natural habitat without humans, many have alternate hosts, while a few are absolutely dependent on their human hosts for survival and propagation. Moreover, agents require a susceptible host. The probability that an infectious agent will encounter a susceptible host while the agent remains viable is a critically important variable in epidemic theory. In constructing mathematical models of epidemics, all possible variations in all these aspects of the agent's behavior in relation to that of the host and the environment must be taken into account.

The Environment. Some agents, and some insect vectors that carry infectious agents, can survive and/or transmit infection only within a narrow temperature range. Some agents coexist with other living things; for example, *Vibrio cholerae* flourishes in a symbiotic relationship with certain plankton species. The bacillus of tuberculosis thrives in dusty dark corners of crowded dwellings. Tetanus spores can survive almost indefinitely in soil. *Staphylococcus* and many other pathogens live on human skin. The variations are limitless. For any given pathogenic organism the range of tolerable environmental conditions may be wide or narrow. Any epidemic model of a specific disease must allow for these variations of the causative organism.

The Host. When an infectious agent invades a host, defensive immune responses are invoked to protect the host from harm. Immunity can also be conferred passively—by maternal to infant transmission of antibodies across the placenta or in maternal milk—or by vaccination or immunization. Immunity may be temporary, long-lasting, even permanent. One has to consider both individual hosts and the population as a whole, known in this context as the “herd.”

Herd Immunity. The probability of an infectious agent encountering a susceptible host in which the agent can survive, propagate the infection, and sustain an epidemic depends on the

proportion of susceptible hosts in the herd, or population. When an infectious agent is introduced into a population that has never previously encountered it, all are susceptible. As the epidemic passes through successive hosts, leaving them immune, progressively higher proportions of the population become immune. When a sufficiently high proportion of the population becomes immune to the infectious agent, the epidemic subsides and eventually ceases. The proportion required to reduce susceptibility to a level where an epidemic cannot be sustained depends on many variations in the properties of the herd, the environment, and the agent. A common cold virus introduced into a virgin herd infects everyone and confers transient immunity on everyone after recovery. If the herd is large, say 100,000 or more, common cold viruses may continue to circulate long enough for immunity to wear off, and the same individuals can be reinfected. Infection with the measles virus confers lifelong immunity. An epidemic begins only when there is a sufficiently large susceptible population. In the early twentieth century, industrial nations with high birth rates saw this happen about every other year.

Empirical observations confirm epidemic theory, showing that the probability of a diphtheria epidemic is reduced to near the vanishing point when 50 to 60 percent of the population have been rendered resistant either by previous infection or immunization. When a population has a level of lifelong immunity to a certain disease such that an epidemic of that disease cannot occur, the population is said to have herd immunity. Mathematical models can be constructed for many common and some rare infectious diseases, factoring in all the possible known variables to calculate the numbers and proportions required to achieve herd immunity. These are very useful for planning and evaluating control strategies.

In epidemics spread by person-to-person contact, a simple mathematical equation, the principle of mass action, expresses the incidence of new cases in relation to the number of current cases, the number remaining susceptible, and the proportion of total possible contacts between infectious cases and susceptible individuals that lead to infection. With common-source epidemics (e.g., waterborne or food-borne), and with vector-borne

epidemics, the number of variable factors is much greater and the mathematics correspondingly more complex.

JOHN M. LAST

(SEE ALSO: *Epidemics*; *Epidemiologic Surveillance*; *Epidemiology*; *Farr, William*; *Pathogenic Organisms*; *Theories of Health and Illness*)

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EPIDEMICS

An epidemic is an occurrence of cases of a disease in excess of usual expectations for a particular population. An outbreak of influenza that affects thousands of people in a month in a nation and a half dozen cases of a rare form of liver cancer affecting industrial workers in a chemical plant over a period of several years are both examples of epidemics. Another kind of epidemic can be seen in the sharp rise in the prevalence of cigarette smoking throughout the twentieth century—first among males and then females—and of smoking-related respiratory system cancers. The surging death rate from coronary heart disease among men in many industrial nations in the middle third of the twentieth century may also be described as an epidemic.

A *pandemic* is a worldwide epidemic that kills or incapacitates huge numbers in many countries. Outbreaks of influenza in 1919 and HIV/AIDS (human immunodeficiency virus/acquired immunodeficiency syndrome) since the 1980s are both examples of pandemics. Conditions that are constantly present in a community are called "endemic;" examples include malaria in some tropical regions, and goiter due to deficiency of iodine in the soil of certain areas.

A single case of a rare and dangerous contagious disease that has never occurred before or has long been absent from a community represents a potential epidemic, as does a small cluster of cases of a disease such as typhoid in an urban community with good sanitation. Infectious pathogens (bacteria and viruses) cause most epidemics, while some are caused by a toxic industrial process or a toxic substance in food or water. A toxin in cooking oil in Spain in 1981 poisoned several thousand people, damaging their kidneys, liver, lungs, and nervous system and causing many deaths and widespread chronic disability. The precise nature of this contaminant was never established. In 1976, members of the American Legion who had attended a convention in Philadelphia began to fall ill and die of an unusual form of pneumonia, mostly after they returned to their homes elsewhere in the United States. Investigations by the Centers for Disease Control revealed this to be an epidemic of what is now called Legionnaire's disease, which is caused by a previously unknown microorganism that can be disseminated via the moist air in poorly maintained air-conditioning systems.

Charles Mackay, in his classic work *Extraordinary Popular Delusions and the Madness of Crowds*, described what is known as a behavioral epidemic. This phenomenon can be seen in the reactions of impressionable teenagers at a rock concert—and in a more sinister form in movements such as Nazism, when an entire nation is gripped by destructive fanaticism. The huge increase in traffic-related death and injury rates during the twentieth century, which has continued into the twenty-first century, is a behavioral epidemic associated with addiction to high-speed automobiles (the phenomenon called "road rage" is a psychopathic variation of this epidemic).

Human history has been punctuated frequently by epidemics, and occasionally by pandemics, that have shaped the rise and fall of civilizations and the victories and defeats of warring armies. The outcome of the Peloponnesian War (431–404 B.C.E.) between Athens and Sparta—and the future course of Western civilization—might have been very different had it not been for the epidemic that decimated the Athenians at the beginning of the war. Although the historian Thucydides, who had the disease himself, described its symptoms and

signs in detail, modern epidemiologists cannot identify it.

Epidemic sweating sickness recurred several times in medieval Europe, but it has vanished since. The Black Death, or plague, that struck Europe in 1347 killed between one-third and one-half of the people in many cities and towns, arresting the advance of civilization for several generations. Some epidemic diseases, such as the plague, smallpox, typhus, and influenza, have persisted throughout recorded history. Smallpox was eradicated worldwide by 1980. Cholera appeared along the world's major trade routes in several devastating epidemics beginning in the eighteenth century, and it still causes massive epidemics, most recently in South America in early 1990s.

In the final quarter of the twentieth century over thirty new infectious pathogens were identified. Many of these have caused deadly localized epidemics (e.g. Ebola virus, hantavirus, and other viral hemorrhagic fevers), and some have spread worldwide—HIV/AIDS being the foremost among these. Since its first recognition in 1981, HIV has affected almost 40 million people and killed over 10 million, making it the most lethal and dangerous pandemic since the Black Death. Other new and emerging infections that have caused epidemics include Legionnaire's disease, Lyme disease, newly identified hepatitis viruses spread in epidemic form through contaminated blood and blood products used in transfusion services, and several bacterial and viral diseases affecting the gastrointestinal tract.

An epidemic is a public health emergency requiring immediate investigation. The steps in investigating an epidemic are as follows:

1. Confirm the diagnosis.
2. Verify that the number of cases is outside normal expectations.
3. Define features in common among the cases (including inapparent cases).
4. Distinguish cases from members of the community who are not affected.
5. Compare the exposure history of the cases with a sample of noncases.
6. Conduct appropriate laboratory tests for pathogenic organisms.
7. Review environment and social conditions.

8. Arrange, classify, and analyze the data.
9. Plot graphs of time trends and the number of cases; create maps of the distribution of cases.
10. Report findings to the public health authorities for action to control the epidemic.

In the investigation it is important to consider the host (the affected individuals), the agent (the cause of the condition), and the environment. Physical, biological, social, behavioral, and cultural factors must also be considered. Investigating an epidemic can be as exciting as detective fiction, and such investigations (both real and fictional) have yielded many best-selling books and movies. The Epidemic Intelligence Service (EIS) of the U.S. Centers for Disease Control and Prevention has an illustrious record of successfully investigating and controlling epidemics, including some great public health importance. The first investigations of HIV/AIDS were done mainly by EIS staff and close collaborators in New York and Los Angeles.

Several kinds of epidemics can be distinguished. A *point-source epidemic* is one in which a group of people all fall ill as a result of a single exposure, typically to an agent in food they have all consumed. An example would be an outbreak of acute food poisoning due to staphylococcal enterotoxin. A *common-vehicle epidemic* is due to an agent that is spread on an ongoing basis in a "vehicle" such as food, water, or air. Food-borne common-vehicle epidemics usually cause gastrointestinal disease, and are sometimes perpetuated by a carrier who is a foodhandler. Waterborne epidemics include typhoid, giardia, viral hepatitis A, and many others. The best known airborne common vehicle epidemic is Legionnaire's disease. Notorious blood-borne common-vehicle epidemics have occurred since the 1980s in many countries after the blood supply became infected with HIV or Hepatitis C virus. *Vector-borne epidemics* are spread by insect vectors and include viruses such as dengue and viral encephalitis, which are transmitted by mosquitoes.

Control and prevention of an epidemic requires elimination of the source, or, if this is not feasible, precautions to prevent transmissions from the source to susceptible human hosts. The same

approach applies when the agent causing the epidemic is not an infectious pathogen but a chemical poison or an allergen; and it can even be applied, with suitable adjustments, to control of behavioral epidemics like mass hysteria and schoolyard vandalism.

Viewed from the perspective of evolutionary biology, epidemics will forever be a part of humankind's experience. The interaction of human hosts with infectious pathogenic organisms is ever-changing, in complex ecosystems that are also ever-changing, often as a result of human activity.

JOHN M. LAST

(SEE ALSO: *Adherence or Compliance Behavior; Black Death; Blood-Borne Diseases; Centers for Disease Control and Prevention; Classification of Disease; Common Vehicle Spread; Communicable Disease Control; Contagion; Emerging Infectious Diseases; Epidemic Intelligence Service; Epidemiologic Surveillance; Epidemic Theory: Herd Immunity; Epidemiology; Food-Borne Diseases; HIV/AIDS; Notifiable Diseases; Vector-Borne Diseases; Waterborne Diseases; and articles on specified diseases mentioned herein*)

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EPIDEMIOLOGIC SURVEILLANCE

Epidemiologic surveillance is the ongoing systematic collection, recording, analysis, interpretation, and dissemination of data reflecting the current health status of a community or population. The scope of epidemiologic surveillance has evolved from an initial focus on infectious disease monitoring and intervention to a more inclusive scope that includes chronic diseases, injuries, environmental exposures, and social factors that influence health status. Surveillance is based on both passive

and active data collection processes. When a clinician or laboratory encounters a patient or sample indicating the presence of certain conditions or pathogens, there is a legal obligation to report the case to local public health officials. The result is a passive monitoring of the levels of the disease in the community. As of 1998, there were fifty-two infectious diseases that were classified "notifiable" in the United States at the national level. Active surveillance, on the other hand, is commonly referred to as "case finding." This occurs when the data necessary to monitor levels of a medical or social condition is sought out actively. This is accomplished through a variety of means, ranging from clinical record reviews to community surveys.

Epidemics have traditionally been defined by the occurrence of more cases of disease than expected in a given area or among a specific group of people over a particular period of time. However, the definition of an epidemic has evolved as the scope of surveillance has evolved. Such issues as domestic or school violence, unemployment, and crime have, from time to time, fit the definition and have been described as epidemics. Issues like these are used, in conjunction with more medically oriented issues, to assess the health status of a community or population.

Epidemiologic surveillance uses a wide variety of data sources, depending upon the circumstance under investigation. For communicable diseases, local and state health departments typically rely on passive reporting. Other sources of data for epidemic surveillance include birth and death certificates; sentinel surveillance sites (i.e., the use of community-based health or occupational sites to monitor for specific health events); cancer, birth defects, and other registries; health interview surveys; and hospital or ambulatory care data collection systems.

Merely monitoring the current status of disease prevalence, health indicators, or social markers does not protect the health of a community. Careful monitoring, however, creates a baseline measurement of threats to the public's health. It is this established baseline that enables public health workers to notice when an anomaly occurs. A sharp increase in the number of cases of a disease will instigate further investigation, intervention, and prevention measures. Surveillance of an epidemic requires a very specific definition of what

constitutes a case that can be counted. The number of suspected cases, probable cases, and confirmed cases of a disease are actively sought and monitored. The number of cases, and the relationship between cases, is used during an outbreak investigation in an attempt to identify causes and those at risk, and to implement an intervention.

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THOMAS C. QUADE

(SEE ALSO: *Chronic Illness; Communicable Disease Control; Community Health; Epidemics; Epidemiology; Incidence and Prevalence; National Health Surveys; Notifiable Diseases; Registries; Surveillance; Surveys*)

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EPIDEMIOLOGIC TRANSITION

Epidemiology is the study of the distribution and determinants of health-related states or events. It has traditionally been associated with the study of external agents of disease (microbial infectious agents). Events such as the Black Death, which killed about one-third of the population of Europe during the Middle Ages, have left their trace in the collective unconscious and are still largely perceived as being caused by external environmental agents. Progress in medical science, however, has changed the perceptions of epidemiology as new patterns of illness and disease are confronted.

The first transition in epidemiology occurred over a period of about one hundred years during the nineteenth and twentieth centuries, when humankind progressively curbed the major epidemics of infectious diseases. Some, such as smallpox, were completely eradicated, while some, such as measles, diphtheria, and tetanus, have been significantly reduced. Even taking into account the

emergence, or reemergence, of diseases like AIDS (acquired immunodeficiency syndrome), Ebola fever, and malaria, infectious diseases, in many parts of the world, are not the immediate universal threat today that they once were.

The reduction of epidemics and infectious diseases has led to a considerable increase in life expectancy. As a result, there has been an increased appearance of manifestations linked to aging (the so-called degenerative, or chronic, diseases, e.g., some cancers, cerebrovascular disease, and certain mental disorders such as Alzheimer's disease). Major changes in behavior and lifestyles have also appeared, albeit more recently, including driving cars, changes in smoking and diet, and an increased pressure related to work or unemployment. These changes have led to new patterns of disease, distinguished by the growth of the "human-made" diseases such as lung cancer, coronary artery disease, and motor-vehicle injury. Many of these diseases, of course, are not new and have complex etiologies, but the shift from the prevalence of infectious diseases to the prevalence of chronic diseases defines this second transition that has occurred in every part of the developed world. In the developing world, this transition is rapidly emerging, putting these countries under a new burden while they are still suffering from the ongoing—and in some cases increasing—onslaught of the acute communicable diseases.

The next transition may be brought about by changes in how individuals relate to disease. Patterns of usage of health services, ranging from the limitation of services on economic grounds to the provision of technologically advanced services such as organ transplantation and in vitro fertilization, are continually shifting. At the same time, efforts made by individuals to manage the consequences of nonfatal impairments and disabilities are also likely to bring changes in the distribution and determinants of health-related states or events. Epidemiologic transitions are, in fact, an ongoing phenomena, with one phase overlapping another. These transitions will continue as the face of disease continues to change.

MICHEL C. THURIAUX

(SEE ALSO: *Aging of Population; Epidemiology; Historical Demography; History of Public Health; Life Expectancy and Life Tables*)

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EPIDEMIOLOGIST

Epidemiologists blend demography, statistics, and community health with biomedical science to study diseases and other health conditions in populations. Epidemiologists employed by federal, state, and local public health agencies support disease-prevention program planning and evaluation by determining risk factors, trends, and patterns of disease occurrence in different population groups. These public health investigators use epidemiological methods to explain disease outbreaks and study emerging conditions such as Legionnaire's disease and Ebola virus infection. Epidemiologists have expanded their role from investigating infectious epidemics to studying a range of health conditions, including chronic diseases, injuries, mental health, and health-service delivery.

ROBERT J. CAMPBELL

(SEE ALSO: *Communicable Disease Control; Community Health; Demography; Disease Prevention; Epidemiology; Noncommunicable Disease Control; Vital Statistics*)

EPIDEMIOLOGY

Epidemiology is the indispensable basic science of public health. It provides the logical framework for the facts that enable public health officials to identify important public health problems and to delineate their dimensions. Epidemiologic methods are used to define these health problems; to classify, identify, and elucidate their causes; and to plan and evaluate rational control measures.

HISTORICAL DEVELOPMENT OF EPIDEMIOLOGY

In ancient times, epidemics and plagues were terrifying natural phenomena that cried out for a

more rational explanation than that they were due to the wrath of god or the machinations of evil spirits. Hippocrates (c. 460-377 B.C.E.) described many kinds of epidemics and in *On Airs, Waters, Places* and other writings. He offered empirical insights into environmental and behavioral factors that might be associated with certain kinds of disease. Although doctors and others engaged in the healing arts did not clearly understand the concept of contagion until several hundred years later, Fracastorius (c. 1478-1553) identified several ways that infections can be transmitted—by direct contact, by what we now call droplet spread, and by contaminated clothing.

The science of epidemiology took root with empirical observations of epidemics and other causes of death. John Graunt (1620-1674), in London, compiled the first mortality tables on England's bills of mortality. Statistical analyses of deaths due to childbed fever by Ignaz Semmelweis (1818-1865) in Vienna in the early nineteenth century and of tuberculosis by Pierre Charles Alexandre Louis (1787-1872) in Paris demonstrated the power of numbers. In London, in 1848 and 1854, meticulous, logical examination of the facts and figures about cholera epidemics by John Snow (1813-1858) revealed the mode of communication of this deadly epidemic disease. Snow is regarded as the founder of modern epidemiology because of his use of such careful methods.

Until early in the twentieth century almost all epidemiology focused on communicable diseases, although Percivall Pott's (1714-1788) observations on cancer of the scrotum in chimney sweeps and James Lind's dietary experiment with fresh fruit to prevent scurvy (1753) were precursors of modern noncommunicable disease epidemiology and clinical trials, respectively. The use of epidemiology in studies of coronary heart disease and cancer in large-scale trials of many new preventive and therapeutic regimens, in nationwide surveys of health status, and in evaluation of health services came to the fore in the second half of the twentieth century. In the final quarter of the twentieth century, powerful computers, information technology, and more rigorous methodological approaches transformed epidemiology and made it a mandatory feature of clinical science as well as the most fundamental basic science of public health.

DEFINITION AND SCOPE

The word “epidemiology” was coined in the mid-nineteenth century to describe the scientific study of epidemics. Its meaning has expanded over the years, and present-day epidemiology encompasses the study of all varieties of illness and injury as they affect defined groups of people. In 1983 a committee representing the International Epidemiological Association defined epidemiology as “the study of the distribution and determinants of health-related states or events in specified populations, and the application of this study to control of health problems.” *Study* includes observation, surveillance, hypothesis-testing research projects, analysis of epidemiologic and other kinds of data, and certain other kinds of experiments. *Distribution* includes analysis of data according to the time scale over which events occur, the places where the events occur, and the categories of persons to whom they occur. *Determinants* are all the physical, biological, behavioral, social, and cultural factors that influence health. *Health-related states or events* include diseases, causes of death, behaviors such as the use of tobacco, reactions to preventive regimens, and provision and use of health services. *Specified populations* are those with identifiable characteristics such as known numbers and age groups. The ultimate aim and purpose of epidemiology—to promote, protect, and restore good health—is manifested in the “application of this study to control health problems.”

Epidemiologists attempt to identify, measure, count, and control diseases, injuries, and causes of untimely death; and to relate these events to the associated inherited, environmental, and behavioral factors that cause or contribute to them. One of the great intellectual challenges of epidemiology is to dissect these factors and unravel their connections in order to identify exactly what is ultimately responsible for a particular disease or health problem.

RELATIONSHIP TO OTHER SCIENCES AND TECHNOLOGIES

The information used by epidemiologists comes from a diverse array of sources; draws on a wide range of sciences and technologies; and calls on the expertise of technologists and other people

engaged in many kinds of crafts. Some connections are obvious—those with vital statistics, biostatistics, microbiology, immunology, and chemistry; with every clinical specialty from pediatrics to geriatrics and palliative care, and from family practice to hematology and neurosurgery. Other obvious connections are to the social and behavioral sciences, and, less obviously, to animal husbandry, wildlife biology, agricultural science, physics, atmospheric sciences, oceanography, engineering, town planning, education, law enforcement, communications technology, and the media. Epidemiology may be the most ecumenical of all the sciences. Probably no other branch of biomedical science has so many connections to such a wide range of other human activities.

RATES

The basis of all epidemiology is the comparison of groups of people. For these comparisons to be valid, it is necessary to convert raw numbers into rates. A rate is a fraction—the upper part (the numerator) is the number of people affected by the problem, event, or condition of interest; the lower part (the denominator) is the number of persons in the population who are at risk of experiencing the problem, event, or condition. Because the events normally continue over a long period, often indefinitely, rates are expressed in relation to a specified time. Since fractions are awkward to deal with, there is commonly a multiplier, and the rate, as shown in the following formula, is expressed in terms of so many per thousand, per hundred thousand, etc., in a specified time, usually a year, though shorter periods are used when circumstances warrant it:

$$\text{Rate} = \frac{\text{Number of events in specified period} \times 10^n \text{ (1000; 100,000; etc.)}}{\text{Number of persons at risk for the event during this period}}$$

In practice there are many variations in the ways rates are expressed, but the basic elements of events, population at risk, and time are common to all.

Rates have many uses. By comparing rates, epidemiologists can examine the experience of particular groups of people at specified times, in different cities, countries, or occupational groups.

The observed differences are the basis for inferences about the reasons for these differences, and are used to test hypotheses about these reasons, possibly about the putative cause of a particular kind of cancer, for instance. In addition to the absolute requirement, for validity, of basing all comparisons on rates, another important use is in calculating the risks to individuals and groups of experiencing an event such as a heart attack, the occurrence of cancer, or traffic injury. Comparisons are often rendered invalid, or relatively unreliable, by differences among the populations being compared—often because of failure to allow for various kinds of biases and confounding factors. A common problem stems from differences in the age composition of populations that are being compared. This problem is overcome by the procedure of age-adjustment. Another problem is that there may be important qualitative differences, such as health or employment status, between groups that are being compared.

The terms “incidence” and “prevalence” are often confused. Incidence refers to the number of new cases, events, or deaths, that occur in a specified time, usually one year. Prevalence refers to the total number of events or cases, both new and long-term, that are present at a particular point in time. Prevalence is therefore expressed as a number, not a rate, as there is no time dimension involved.

INVESTIGATING EPIDEMICS

An epidemic is the occurrence of a number of cases of a disease clearly in excess of normal expectation. This is usually a large number when the disease is one of the common infectious fevers, but even a single case of a dangerous contagious disease, such as typhoid, that has long been absent from a community should suffice to activate the highest level of epidemic surveillance and control measures. The occurrence of a small number of cases of a rare variety of cancer, closely clustered in time and space, may also signal an epidemic. Observational and analytic epidemiology blend in the investigation of epidemics. The investigation demands meticulous attention to detail in collecting information about all the cases of the condition, including mild and inconspicuous cases as well as those with florid manifestations, and must include details about all possible associated factors, such as

dietary intake (this is especially important in outbreaks of food poisoning), occupation, living conditions, and unusual recent experiences. Particular attention is paid to the index case—the first identified case of a condition. In most infectious disease epidemics, this could be the case that introduced the infection into the affected community. Information is also gathered about healthy people in the same community, aimed at discovering why they have not been affected. Laboratory tests are used to confirm the diagnosis, identify the pathogenic organism, toxic chemical, or other agent that caused the disease; and to measure immunological responses among both sick and healthy people. Analyzing all this information often clarifies the nature and cause of an epidemic and points the way to appropriate control measures.

Investigating epidemics can be tedious because it needs to be so painstaking, even, seemingly, a boring routine task. But often it is as exciting as detective fiction. For example, an epidemic of typhoid in Aberdeen, Scotland, was traced eventually to a contaminated can of processed beef from Argentina. The can had been cooled in a river adjacent to the canning works. As the pressure inside the can fell when it cooled, a partial vacuum was created and typhoid bacilli in raw sewage in the water were sucked into the can through a minute hole.

Identifying the existence of an epidemic sometimes requires unusual vigilance and an ability to make connections among seemingly isolated events. An epidemic of lethal pneumonia among members of the American Legion who attended a convention in Philadelphia in 1976 and then returned to their hometowns before becoming ill, would not have come to light without rigorous scrutiny on the part of epidemic intelligence service officers of the Centers for Disease Control. Subsequent investigations led to the identification of Legionnaire’s disease.

Techniques of molecular biology, notably DNA typing and the identification of biomarkers, have immensely enhanced the precision of epidemic investigation. It is now possible to trace the exact passage of an infectious agent such as the gonococcus or HIV (human immunodeficiency virus) as it is transmitted by direct contact from one individual to another among a group of people; or to show that coughing by a passenger with

open pulmonary tuberculosis on a crowded airline flight can cause primary tuberculous infection of other passengers in the same compartment of that flight; or to determine how certain cancer-causing agents actually induce cancer. Books and articles in the popular press, notably the accounts by the journalist Berton Roueché in the *New Yorker*, and on some TV programs have communicated the excitement and challenge of epidemic investigations.

EPIDEMIOLOGIC METHODS

The application of several analytic methods of epidemiologic study has contributed substantially to scientists' understanding of disease causation, and therefore to control and prevention of many conditions of great public health importance. The available methods are observational epidemiology (the empirical study of naturally occurring events), analytic study, and, under carefully defined conditions and with all due ethical safeguards, human experimentation.

Observational Epidemiology. This method begins with surveillance of populations, using vital and health statistics—including analysis of death rates arranged by age, sex, locality, and cause of death. Other information is derived from notified cases of infectious diseases of public health importance, from registries of cancer or other diseases, and from hospital discharge statistics. Since 1957, the National Center for Health Statistics has conducted continuously a National Health Survey that has carried observational epidemiology to new levels of comprehensiveness.

It is often possible to make imaginative use of many other kinds of available information about defined population groups. Schools and many employers keep records of absences due to sickness, sometimes with reasons for these absences. Police and other law enforcement agencies keep records of calls to settle domestic disputes and of damage due to vandalism, which are useful indicators of social pathologies associated with local variations in the frequency of domestic violence, alcohol abuse, and broken families. All such sources of information combine to make it possible for epidemiologists and public health specialists to produce a multidimensional "community diagnosis." Serial measurements can indicate whether

things are improving or getting worse, and in which ways these trends are moving for each of different indicators ranging from adolescent smoking behavior to reasons for long-term disability among the elderly.

Analytic Observational Studies. The possibilities of observational epidemiology are considerable, but not limitless. They are powerfully reinforced by analytic studies. The two main analytic methods are the case-control study and the cohort study.

Careful questioning of patients has enabled many doctors to make inferences about the influence of past experience on present disease. Percivall Pott, an eighteenth-century British physician, observed that cancer of the scrotum occurred among former chimney sweeps, and correctly inferred that it was associated with the accumulation of tar in the skin creases. Two hundred years later, in 1940, Norman Gregg, an ophthalmologist in Sydney, Australia, similarly inferred correctly that the cases he was seeing of congenital cataract must be associated with rubella (German measles), which their mothers had had during early pregnancy.

The case-control study is a systematic extension of routine medical history taking, in which the past histories of patients (the cases) suffering from the condition of interest are compared to the past histories of persons (the controls) who do not have the condition of interest, but who otherwise resemble the cases in such particulars as age and sex. Analysis of data about a series of cases and controls may show differences that are statistically significant. Sometimes only small numbers of cases are required to demonstrate significant differences between cases and controls. This makes the case-control study a suitable way to search for causes of rare conditions. For example, the discovery that a very rare form of liver cancer was strongly associated with occupational exposure to vinyl chloride required only four cases, and the fact that expectant mothers' use of artificial estrogens during early pregnancy can cause cancer of the vagina many years later in their daughters was based on a case-control study of eight cases. Although case-control studies can be flawed by the presence of biases that are often difficult or even impossible to eliminate, they are a valuable method of investigation because they can be done rapidly and at

relatively little expense. The findings can be confirmed or refuted by more rigorous research methods such as cohort studies.

A cohort study is conducted by identifying individuals in a defined population who are exposed to varying levels of known or suspected risk for the condition of interest, such as cancer of the lung or coronary heart disease. The population is observed over a certain period, and the death and disease incidence rates among those exposed to varying and known levels of risk are compared. Cohort studies require large numbers, commonly many thousands, and prolonged observation, commonly years or even decades. They are therefore expensive, requiring a large and dedicated staff and maintenance of detailed records of very large numbers of people, only a small proportion of whom will ultimately fall ill and die of the condition of interest. Some cohort studies have become famous. The people of Framingham, Massachusetts, have been the subjects of cohort studies of coronary heart disease since 1948. In 1951, Richard Doll and Austin Bradford Hill began a cohort study of lung cancer in relation to tobacco smoking in a cohort of about 40,000 male British doctors. Later phases of this study have expanded to include risk factors for coronary heart disease and other chronic conditions; and by the late 1990s this study had yielded dramatic evidence of the relationship of tobacco smoking to cancers of many kinds—and to coronary heart disease, chronic obstructive lung disease, and various other life-shortening chronic diseases.

It is possible to get results from a cohort study without waiting many years, if detailed information about exposure to risk factors at some time in the past is available in sufficient detail for a population of sufficient size. A method that permits reliable linking of past and present medical and other relevant records, such as a record linkage system, facilitates this approach. Record linkage is the process of relating information from two or more sets of records—compiled years apart and sometimes by different agencies—about the same individuals. A prerequisite is a way to identify individuals with a high degree of precision, such as a unique numbering system, or a system combining a sequence of digits for birthdate, birthplace, and sex; with alphabet letters or a phonetic code used for other details, such as the individual's mother's maiden name. Obviously the logistics of

all this make it a costly method, but the yield can justify the expense. This method, known as an historical cohort study, has demonstrated the relationship of childhood cancer and developmental anomalies to prenatal maternal exposure to small diagnostic doses of X-rays. Record linkage and historical cohort studies have also demonstrated a relationship between birthweight and the occurrence of cardiovascular disease in middle age.

Experimental Epidemiology. In the 1920s, experimental epidemiology meant observing the passage of infectious pathogens in colonies of rodents, but such experiments are rarely necessary, and the meaning of the term has changed. Experiments in which the investigator studies the effects of intentional alteration or intervention in the course of a disease are now done on humans rather than experimental animals, usually using a randomized controlled-trial design.

The randomized controlled trial (RCT) is a form of human experimentation in which the subjects, usually patients, are randomly allocated to receive either a standard accepted therapeutic or preventive regimen, or an experimental regimen. The purpose of random allocation is to eliminate or minimize bias in the selection of subjects. This greatly enhances the validity of the results. Preferably, the subjects and those observing the trial's results should be unaware of which subjects are receiving the experimental and control regimens, thus eliminating the power of suggestion as a factor influencing the response of individuals to the regimen. There are very important ethical constraints on the conduct of randomized controlled trials. The only ethically acceptable justification for conducting a randomized controlled trial is uncertainty about which of the available regimens is the best, a state of affairs known as "equipoise." It is absolutely essential to obtain the genuinely informed consent of all human subjects on whom a trial is conducted.

CLINICAL EPIDEMIOLOGY AND EVIDENCE-BASED MEDICINE

In the final quarter of the twentieth century, physicians in clinical practice discovered the value of epidemiologic methods in enhancing the efficacy of treatment regimens, mainly through rigorous attention to the nature and quality of the evidence

on which clinical decisions are based. Evidence-based medicine then moved into public health practice, where it is illuminating decisions about many aspects of public health practice, such as the most effective way to deploy public health nurses in a local health department.

OTHER RECENT ADVANCES

Epidemiology made spectacular progress in several other directions in the 1990s. One was in the application of molecular biology, resulting in what is sometimes called molecular epidemiology. Other advances have been made in genetic epidemiology, where the meeting of molecular genetics with public health, occupational and environmental health, and infant and child health has produced both exciting stories of great progress and difficult ethical and moral problems. What are scientists and physicians to do, for instance, with the new-found knowledge and technical capability to identify defective genes, especially genes that, in interaction with some environmental circumstances, can disqualify certain individuals from particular occupations and can render others ineligible for life insurance? Such dilemmas presage a testing time for society's values.

Another set of new challenges face epidemiologists who specialize in studies of risk management. The global environment is changing as the burden of greenhouse gases increases and leads to a rise in average global ambient temperatures, and remote sensing and climate models enable us to predict the likely future distribution of vector-borne diseases such as malaria, dengue, and schistosomiasis. A new realm of risk factor analysis is thus emerging, based on future health scenarios that incorporate climate models and—in the most sophisticated applications—include sets of models for future patterns of biodiversity, human settlements, and economic and industrial dynamics. In these ways epidemiologists are helping to plan the public health services that will be needed in the future.

JOHN M. LAST

(SEE ALSO: *Case-Control Study*, *Cohort Study*, *Cross-Sectional Study*; *Epidemiologic Transition*; *Graunt, John*; *Hippocrates of Cos*; *Mortality Rates*; *Notifiable Diseases*; *Pott, Percivall*; *Rates*; *Rates: Age-Adjusted*;

Record Linkage; *Semmelweis, Ignaz*; *Snow, John*; *Vital Statistics*; and other articles on specific diseases mentioned herein)

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EQUITY AND RESOURCE ALLOCATION

The work of the philosopher, John Rawls (b. 1921) on the theory of justice has provided the fundamental underpinnings for the concepts of equity and resource allocation for health. According to his moral viewpoint, inequalities of birth, natural endowment, and historical circumstances are undeserved. Rawls argues that all vital economic goods and services should be distributed equally, unless an unequal distribution would work to everyone's advantage, including the worst off.

Consistent with this view is the concept of equity, which means "fair shares" and "fair opportunities" in the distribution of and access to resources and services. Equity is different from equal shares or equal opportunities, however. Equity means that greater resources and more services should be made available to the most vulnerable and needy groups. In the context of health care, equity means care according to need. (A subtlety not to be missed is that the pursuit of equity in health care requires a capacity for identifying differential need, so that care can be supplied according to such needs.)

The fair opportunity rule says that properties distributed by the lottery of social and biological life are not grounds for morally acceptable discrimination between persons if they are not the sorts of properties that people have a fair chance to acquire or overcome. This argument provides a justification for a corrective redistribution of shares to many classes of disadvantaged persons, as well as a basis for numerous health policies.

THE RIGHT TO HEALTH CARE

The fair opportunity rule suggests that the justice of social institutions is gauged by their capacity to counteract lack of opportunity caused by unpredictable bad luck and misfortune over which a person has no meaningful control. When those misfortunes are expressed in terms of threats to health, the call for corrective action becomes the *right to health care*.

The most intractable problem has been how to specify the exact commitments of a right to health care. Two major contemporary views hold that there is a right to equal access to medical care and a right to a decent minimum of medical care. The “right to equal access” to health care takes on several meanings. One would be an equal right to certain goods and services. A more elaborate view of equal access requires that everyone should have equal access to any treatment that is available to anyone.

Given the considerable uncertainty carried by the call for equal access to health care, it may be easier to consider the less expansive expression of the right to health care, namely, the right to a decent minimum of health care. This suggests a government obligation to meet certain basic health needs of all citizens. This approach accepts a two-tiered system of health care: social coverage for basic and catastrophic health needs (tier 1), together with private coverage for other health needs and desires (tier 2).

On the first tier, distribution is based on needs, and needs are met by equal access to health services that are responsive to differential needs. This approach would generally be considered as primary health care, supported by secondary and tertiary services as determined by needs. Further services might be available for purchase at personal expense (tier 2), but everyone’s basic health

needs would be met at the first tier. This approach avoids the straight jacket of a one-tiered, equal access for all, health care delivery system.

Despite its attractions, this proposal of a decent minimum has proved difficult to explicate and implement. It raises problems of whether a society can fairly, consistently, and unambiguously structure a public policy that recognizes a right to care for primary needs without creating a right to exotic and expensive forms of treatment, such as liver transplants.

FORFEITURE OF THE RIGHT TO HEALTH CARE

Can an individual forfeit the right to health care, or at least to certain forms of health care, as a result of one’s personal neglect or misdeeds, such as personal lifestyles or individual actions? Examples would be patients who acquired AIDS as a result of risky sexual activities or intravenous drug use, patients with lung disease as a result of smoking, and patients with liver disease as a result of heavy consumption of alcohol. Does society have the same obligation to provide health care to these groups as it does to patients who are “victims” of the natural social and environmental lotteries?

A person may forfeit his or her right to liberty by criminal action that violates basic social responsibilities, and some argue that a person may forfeit his or her right to health care by failing to act responsibly. However, several principles set limits on policies of exclusion of individual risk takers from societal funds for health care. First, it must be possible to identify and differentiate various causal factors in morbidity—such as the natural lottery, the social environment, and personal activities—and to confirm that a pertinent disease or illness is the result of personal activities. Second, it must be possible to show that the personal activities in question were autonomous, in the sense that the actors were aware of the risks and voluntarily accepted them.

Regarding the first condition, it is virtually impossible to isolate causal factors for many of the most crucial examples of ill health because of the complexity of causal links and the limitations of knowledge. It would not be unfair to require individuals who engage in certain risky actions that

result in costly medical needs to pay higher premiums or taxes. Risk takers might be required to contribute more to particular pools, such as insurance schemes, or to pay a tax on their risky conduct, such as increased taxes on cigarettes. These requirements may fairly redistribute the burdens of the costs of health care, and they may deter risky conduct without unduly compromising the principle of respect for autonomy.

PRIORITIES IN THE ALLOCATION OF HEALTH CARE RESOURCES

Macro-allocation decisions determine how much should be expended and what kinds of goods will be made available in society, as well as how they are to be distributed. Such decisions determine: (1) what kinds of health care services will exist in a society, (2) who will get them and on what basis, (3) who will deliver them, (4) how the burdens of financing them will be distributed, and (5) how the power and control of those services will be distributed.

The most general question for a society committed to providing a decent minimum of health care to all citizens is how much of its budget should be allocated for health care and how much for other social goods, such as housing, education, culture, and recreation. Once a society has determined its budget for health care, it still has to allocate funds within health care. A vital question is whether priority should go to prevention or to critical care. It is reasonable for a society to turn to fair, democratic political procedures to make a choice among just alternatives. Given the great imprecision in the notion of adequate health care, however, it is especially important that the procedures used to define that level be—and be perceived to be—fair. Overall, in considering equity and resource allocation, it is fair to say that the field of ethics has brought considerable concern and helpful moral reasoning to the field of health care and related policies, including resource allocation.

JOHN H. BRYANT

(SEE ALSO: *Access to Health Services; Economics of Health; Ethics of Public Health; National Health Insurance; Right to Health*)

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ERADICATION OF DISEASE

A communicable disease is considered to be eradicated when all transmission has ceased and the causal agent has been exterminated. This may have happened naturally with some epidemic diseases that flourished in the past, such as the sweating disease epidemics that occurred in medieval Europe. Smallpox eradication was accomplished by 1980 through a carefully planned campaign conducted by the World Health Organization.

Eradication relies on a combination of surveillance and control—surveillance to identify the focal point of the infection, and control measures to treat active cases and remove the risk of transmission. Control measures will vary according to the causal agent and its mode of transmission. With smallpox, the effective strategy was containment—every diagnosed case of smallpox was isolated and all known contacts of every case received the smallpox vaccine. This created a situation in which the virus was not able to migrate to a susceptible host, and since the smallpox virus lives only in humans, all natural transmission was blocked. The disease was eliminated from one region after another, and eventually eradicated worldwide—one of the greatest triumphs ever for preventive medicine.

In countries and regions where vaccination against measles and poliomyelitis are virtually universal, national or regional eradication of these diseases is feasible; this is described as *elimination*, rather than eradication, because the possibility always exists for reintroduction of the causal agent from parts of the world where the disease still occurs.

JOHN M. LAST

(SEE ALSO: *Disease Prevention; Immunizations; Measles; Poliomyelitis; Smallpox*)

ERGONOMICS

Ergonomics is the science of fitting the demands of work to the physical capacities of the worker. Its inception during World War II by the U.S. military was in response to the realization that disparities in work demands and physical capacities can result in serious injury and death.

Ergonomic injuries have become the most common cause of workplace illness and injury in the United States. Back injuries and cumulative trauma disorders (CTDs) such as carpal tunnel syndrome, tendinitis, bursitis, and epicondylitis account for the overwhelming majority of nonfatal occupational injuries and illnesses, costing employers more than \$12 billion per year in lost work time, workers' compensation payments, and medical expenses.

CTDs have increased dramatically since 1980, comprising roughly 18 percent of occupational illnesses in 1980 versus 65 percent in the late 1990s. Australia, Japan, and other countries experienced dramatic increases in ergonomics problems during the last two decades of the twentieth century. Over 332,000 cases of work-related CTDs were reported in the United States in 1994. Back injuries make up roughly 27 percent of the nonfatal occupational injuries annually, and the back is the part of the body most commonly injured during work. In November 2000, the U.S. Occupational Safety and Health Administration issued an Ergonomics Program Standard to help control ergonomics risks at work.

OCCUPATIONAL RISK FACTORS FOR ERGONOMIC DISORDERS

Occupational risk factors for ergonomic injuries include high force, high repetition, awkward postures, direct trauma or contact stress from hard or sharp surfaces, prolonged exposure to cold ambient temperatures, and exposure to whole body or segmental vibration. For cumulative trauma disorders, these risk factors may be present during hand-tool use, in manufacturing assembly or packaging jobs, or while working at computer workstations. High rates of CTDs are found in manufacturing, construction, and office trades. Back injuries are most prevalent among workers

involved in manual materials handling, including truck drivers, nurses and nurses aides, forklift operators, and construction workers. High rates of back injuries are also found among workers in sedentary jobs, typically associated with postural stress.

While back injuries are administratively often handled as injuries (suggesting a single traumatic exposure) experts recognize that most back injuries and CTDs develop gradually over time from a combination of wear and tear on the nervous, vascular, and connective tissues of the body. Based upon this, corporations and experts focus their prevention strategies on reducing cumulative exposures to the risk factors described above.

STRATEGIES FOR PREVENTION

Redesigning tools or workstations to reduce the risk factors is considered to be the best approach for preventing back injuries and CTDs. Making workstations adjustable to fit the range of body sizes of workers and providing specific training in risk avoidance goals and adjustment procedures are central to prevention. For example, computer workstations that can be adjusted to optimize the height and angle of the monitor, keyboard, and chair help to reduce ergonomic risks to the extremities and back, but are effective only if employees know how to adjust them. Other steps to manage ergonomic risks include providing a system for managers and employees to work jointly toward identifying and resolving problems, employee and supervisor training on risk factors and symptoms, job hazard analysis of ergonomic risks, and proper medical surveillance and management.

RICHARD M. LYNCH

(SEE ALSO: *Carpal Tunnel Syndrome, Cumulative Trauma; Ergonomics; Occupational Safety and Health; Occupational Safety and Health Administration*)

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ESSENTIAL PUBLIC HEALTH SERVICES

In its 1988 book, *The Future of Public Health*, the Institute of Medicine proposed three “core functions” of public health: assessment, policy development, and assurance. During the five years following the release of the publication, these core functions became a de facto framework delineating the practice of public health, particularly at the state and local levels.

Stimulated in part by the potential to include public health in the then active discussions about national health care reform, and by the clear need to develop a more descriptive framework describing public health, the U.S. Public Health Service (PHS) convened a national workgroup in 1993. This group, the Public Health Functions Steering Committee, was chaired by the Surgeon General and included representatives from most PHS agencies and from a number of national public health organizations.

In the fall of 1994, the committee produced *Public Health in America*, a document that described a vision, a mission statement, a list of public health goals, and a list of ten public health services needed to carry out basic public health responsibilities. The ten services have subsequently been called the “Ten Essential Public Health Services.” It was the committee’s specific intent that these essential services represent the full range of responsibility in public health across federal, state, and local levels.

The ten essential services are:

1. Monitor health status to identify community health problems.
2. Diagnose and investigate health problems and health hazards in the community.
3. Inform, educate, and empower people about health issues.
4. Mobilize community partnerships to identify and solve health problems.
5. Develop policies and plans that support individual and community health efforts.
6. Enforce laws and regulations that protect health and ensure safety.
7. Link people to needed personal health services and assure the provision of health care when otherwise unavailable.

8. Assure a competent public health and personal health care workforce.
9. Evaluate effectiveness, accessibility, and quality of personal and population-based health services.
10. Research for new insights and innovative solutions to health problems.

By the year 2000, the ten essential services were widely recognized, although they had not displaced core functions in many states and locales. They were used as the basis for measuring performance by local and state health departments. The performance measurement tools come from the National Public Health Performance Standards Program, a voluntary program developed under the aegis of the Centers for Disease Control and Prevention and a number of national partners. The essential services are used in studies of national public health expenditures, and in the design of Mobilization for Action through Planning and Partnership (MAPP), a community assessment and planning tool used by the National Association of County and City Health Officials (NACCHO). Efforts began in the late 1990s to achieve wider consensus at state and local levels regarding their use as the principal framework for public health.

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(SEE ALSO: *Centers for Disease Control and Prevention; Director of Health; Evaluation of Public Health Programs; Mobilization for Action through Planning and Partnerships*)

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ETHICS OF PUBLIC HEALTH

Since antiquity, people have sought to establish ways of living together and minimizing conflict among themselves in order that they might prosper. From this most practical undertaking, a vigorous debate has arisen about what is “right” and what is “wrong.” Indeed, much of the history of humankind is the history of the tensions that have arisen among groups differing in their cultural values, their morality, and their ethics.

Values express what people believe to be valuable about the way they live, both as individuals, and as members of a community. Consequently, values serve as the basis for morality. Morality follows valuing in that it translates personal beliefs into societal norms of conduct. For instance, consider the issue of abortion. It is fair to say that most people value human life. It is also fair to say that most people, certainly in the developed world, value autonomy—the right of individuals to make personal decisions about their own well-being. The central tension in the abortion debate is the disagreement between the pro-life and pro-choice sides as to which of these two values is more important. Each side holds a different moral position because they have made different judgments about the relative value of “respect for autonomy” on the one hand, and “right to life” on the other hand.

Ethics is the branch of philosophy that deals with morality and the distinctions between right and wrong. Ethics makes a study of the tensions that arise among people’s values, and it attempts, through applied logic, to set out rules of conduct for each particular class of human action. Because it has its basis in logic rather than in, say, religion, ethics is usually considered more objective than morality. Both ethics and morality, however, attempt to tell people what they *ought* to do.

Law, like ethics, has its basis in morality, but differs in that it does not merely tell people what they *ought* to do, but rather what they are *allowed* to do, usually under threat of penalty. Laws generally reflect the values and morals of society, but they

are not synonymous with values and morals. Abortion may be legal, but many people find it immoral because they believe that human life is more important than personal autonomy. Physician-assisted suicide may be illegal, but many people believe that it is ethical because, in addition to preserving life, medicine also has an obligation to relieve suffering, preserve dignity, and allow people to have autonomy over their own life and death.

When parents raise children, they instill a sense of what is socially acceptable, making distinctions between what is “right” and what is “wrong.” However, the individual’s responses become instinctual, and there is rarely any basis for arguing in a rational way one’s personal view of what is right or wrong. Because humans need to provide a rational basis for their decisions, the subject of “ethics” is one that is gaining more attention in training programs for children, adults, and professionals. In public health, every decision concerning research and every action taken has ethical implications.

PUBLIC HEALTH ETHICS

Like ethics, public health has been a concern of human societies since antiquity. Plagues of contagious diseases have decimated populations since civilization began, and their significance has always been recognized. Because of the life-and-death importance of disease and the skill and training required to treat it, societies have always recognized the importance of physicians and have accorded them substantial jurisdiction over life and death. With this jurisdiction comes much power and, more importantly, much responsibility. This power and responsibility resulted in the first code of professional ethics, the Hippocratic Oath, which set out rules of conduct for physicians in their dealings with patients. Medical ethics, however, has evolved far beyond its roots and encompasses not only doctor-patient ethics, but also biomedical research ethics, the more socially based health ethics, and public health ethics.

Public health must balance the public good with the good of individuals. This perspective sometimes leads to conflict. For example, one of the most respected ethical traditions is doctor-patient confidentiality. However, in the case of a public health threat, such as a communicable disease, a tension naturally arises between the ethical

responsibility to maintain confidentiality and the responsibility to protect the public health.

ETHICAL THEORY

Human interactions have the potential to result in ethical tensions. These tensions reflect a particular, unique context. In each context, opposing sides differ in that they subscribe to a particular set of values. Each side may be equally committed to, and able to defend, its moral judgment. How, then, are ethical tensions to be resolved when each situation is unique? The great volume of academic study in ethics over thousands of years has produced numerous approaches to ethical analysis. Fortunately, however, ethics has been studied well enough that some common threads have been recognized.

The dominant approach in public health has been to apply the utilitarian theory of ethics to resolving issues relating to public health. This theory focuses on achieving the greatest good for the greatest number of people and, thus, tends to focus on protecting the population rather than the rights of individuals (e.g., laws requiring the reporting of communicable diseases and the mandating of vaccination programs). Causing more good than harm is what drives public health decision making. However, in addition to this approach, other approaches are now commonly used. For example, duty-based ethical theory (deontology) and the four principles of bioethics as articulated by Tom L. Beauchamp and James R. Childress (1994) are helpful for both illustrating ethical tensions and serving as a basis for decision making. The four principles are:

1. Respect for autonomy. This is the principle of allowing people to make decisions about themselves for themselves. It is about respecting human dignity, believing in a person's ability to make good decisions, and is the opposite of paternalism.
2. Nonmaleficence. This means that actions should not harm others. It is derived from the Hippocratic injunction to "first, do no harm."
3. Beneficence. This is the mirror image of nonmaleficence, meaning that actions are taken in order to maximize benefits to

individuals and society. It is the principle of doing good.

4. Justice. This refers to distributive justice and is the principle requiring that benefits and harms should be equally distributed among people. Related ideas are fairness, equity, and impartiality.

These principles provide a useful framework for informing actions, interventions, policies, and research in public health and its related disciplines. By themselves, however, they do not usually provide clear answers to ethical dilemmas. Instead, they are used as a framework for understanding the problem at hand. For example, should physicians be required to inform patients and gain their consent to test for HIV (human immunodeficiency virus) antibody status in a hospital? On the one hand, patients who suspect that they might be HIV-positive may refuse to allow themselves to be tested, potentially aggravating an already disastrous public health problem and perhaps exposing hospital personnel to HIV. In this case, the principle of beneficence would seem to obligate the state to insist on HIV testing regardless of patient consent. On the other hand, the principle of respect for autonomy would dictate that patients have a right to make their own decisions. Thus, there is a tension between the principles of beneficence and respect for autonomy. This is not unusual in the principle-based approach.

Tensions are resolved by taking the overall context of the issue of concern into consideration. Above all, an ethical analysis is not conducted against a checklist. Rather, it is a thoughtful appraisal of all related concerns, paying due cognizance to the broader social context that gave rise to the tension in the first place. A major contextual distinction is made between public health research and public health practice. For example, in research, studies of the broader determinants of health, such as socioeconomic factors, are of benefit. However, while the linking of income tax records with health records could provide a rich source of data, such research is prohibited. On the practical side, in communicable disease investigations, the utilitarian approach dominates. In sum, for research, individual privacy takes precedence over utility; in public health practice, utility takes precedence in that beneficence dominates over privacy.

More often than not, the four principles illustrate the tensions that exist and the issues that are involved rather than providing easy solutions to complex ethical questions. This is as it should be. Human interactions are complex and dynamic, requiring equally complex judgments in order to succeed. People are not machines whose actions are prescribed by a rigid set of rules. Learning how to do ethical analysis can be helpful in making an ethical decision.

A complementary approach to principle-based bioethics is the case-study approach, also called casuistry. In this approach, typical cases of ethical dilemmas and their results are recorded in an attempt to provide precedents to guide future decision making. It is analogous to the way that most modern democracies structure their legal systems. By analogy, one might think of written legislation as similar to the principle-based bioethics approach. As everyone knows, however, the law as it is written cannot address every individual situation. To resolve individual cases, there are courts that interpret legislation and set precedents through their judgments. This body of precedents forms the case law and assists judges in deciding future cases. Similarly, in bioethics, the principles of respect for autonomy, beneficence, nonmaleficence, and distributive justice are complemented by a body of case studies that help professionals understand how the principle-based approach can be applied. The American Public Health Association published a collection of case studies in *Case Studies in Public Health Ethics* (1997), in an attempt to document normative ethical practices.

THE ROLE OF ETHICS GUIDELINES AND PROFESSIONAL SELF-REGULATION

Although there is much agreement on the basic principles of ethical public health research and practice, further specification of the principles is required to help deal with real-world dilemmas. Therefore, codes of conduct or guidelines to ethical behavior are established among groups of professionals. The first such code in public health was the penal code for physicians of 1520 compiled by the Royal College of Physicians of London. The recommendations of the World Medical Association Declaration of Helsinki (1975) are used worldwide as a guide for the treatment of human subjects in biomedical research. An example of

guidelines with a practical focus is the 1991 Ethical Guidelines for Epidemiologists. These guidelines have been organized as a set of obligations or duties and are reflective of the ethics of public health research. They are:

1. Obligations to the subjects of research:
 - a. to protect their welfare
 - b. to obtain their informed consent
 - c. to protect their privacy
 - d. to maintain confidential information
2. Obligations to society:
 - a. to avoid conflicts of interests
 - b. to avoid partiality
 - c. to widen the scope of epidemiology
 - d. to pursue responsibilities with due diligence
 - e. to maintain public confidence
3. Obligations to funders and employers:
 - a. to specify obligations
 - b. to protect privileged information
4. Obligations to colleagues:
 - a. to report methods and results
 - b. to confront unacceptable behavior and conditions
 - c. to communicate ethical requirements

Colin L. Soskolne, in a 1989 article in the *American Journal of Epidemiology*, made an analogy to the legal system, comparing legislative control over public behavior to self-regulation among the professions. In this analogy, legal enforcement by the police and courts is analogous to the professional practices of peer review, subscribing to ethics guidelines, and awarding and removing the license to practice by professional associations.

Medically qualified public health practitioners, such as nurses and physicians, generally have their own professional associations that guide granting (or removing) the license to practice, based on codes of conduct. Public health scientists, researchers, and advocates, on the other hand, are not usually licensed, but abide by the voluntary ethics guidelines promulgated by their respective professional societies (e.g., the American College of

Epidemiology). The intention of these voluntary guidelines is to enable an individual's judgments to be informed by the shared values and experiences of his or her colleagues. Thus, they provide guidance rather than regulation.

It should not be inferred from this lack of licensure that unethical practice is rampant. Rather, like science in general, public health science is governed by peer review and peer pressure. Unethical conduct, when it is discovered, can be met with a denial of public funding, the inability to participate in the scientific community through the publication of research, and collegial sanction.

MAJOR ETHICAL TENSIONS IN PUBLIC HEALTH

Because social values and technological advances change over time, new ethical challenges emerge whenever new technologies or circumstances arise with consequences for public health. The following are some of the major issues confronting public health ethics at the start of the twenty-first century.

Individual and Community Rights. Perhaps the clearest example of an ethical tension in public health is the balancing of individual and community rights when a person is discovered to have a communicable disease. A necessary part of the control of communicable disease is the control of individual behavior. Indeed, some of the strongest legislation in the Western world is public health legislation that permits the state to constrain and even to incarcerate a person indefinitely for being sick. Typical public health legislation is the Illinois Department of Public Health Act (20ILCS523051), which states that the department has "supreme authority in matters of quarantine" and "may order a person to be quarantined . . . until such time as the condition can be corrected" (Section 2A). Analogous legislation exists in Canada. This represents one extreme of protecting the populace by restricting individual freedoms. To put this in context, however, that strategy has been employed seldom in the history of the United States. One famous case was that of Typhoid Mary (Mary Mellon), who was quarantined for life after infecting dozens, if not hundreds, of people in the New York area with typhoid fever in the early 1900s. There have also been a few cases in which a person

who was HIV-positive knowingly had unprotected intercourse and quarantine laws were applied.

The identification, reporting, and sometimes isolation of victims of communicable disease are generally accepted practices. Historically, when diseases such as leprosy, typhoid, plague, cholera, smallpox, or polio menaced populations, draconian control measures were deemed mandatory. In the past, lepers were routinely isolated in leper colonies, typhoid carriers were banned from certain occupations, and French towns known to have cholera victims were blockaded—and such actions in the past are not viewed today as having been unreasonable. The alternative would have been doing nothing to stop the continued spread of the disease and the decimation of populations. That is not to say that such treatment would be considered ethical in the twenty-first century, because there are professionals who can treat these conditions and there is widespread education to prevent panic about the unknown.

The HIV/AIDS (human immunodeficiency virus/acquired immunodeficiency syndrome) pandemic presents an example of a modern plague and the response of the modern world to an incurable, widespread communicable disease. When HIV/AIDS was first discovered in homosexual men, one element of society sought to label them as deviants deserving of their condition. It was suggested that those infected with HIV be quarantined. This reaction sometimes resembled the witch-hunts of the Middle Ages, with victims driven from their jobs and children rejected by schools. Indeed, Cuba adopted this as policy at the outset. Fortunately, however, in most other countries, advances in knowledge of how the virus is and is not transmitted, coupled with widespread education and advocacy in Western countries, have reduced the negative reaction to sufferers of HIV/AIDS and helped in curbing the spread of the epidemic. In fact, the impact of that initial public reaction has had the effect of strengthening individual rights.

In Western countries, a test for HIV requires the prior informed consent of the patient. The privacy of HIV-positive patients and the confidentiality of their records is respected and counseling is given to patients, their families, and their sexual contacts. Also, because the risk of occupational

HIV-transmission is relatively low, health care workers are not permitted to discriminate against HIV-positive patients. Surveillance activities are usually carried out using anonymous, unlinked data in order to minimize the possibility of a person's HIV status being made public. Overall, the treatment of people with communicable diseases has become the benchmark for ethical practice within the public health community.

The new millennium brought with it the sequencing of the human genome. Genetic testing has consequences not only for the individual tested, but also for his or her family. Consequences include issues of confidentiality, insurability, employability, stigmatization, and the loss of hope that arises from the knowledge that some increased but uncertain risk exists for future illness or early death. Test results have implications for both living and unborn children, as well as relatives owing to a sense that a poor health outcome is genetically predetermined. These concerns are especially troubling because genetic testing is a new technology that has not yet been fully evaluated for clinical predictiveness. Genetic tests have great benefit in family planning where a family history of genetic defects is established.

Weighing Benefits, Harms, Risks, and Costs.

All public health interventions require a balancing of benefits versus harms and costs. Vaccination campaigns always have an associated risk of harm because of adverse reactions to the vaccine. This potential for harm is known, but is usually very small in comparison to the benefit to the population. The clear ethical duty of public health officials who conduct vaccination campaigns is to inform each person (or his or her guardian in the case of children) of the risks and benefits of the vaccination. It is questionable whether this can be called informed consent in some cases, because vaccinations are often mandatory by law. Those experiencing adverse reactions deserve compensation.

Another example of weighing benefits and costs comes from environmental health. It is well known that pollution from automobiles and industry can cause potentially life-threatening air-quality conditions. However, the population of adversely effected persons is relatively small in comparison to the cost of, say, banning internal combustion

engines. Therefore, some chemical and air pollution are allowed to continue.

In the modern era of trade liberalization, it may become even more difficult to control environmental health hazards. In the mid-1990s, California moved to ban a gasoline additive called methyl tertiary butyl ether (MTBE), a possible human carcinogen and environmental toxin, because it is very water soluble and could severely contaminate groundwater supplies. The cost of a future clean-up of such a contamination would be enormous. However, under the North American Free Trade Agreement (NAFTA), a government that limits a company's ability to sell a product can be held liable for the corporation's lost profits. Methanex, the corporation that makes MTBE, is suing the State of California under these NAFTA regulations. At the time of this writing, the case has not yet been resolved. However, in 1998, Ethyl Corporation successfully challenged the Canadian government under NAFTA following a similar Canadian ban on another gasoline additive. It will be interesting to see how efforts by states to protect public health will fare under the growing trend toward trade liberalization and corporate rights. It would seem that the principles of distributive justice, beneficence, and nonmaleficence would all favor allowing states to protect citizens against the harmful effects of pollution, even at the expense of corporate profits.

Conflicting Interests: A Special Problem in Occupational Health. Many public health workers are employed by governments, and many public health researchers are engaged by academic institutions. The ability of such public health practitioners to remain impartial and free of conflicting interests is relatively secure. However, occupational health specialists employed or contracted by corporations sometimes find themselves in a more tenuous position. While their primary goal is to safeguard the health of workers, their pay and continued employment are dependent on the company they work for. External pressure can come from government regulatory agencies and the media. There are several cases of occupational epidemiologists who were ordered by their company to withhold information that might have been beneficial to workers. Sometimes a company may even take punitive legal measures with the intention of effectively gagging a whistleblower.

In recognition of the sometimes difficult position of industrial health workers, the International Commission on Occupational Health (ICOH) compiled, in 1991, the International Code of Ethics for Occupational Health Professionals, intended to give them professional recourse in a situation involving conflicting interests. This code emphasizes the primary obligation of the occupational health worker to protect workers' health and safety, and encourages them to request that an ethics clause be written into their contracts of employment to help ensure professional independence.

Privacy, Confidentiality, and Informed Consent. Privacy of health data, and other sorts of data, is a major social concern. In the past, medical records were kept in paper files. The security of medical records has probably never been particularly good, but at least it would be difficult for large amounts of information to be pilfered from paper files. Today, the records of millions of people can be kept in a single computer file that is easily transmittable by electronic mail. Thus, the potential for commercial abuse of these records, especially in the upcoming era of genetic testing, is of concern.

In response to these concerns, governments around the world are implementing policies to protect people's personal data. While these policies are generally welcome and necessary, they sometimes endanger potentially valuable public health research. A 1995 Directive of the European Parliament and the Council of Europe nearly made it impossible to conduct public health research involving the linkage of records from different data systems based on personal identifiers. Fortunately, the epidemiology community was able to intervene by requesting an exemption for legitimate public health research. Events such as this make it clear that while personal privacy is important, the good of the community sometimes requires that individuals make reasonable concessions on their privacy. By the same token, researchers must respect the confidentiality of research records.

Maintaining privacy and confidentiality is integral to informed consent. All informed consent in public health must include a statement about the intended uses of the data collected. In Canada, Supreme Court decisions have caused the previous "professional disclosure" standard to evolve

into a "full disclosure" standard. Rather than the physician being the arbiter of what the patient needs to know, it is now required that physicians and researchers disclose all potential harms of treatment or research to patients. It follows that public health professionals should avoid any possibility of doing harm to individuals and vigorously protect their personal data.

Impartiality, Advocacy, and Research Integrity. Another debate that sometimes rages in the public health community, especially in epidemiology, is the potential conflict between being an impartial scientist and a public health advocate. Sometimes, a researcher may have very strong feelings about a particular issue and, in the interest of protecting the public health, may make recommendations that are not scientifically objective. On the other hand, the purpose of public health is to protect, and epidemiologists have an ethical duty to act on their findings.

The Toronto Resolution (1991), a "code of ethics in science and scholarship," says that all scientific and scholarly codes of ethics should articulate some concern for social issues beyond their own subspecialty areas. For example, ethical codes should require adherents to oppose prejudice, anticipate the consequences of their research, protect ecosystems, and promote universal disarmament. Indeed, these are laudable goals and they highlight the advocacy role of researchers.

Most public health researchers would choose the middle road between scientific impartiality and vigorous advocacy, recognizing that both serve the needs of public health. Scientific impartiality, mixed with respect for the welfare and the rights of research subjects, should take precedence until a reasonable body of supportive scientific information is established. After that, the researcher may take on the role of passionate advocate with good scientific justification.

Public Health and the State: Beneficence or Paternalism? The formation and enforcement of public health policy is a government function. Many public health interventions, such as water fluoridation and mass vaccination programs certainly have benefits, but respect for autonomy may be undermined. When the state does something to protect people, some may hold different values and feel that the state is acting paternalistically toward them.

Health promotion and health education provide people with knowledge and control over their own health, rather than their being passive recipients of medical care. Possible negative consequences of health promotion and education campaigns include the alienation of people holding different values, an increase in the health gap between socioeconomic groups, and the stigmatization of people who engage in perceived antisocial behaviors (e.g., tobacco use). Each person in society pays for the government's advertising campaigns and health education programs through his or her taxes, regardless of whether he or she supports the campaigns.

An increasingly important public health issue is population control and the type of policies implemented to slow population growth. Family planning programs in China, and to a lesser degree in India and Singapore, have included such measures as forced sterilization, abortion, and tax penalties. Most Westerners would consider such methods abhorrent. In contrast, Western countries use resource allocation as the approach to control population growth. Resource allocation is used as a policy strategy to create, usually financially or legally, incentives or disincentives for achieving social goals. In Western countries, autonomy is respected in that people are allowed to make their own decisions about family size. However, because funds for family planning clinics and abortion centers are often collected through taxation, even those people against such practices contribute to their operation.

CONCLUSION

Public health aims to do good for as many people as possible and has largely succeeded in that goal. Most of the plagues of the past have been eliminated in the developed world. When contagious diseases were the main killers, the tension between individual and community rights was fairly easily resolved. In the twenty-first century, however, injuries, heart disease, cancer, and stroke are the main health threats in the developed world. These require a different public health response—one in which there will be many conflicts between individual autonomy and the right of the community to prohibit potentially dangerous behaviors.

Public health is entering a new age of challenges. What should be done about increasing

population growth? How can society deal with the ethical conflicts of euthanasia and abortion? How do technological advances arising from the sequencing of the human genome impact on individual rights? How strongly can governments forbid behaviors like smoking, riding motorcycles, or even bicycles, without a helmet; or eating fatty foods? How much emphasis should be put on economic growth versus environmental degradation? How can the disparities between rich and poor be reduced? These are all difficult ethical questions because they strike at the heart of passionately held values, beliefs, and ideals. All public health research, practice, resource allocation, and the like should be based on ethical decision making. To help address these challenges, educating people about the approaches to ethical analysis should be a priority.

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(SEE ALSO: *Autonomy; Beneficence; Benefit-Cost Analysis; Benefits, Ethics, and Risks; Codes of Conduct and Ethics Guidelines; Confidentiality; Conflicts of Interest; Genetics and Health; Hippocrates of Cos; HIV/AIDS; Human Genome Project; Informed Consent; Mass Medication; Nonmaleficence; Paternalism; Politics of Public Health; Privacy; Quarantine; Typhoid Mary*)

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ETHNICITY AND HEALTH

The issue of cultural sensitivity is central to ethnicity and health, and to developing health-promotion and disease-prevention programs for different racial and ethnic populations. This article provides definitions and a conceptual framework for understanding cultural sensitivity and the rationale for tailoring health-promotion programs for different cultural groups. Most of the examples provided relate to African Americans and Hispanic/Latino populations. Nonetheless, the principles discussed are applicable to other racial, ethnic, and sociodemographic subpopulations.

CULTURAL SENSITIVITY

Cultural sensitivity goes by many names, including cultural competence, culturally appropriate, culturally consistent, multicultural, cultural diversity, cultural pluralism, cultural tailoring, and cultural targeting. Although definitions and distinctions for these terms have been offered, the terminology has no accepted standards. In response to this need, the following definitions are proposed:

Cultural Sensitivity. The extent to which ethnic and cultural characteristics, experiences, norms, values, behavioral patterns, and beliefs of a target population, as well as relevant historical, political, environmental, and social forces, are incorporated in the design, delivery, and evaluation of targeted health-promotion materials and programs.

Cultural Competence. The capacity of individuals to exercise interpersonal cultural sensitivity. "Culturally competent" refers to practitioners, whereas "culturally sensitive" relates more to intervention programs, materials, and messages.

Multicultural. Incorporating and appreciating perspectives of multiple racial and ethnic groups

without assumptions of superiority or inferiority. In this sense, culturally competent individuals and culturally sensitive interventions are implicitly multicultural. Cultural pluralism is a synonym.

Cultural Tailoring. The process of creating culturally sensitive interventions; often involving the adaptation of existing programs, materials, and messages to racial/ethnic subpopulations.

Culture-Based. This term refers to programs and messages that use culture, ethnicity, history, and core values to motivate behavior change.

Ethnic Identity (EI). Ethnic identity involves the extent to which individuals identify with and gravitate to their own racial or ethnic group. Ethnic identity includes elements such as racial and ethnic pride, affinity for group culture (e.g., food, media, and language), attitudes toward majority culture, involvement with group members, experience with and attitudes regarding racism, attitudes toward intermarriage, and the importance placed upon preserving one's culture and aiding others of like background. For immigrant groups, ethnic identity includes aspects of acculturation (i.e., adoption of values and practices of the host country).

Cultural sensitivity can be conceptualized in terms of two primary dimensions: "surface structure" and "deep structure." Surface structure involves matching intervention materials and messages to characteristics of a target population. For audiovisual materials, this may involve using people, places, language, music, and foods familiar to, and preferred by, the target audience. Surface structure includes identifying the channels (e.g., media) and settings (e.g., churches, schools) that are most appropriate for delivery of messages and programs. It also entails understanding characteristics of the behavior in question. Surface structure refers to the extent to which interventions correspond to the needs of the target population and to how well interventions fit within the culture, experience, and behavioral patterns of the population.

The second dimension of cultural sensitivity, deep structure, reflects how cultural, social, psychologic, environmental, and historical factors influence health behaviors in different populations. This includes understanding how members of the target population perceive the cause, course, and treatment of illnesses; as well as perceptions regarding the determinants of specific health

behaviors. Specifically, this involves appreciation for how religion, family, society, economics, and the government—both in perception and in fact—influence the target behavior. Among many African Americans, for example, there is a belief that the U.S. government may be covertly encouraging the spread of HIV/AIDS (human immunodeficiency virus/acquired immunodeficiency syndrome), guns, and drugs in their communities. Some Hispanics feel that certain illnesses are a punishment from God or the result of the "evil eye." Messages that incorporate, though not necessarily accept or refute these beliefs, will likely enhance program acceptance and effectiveness.

Core cultural values for African Americans include: communalism, religion and spiritualism, expressiveness, respect for verbal communication skills, connections to ancestors and history, commitment to family, and intuition and experience rather than empiricism. African-American culture is also characterized by a unique sense of time, rhythm, and communication style. The use of oral communication (i.e., interpersonal vs. print interventions), as well as stories, religious/spiritual themes, and historical references to convey messages in health-promotion programs for African Americans can improve the success level of programs. For Hispanics, core cultural values include *familismo* (importance of family), *respecto* (respect for elders), *dignidad* (the value of self-worth), *caridad* (the value of rituals and ceremonies), fatalism, and *simpatía* (the importance of positive social interactions). The novella format (i.e., the use of stories) may be a particularly effective mechanism to convey these concepts to motivate health behavior change among Hispanic populations.

Whereas surface structure generally increases the receptivity, comprehension, or acceptance of messages, deep structure conveys salience: Surface structure establishes feasibility, whereas deep structure determines program impact.

CULTURAL SENSITIVITY IN HEALTH PROMOTION

The rationale for targeted and tailored health-promotion programs derives from essentially three observations: (1) differences in disease prevalence rates among racial and ethnic groups; (2) differences in the prevalence of the behavioral risk factors among racial and ethnic groups; and (3)

differences in the predictors of health behaviors among groups. Whereas the first two factors provide the rationale for targeted (delivery of programs to subpopulations) prevention programs, it is the latter that provides the basis for tailoring (adapting programs and messages for subpopulations) programs.

SOCIOECONOMIC FACTORS

Because African Americans tend to have lower socioeconomic status than whites, and because numerous health indicators are related to socioeconomic variables, it is important when examining between-group differences in health indicators to account for socioeconomic differences. Failure to do so may lead to inappropriate attribution of differences to ethnic, racial, or genetic factors rather than socioeconomic disparities, which in turn may perpetuate views of racial inferiority as well as misdirect health care research and service dollars. Total mortality and cancer rates, as well as some chronic-disease risk factors, are inversely related to income and education among both African Americans and whites. The magnitude of the association appears similar among both groups, at least with regard to all-cause mortality, cancer rates, and smoking prevalence. Any differences that exist diminish, or even reverse, after controlling for socioeconomic status, further suggesting that racial and ethnic differences may be related more to socioeconomic factors than to ethnic, cultural, or biologic factors.

On the other hand, infant mortality rates, as well as other health indicators such as obesity, body-image preferences, high blood pressure, sedentariness, smoking quit-rates, diabetes markers, and poor diet, remain higher among African Americans, even after adjustment for education and/or income factors. Conversely, African-American adolescents appear less likely to smoke cigarettes than whites, and adult African Americans have a higher dietary carotenoid intake after adjusting for education and income. Thus, some ethnic differences in health indicators appear independent of sociodemographic factors.

One explanation for these inconsistent results is that there is often an insufficient number of middle and upper socioeconomic-level African-American participants in epidemiologic studies,

and conclusions regarding the effects of socioeconomic status on health indicators across ethnic groups are often based on small samples and unstable parameter estimates. Another explanation is that socioeconomic factors function differently among African Americans and whites. For example, African Americans reap a lower increase in income per year of education and they have lower net worth at all income levels than whites. It is also possible that ethnicity, genetics, and socioeconomic factors can each independently influence the same health indicator.

Racial and ethnic differences in the prevalence of socioeconomic and environmental risk factors associated with health behavior are also evident. These include, for African Americans, higher school dropout rates, low socioeconomic status, and a more chaotic family life. For Hispanics, acculturation stress is a major factor. Compared to whites, African Americans experience a greater number of stressful events. They also experience different types of stressors and employ different types of coping strategies in response to stress, and they derive social support (a buffer against stress) from different sources. African-American adolescents are more likely than their white counterparts to be the victims of, or witnesses to, violence; to experience death of a parent or sibling; to be involved in the criminal justice system; and to have parents whose income has recently decreased. African-American youth also rate the impact of stressful events differently than white adolescents.

Another important source of stress for African Americans is racism, which can increase feelings of anger, hostility, alienation, and helplessness—all of which have been associated with negative health outcomes. The higher levels of risk would appear inconsistent with the lower rates of alcohol, tobacco, and other drug (ATOD) use among African Americans. One explanation for this apparent paradox is that the predictors of substance use, both risk and protective factors, function differently among racial and ethnic subgroups.

THE IMPORTANCE OF HETEROGENEITY

Failure to appreciate the heterogeneity *within* ethnic groups can lead to what has been called “ethnic

glossing," and ultimately to insensitive and ineffective interventions. Thus, to achieve cultural sensitivity it is essential to understand the heterogeneity of the target population. For example, among African-American youth living in low-income public housing complexes (a seemingly homogeneous population), there will be considerable variability with regard to important predictors of behavior, including parental attitudes and behaviors, religiosity, educational attainment, and political beliefs. For Hispanic and other populations, there may also be variability in levels of acculturation. Whereas it may not be feasible or desirable to develop interventions segmented to each of these parameters, interventions can nonetheless incorporate multiple perspectives that appeal to a broad spectrum of the target population. In effect, through audience segmentation, even materials designed for a single racial or ethnic group can be multicultural in design. A related phenomenon is the fluidity of racial or ethnic group membership. Different populations may be defined by external parameters established by researchers, rather than by any indigenous cultural ethos. For example, an African-American group defined by church membership will yield a different cultural subgroup than one defined by income status.

Culturally sensitive health-promotion programs are necessitated by differences in disease rates, risk-factor distribution, and behavioral predictors. Controlled research demonstrating how these factors can be incorporated into prevention interventions and what impact, if any, they have on outcomes is lacking, however. While the ethical or philosophic arguments for cultural sensitivity may not require scientific evidence, there are nonetheless several key empirical questions regarding feasibility and effectiveness that merit investigation.

With regard to surface structure, some of the assumptions are *a priori* valid. For example, it is largely self-evident that interventions should be written in the language of a population or at an appropriate reading level. However, other surface structure issues, such as whether materials should portray role models exclusively from the target audience or if images should reflect the same socioeconomic background as the target audience, require empirical examination. Some bilingual populations may prefer interventions in English, while others may prefer a mix of languages.

A key phenomenon that remains under-researched is the substantially lower substance-use rates that have been documented among African-American (and Asian) youth. Rather than approaching minority populations from a deficit model, these lower rates provide an opportunity to use African-American culture as the exemplar. The possible protective role of parental monitoring, family bonding, spirituality, and other positive attributes of African-American family life and culture that may buffer African-American youth from ATOD use have not been adequately explored. Other avenues of exploration include how exposure to drug use, as well as the crime and violence associated with the sale and use of drugs in the home and the community, may discourage use among minority youth.

Even less is known about the efficacy of deep structure messages. Controlled trials comparing the efficacy of culturally sensitivity materials versus standard (non-culturally sensitive) materials are needed. To a great extent, it is not known if culturally sensitive programs are, in fact, more effective. In one study, the effects of a culturally tailored substance-use prevention intervention were not superior to a generic intervention among a sample of African-American and Latino youth at one-year follow-up, although effects for the tailored intervention appeared to be superior at the two-year follow-up. To investigate the efficacy of culturally sensitive materials with a high degree of internal validity, it is important to use comparison materials that are similar in as many dimensions as possible to the culturally sensitive materials. For example, it may be possible that key scientific content and health education messages, as well as the length of video or print interventions, can be identical, with only the method of conveying content (i.e., the tailored elements of the intervention), being varied. In one such study, researchers found little difference in six-month smoking cessation rates among African-American smokers randomized to receive a culturally sensitive cessation video and a standard video developed for European Americans.

Similarly, despite the inherent appeal of using culture to enhance self-esteem and motivate positive behavior change, little is known about the feasibility or efficacy of culture-based interventions. Many programs have incorporated culture-based themes, but they have rarely been isolated

experimentally, so the unique impact of the culture-based components is not well understood. Given the diversity of racial and ethnic identification among African Americans, it is possible that programs that use culture-based messages may be not only ineffective but, somewhat paradoxically, even culturally insensitive for some populations. Afrocentric interventions may, for example, be more acceptable and salient among African-American teens, but less so among older African Americans. Controlled studies comparing culture-based versus culturally sensitive interventions are needed.

Additional research issues include determining how surface and deep structure messages may function differently across racial, ethnic, and sociodemographic subpopulations; which populations are more or less responsive to culture-based messages; and which elements of ethnicity and culture are independent of socioeconomic factors. Research is also needed to delineate core cultural values among racial and ethnic populations, the extent to which individuals ascribe to these values, and how they can be incorporated into disease-prevention and health-promotion programs.

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(SEE ALSO: *Acculturation; African Americans; American Indians and Alaska Natives; Asian Americans; Assimilation; Biculturalism; Cross-Cultural Communication, Competence; Cultural Appropriateness; Cultural Factors; Cultural Identity; Cultural Norms; Hispanic Cultures; Indigenous Populations; Race and Ethnicity*)

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ETHNOCENTRISM

Any policy, research, and action on the part of individuals or institutions that promote (intentionally or unintentionally) the believed superiority of one group, profession, or set of ideals over another can be considered ethnocentric. The *Oxford English Dictionary (OED)* defines ethnocentrism as "regarding one's own race or ethnic group as of supreme importance" (1989, p. 424). The dictionary records the first use of the term to be in 1900 when W. G. McGee, in the *Annals and Reports*

of *American Ethnology*, referred to ethnocentrism as a characteristic of primitive cultures. McGee couldn't imagine his own European culture as having ethnocentric biases. Ethnocentrism, as it is understood in the twenty-first century, was first defined in 1951. Noted anthropologist E. E. Evans-Pritchard, in the publication *Social Anthropology*, saw ethnocentrism as claiming or believing that one group has superiority over others and urged that "this ethnocentric attitude has to be abandoned if we are to appreciate the rich variety of human culture and social life" (*OED* 1989, p. 424). It is apparent that a broader use of the term has entered common usage.

Success in the field of public health requires cultural and social sensitivity. Recognizing the limiting effects of ethnocentrism and heeding the call of Evans-Pritchard is essential. Public health workers and the programs they design must recognize the distinctive features and characteristics of the populations they serve. S. Van der Geest notes that ethnocentrism encourages narrow-mindedness. It prevents one from entertaining different worldviews, and one becomes less inclined to challenge or question how different groups of people learn or to understand what they are interested in learning. The appreciation of different forms of knowledge and values are at the core of ethical practice, policy, and research in public health.

Understanding ethnocentrism and its relation to race in public health research is particularly important in the United States because of its history of using race in classifying and judging different groups. M. T. Fullilove notes that race is an arbitrary system of visual classification that has no scientific relevance in public health research. R. Bhopal and L. Donaldson suggest the use of nonracialized terms in public health research and caution that the use of racial categories in scientific research can be interpreted as an endorsement of racial determinism. The historical use of racial categorization was founded on the ethnocentric belief that the so-called white race was superior to the so-called black, red, and yellow races and promoted an attitude that there was no need for equality in entitlement to public goods and services. The most often cited example of racist and ethnocentric conduct in U.S. public health history is the forty-year Tuskegee syphilis study, where African-American men with syphilis

were recruited to participate in a study and told they were being treated, only to be left untreated even though an effective cure was available.

In twenty-first-century America, there is concern over persistent disparities in health status between those of European or Caucasian descent and other groups—a distinction often based on racial or minority status. The disparity has persisted in part because of ethnocentric attitudes and beliefs on the part of health care providers, researchers, and health-policymakers over the most effective methods for addressing health promotion and disease prevention on the one hand, and for providing the most efficient health care services on the other. Effectiveness and efficiency are dependent on social and cultural characteristics and skills. It has been demonstrated that ethnic and cultural values and beliefs influence the way individuals and groups view health and disease and determine what practices are followed when illness occurs. Ethnocentric points of view can prevent attempts to acknowledge ethnic differences and cultural values in making health decisions that better address the health concerns of U.S. minorities. To challenge ethnocentrism is to recognize and value differences and qualities that exist in diverse groups. Such differences can include eating practices, spiritual values, body shape and size, and preventive and curative beliefs, to name but a few.

Public health often focuses too much on risk factors and not enough on protective cultural and cognitive factors in the same individuals. Public health does focus on these in attempting to promote positive health practices, attitudes, beliefs, values, and living conditions. All groups have both risk (negative) and protective (positive) factors that can determine health-related behavior and skills. The positive aspects of a group's beliefs and practices as they relate to health need to be recognized and promoted. When negative aspects of a minority group's beliefs and values must be changed, it does not follow that the strategy and approach for such change needs to conform with the strategy and approach for changing negative beliefs and values in the majority group. Failure to understand differences in the way various groups address their preventive and curative health needs often leads to ethnocentrism in public health. To eliminate the disparity in the health status of ethnic minorities in the United States, public health

professionals must encourage diversity in approaches to health promotion and disease prevention and eliminate ethnocentrism in public health.

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(SEE ALSO: *African Americans; Anthropology in Public Health; Asian Americans; Assimilation; Biculturalism; Cultural Identity; Cultural Appropriateness; Ethnicity and Health; Immigrants, Immigration; Minority Rights; Values in Health Education*)

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EUGENICS

Attempts to improve human beings and to understand human differences have often been seen in terms of a "nature verses nurture" debate. The history of eugenics is the history of the belief that nature is more important than nurture in this equation. This debate dates back at least to Plato's *Republic*. In that volume, Socrates maintained that human differences reflect human essences, that people's behaviors derive from the material of which they are made. As materials scale upward in

metaphorical quality from iron and brass through silver to gold, so too do the qualities that make up individual persons. While one cannot know today whether this argument for human differences was accepted by ancient Athenians, it is clear that a form of this idea gained considerable popularity in the late nineteenth and early twentieth centuries as part of a worldwide eugenics movement.

FRANCIS GALTON

The history of eugenics began in Britain with Sir Francis Galton (1822–1911), who coined the term “eugenic” meaning “wellborn,” in 1883. Galton observed that the leaders of British society were far more likely to be related to each other than chance alone might allow, and he searched for reasons. While he might have concluded that the insular world of England’s schools and business and political environment explained this phenomenon, he drew a very different conclusion. He explained adult leadership in terms of inherited qualities. It was the superior biological inheritance of members of the British ruling classes, he insisted, that determined their social position. To Galton, nature was far more important than nurture in human development, and by the 1860s he had popularized programs of human improvement through competitions for marriage partners, where only “best” would marry “best.”

NINETEENTH-CENTURY BIOLOGY

The late nineteenth century was a revolutionary period in biology, during which environmentalist interpretations of human improvement were rejected. The pre-Darwinian theories of Jean-Baptiste Lamarck (1744–1829), who argued that the muscles of blacksmiths would be transmitted to their children as “acquired characters,” were refuted by the research of August Weismann (1834–1914), who discovered that germ plasm was continuous from generation to generation and was unaffected by environmental change such as physical activity.

Perhaps of greatest significance in the development of the American eugenics movement was the popularization of the work of Gregor Mendel (1822–1884) after its rediscovery in 1900. Mendel, a Moravian abbott, had carefully bred peas in his garden and recorded the patterns of inheritance

of their different traits for many generations. He discovered that he could control traits such as size, color, and texture, and could therefore predict the qualities of future generations with mathematical precision. These discoveries seemed to support the eugenicists’ belief that a wide variety of complex moral, intellectual, and social traits in humans could also be easily explained by heredity. In addition to intelligence, hereditary traits were thought to include patriotism, shiftlessness, pauperism, boat building, and a tendency to wander.

AMERICAN EUGENICS

For many early-twentieth-century intellectuals it seemed that heredity was of signal importance in predicting human performance and that it should play a key role in social policies and programs for human betterment. Anxious about their social status and changes in America’s ethnic makeup, they saw eugenics as a way to legitimize racial and ethnic interpretations of differential human worth. Based upon this mix of scientific and pseudoscientific theories, they pursued a series of specific eugenic policies. In the 1920s, for example, they actively supported laws for state-sponsored sterilization and the restriction of immigration from southern and eastern Europe. School textbooks lauded the promise of eugenics, movies such as the *Black Stork* (1917) and *Tomorrow’s Children* (1934) warned of eugenic decline, and Fitter Families contests offered medals to those of presumed eugenic excellence. Perhaps the most destructive of these policies was the adoption of a model American eugenic sterilization law by the National Socialist government in Germany, which contributed to policies that eventually led to the taking of more than 6 million lives in the Holocaust.

CONCLUSION

By the late 1920s, the implications of the work on chromosomal inheritance by Thomas Hunt Morgan and his students at Columbia University made it clear that human intelligence and morality were far too complex to be understood in simple Mendelian terms. Such efforts helped discredit eugenics as a scientific endeavor. Yet the belief in hereditary determinism has regularly returned to claim a place in public policy. It is of course true that

conditions such as Huntington's disease and Down syndrome can be traced to inherited genetic or chromosomal abnormalities. But it is now the consensus of the majority of scientists who have studied the issue that complex human behavior is determined by multiple interacting factors.

While eugenics was indeed popular during the first half of the twentieth century, it was poor science and was eventually rejected. Discoveries from the Human Genome Project in the early twenty-first century will likely reveal much about human genetics and will surely lead to improvements in medical treatment. But just as people are not simply an expression of their biology, genes do not produce behavior. Genes produce enzymes, and enzymes control chemical processes. Many scientists believe that nature cannot be separated from nurture in the production of complex human behavior and that human traits are not to be improved solely through manipulating nature.

It might be said that there has been a return to eugenic ideas as represented in an increasing interest in in vitro fertilization, sperm banks of Nobel laureates (allegedly guaranteeing an intellectually superior fetus), and cloning. These twenty-first-century initiatives are different from earlier eugenic attempts. This is due, in part, to their medical purposes rather than their racial or nativist motivations. Yet, these initiatives should be subject to careful consideration from the public. The ethical issues raised by eugenics may be even more important in light of advances in human medical genetics. However, despite advances in science, it remains true that policies directed toward human improvement and social justice can best be achieved through political, educational, and ethical action.

STEVEN SELDEN

(SEE ALSO: *Biological Determinants; Environmental Determinants of Health; Genetics and Health; Medical Genetics*)

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EVALUATION OF PUBLIC HEALTH PROGRAMS

Public health programs are essential to protect and enhance the health of the population and are, by definition, publicly funded. It is therefore essential that they be evaluated. The benefits of public health programs often extend well beyond the immediate target population—reductions in communicable diseases or environmental hazards may benefit the whole world. Different disciplines approach evaluation in different ways.

Epidemiologists distinguish between an intervention's efficacy (its ability to work under ideal circumstances), its effectiveness (results obtained under real-world circumstances), and its efficiency (results obtained relative to the resources expended). An intervention cannot be effective unless it is efficacious. Randomized studies are the gold standard for studies of efficacy, since they ensure that study groups are comparable (in the long run). They thereby help to ensure that the results are due to the intervention. But they are more feasible for single interventions directed at individuals than for complex programs directed at groups, so their potential for evaluating public health programs is limited. Community trials, in which groups are the unit of randomization, are difficult and expensive. Quasi-experimental approaches try to obtain the advantages of randomization through careful selection of comparison

groups (often multiple groups) and sophisticated statistical analysis.

Administrative sciences tend to assume that a program's efficacy has been demonstrated and concentrate on other dimensions of evaluation. Using the World Health Organization's 1991 *Health Programme Evaluation* as a basis, J. E. Veney and A. D. Kaluzny (1991) recommend that five aspects of a health program be evaluated: its relevance (to the needs of the population and to social priorities), progress (implementation), efficiency (outcomes achieved in relation to resources expended), effectiveness (extent to which predetermined objectives are met), and impact (long-term outcomes). Approaches for measuring these dimensions include monitoring, case studies, and various epidemiologic designs.

Economists compare a particular program to a possible alternative. Costs are expressed in monetary units and should be marginal (cost of producing the last unit of output) rather than average (across all units of output). Outcomes may be assumed to be identical and therefore not measured (cost-minimization analysis) or expressed in natural units like cases prevented (cost-effectiveness), monetary units (cost-benefit), or universal units like quality-adjusted life years (cost-utility).

Public health managers often use logic models for evaluating public health programs, setting out the program's expected operation in matrix format and showing the activities, target groups, and short- and long-term outcomes for each component. Much more highly developed is the PRECEDE-PROCEED framework of L. W. Green and M. W. Kreuter, a nine-step process for the design of a health-promotion program (social, epidemiologic, behavioral/environmental, educational/organization, and administrative/policy diagnoses) and its evaluation (implementation and process, impact, and outcome evaluation). Less systematically, a program can be illustrated as a flow chart. All these approaches force program developers to think through a program systematically, and they show program evaluators what to measure. By sampling the program process at various stages evaluators can distinguish between an implementation failure (a potentially good idea that was never properly tested) and a program failure (a bad idea). Governments often produce

standards against which local public health programs can be tested. The National Public Health Performance Standards Program is the standard being developed in the United States.

ROBERT A. SPASOFF

(SEE ALSO: *Case-Control Study*; *Centers for Disease Control and Prevention*; *Epidemiology*; *Health Measurement Scales*; *Statistics for Public Health*)

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EVIDENCE-BASED MEDICINE

Evidence-based medicine is the conscientious, judicious use of current best evidence in making decisions about patient care. The concept of evidence-based medicine began to emerge in 1980 as physicians first performed systematic reviews of the evidence for preventive services as a step in writing clinical practice guidelines. There are six steps in the provision of evidence-based medicine: (1) decide what information is needed; (2) formulate one's information needs in the form of a question that a research study could answer; (3)

search the published literature to find the evidence; (4) decide which studies are valid and applicable to the patient at hand; (5) apply the findings to the patient; and (6) evaluate the outcomes. David Sackett, M.D., has been a leader in formulating the concepts of evidence-based medicine.

HAROLD C. SOX

(SEE ALSO: *Personal Health Services; Physical Activity; Primary Care*)

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EVOLUTION

See Darwin, Charles Robert

EXERCISE

See Physical Activity

EXPERIMENTAL STUDIES

See Epidemiology

EXPOSURE ASSESSMENT

The field of exposure assessment has its origins in industrial hygiene. It has evolved rapidly since 1980, and is now used to examine personal contacts with toxicants found in the personal or community environments. The accurate characterizations of exposure to toxic agents can lead to identification of the distribution of exposure and determination of the mean and high-end values, all of which are central to effective risk assessment. The science to conduct exposure analyses and assessments can be placed within a continuum that follows the movement of a toxicant from its source, through to an ultimate health effect. Information on human exposure provides a firm scientific link between the information obtained by traditional environmental sciences, which focus on effluents,

and health effects that can result from contact with environmental toxicants. Understanding and interdicting specific pathways for contact are essential in protecting the public health and the environment.

An exposure is defined as "an event consisting of contact at a boundary between a human and the environment at a specific contaminant concentration for a specified interval of time" (National Research Council). Understanding total exposure requires that its fundamental variables of concentration and time are summed over all possible microenvironments where people spend their time.

The data collected to complete an exposure assessment requires both indirect and direct measurements techniques. Direct measurements assess a person's exposure, using monitors attached to the individual, or through the sampling of biological media such as blood or urine. Indirect measurements involve collecting information about where, when, and how people spend their time, and about the concentrations of a contaminant associated with a medium that contributes to important routes of exposure. The data from indirect measurements are used to estimate a person's exposure using both simple and complex models. Detailed exposure and dose analyses frequently use a combination of direct measurements.

Theoretical advances for simulating exposure occurred in the early 1990s, contributing to an understanding of integrated multimedia and multiroute exposures and helping provide initial estimates of exposure within the general population and high-exposure subgroups. All modeling activities, however, must be validated by measurements.

The construction of models of individual or population exposures to contaminants is essential, since it is nearly impossible to measure all exposures experienced by an individual or by the general population. Therefore, statistically representative groups are selected from the population, and measurements from these groups are used to estimate the exposure of the population, using deterministic or fundamental models.

Exposure assessment is particularly pertinent to understanding risks associated with environmental hazards. Risk is a function of both hazard, which is intrinsic to the chemical or physical agent,

and the intensity of a person's or population's exposure. Failure to pay attention to specific conditions within a community (e.g., consumption of homegrown vegetables) can lead to either underestimating risk. Community studies focus on measuring or estimating exposure of susceptible populations and of individuals or populations with the highest levels of exposure.

PAUL J. LIOY

(SEE ALSO: *Pollution; Risk Assessment, Risk Management; Safety Assessment; Uncertainty Analysis*)

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EXTERNAL FACTORS

See Environmental Determinants of Health

F

FAIR LABOR STANDARDS ACT

The Fair Labor Standards Act controls the employment of children. Child labor, defined as employment of children less than eighteen years of age, has become increasingly common in American society, and it is widespread in many societies around the world. In many countries, children begin working at ages as young as three or four. Legal requirements to attend school are ignored or evaded through measures such as providing a few minutes of instruction each day in “carpet schools.”

In the United States, under the Fair Labor Standards Act, children under sixteen years of age may not work during school hours, and, by law, limits are set on the number of hours of employment allowed on each school day and cumulatively for each school week. In general, employment should be in a nonhazardous, nonagriculturally related job where restrictions are in place regarding work that would be hazardous to this age group. For example, no one under eighteen is allowed to work in mining, logging, brickmaking, roofing, or excavating, or to operate power-driven machinery. In other settings, work is prohibited with equipment such as meat slicers, box crushers, and power-driven heavy equipment.

The agricultural setting does not generally come under the Fair Labor Standards Act, and there are no regulations regarding children working on family farms. Children as young as four or

five have chores related to farming activity. Unfortunately, farming activity, while not regulated, is a serious source of hazard. Over one hundred American children below the age of eighteen die working on farms each year. The only restrictions for agriculture are to preclude children from applying pesticides and herbicides.

In reality, many adolescents under eighteen often work far more hours than are allowed, and some do jobs that put them at considerable risk. Some jobs appear to be relatively benign, such as packers in grocery stores, but in the fast-food business adolescents are often abused with regard to working hours (e.g., “clocking out” but continuing to work), or they are asked to handle dangerous equipment such as deep fat fryers. In most states there is a lack of supervision of children in the workplace, and accurate data collection is often not available. Studies have begun to document poor school performance due to excessive work hours.

Another aspect of poor record keeping regards filing for health claims. When a child is hurt in a workplace setting, he or she is often asked to obtain care under parental insurance, rather than applying through the worker’s compensation system, which would allow for a better tracking of difficulties in the workplace.

There are seasonal variations in injuries and fatalities among working children, with more injuries occurring during the summer months when

children are out of school. This especially applies to agriculturally related injuries and fatalities.

ARTHUR L. FRANK

(SEE ALSO: *Child Welfare; Childhood Injury; Children's Environmental Health Initiative; Farm Injuries; Occupational Disease; Occupational Safety and Health; Risk Assessment, Risk Management*)

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FAITH HEALERS

Faith healing is the process of preventing and curing illness or disease through a belief in an omnipotent force or creator (God) of the universe. It is a healing process that focuses on both the body and the mind. An important foundation for successful healing in a spiritual context is faith, which has always been at the core of spirituality and religion. Increasingly, the public health and medical communities have come to realize the value of faith in the healing process and have been trying to understand how spiritual and religious factors affect healing. Indeed, faith is considered to be "one of the miracles of human nature which science is as ready to accept as it is to study its marvelous effects" (Osler 1910, p. 1471). Faith in today's practice of medicine can, in a sense, be observed in instances such as a physician praying before surgery, a traditional healer's prayer during treatment, or physicians and healers leaving a prognosis up to the patient's "will to live."

Spirituality and traditional healing experiences of immigrants and ethnic minorities (primarily from Africa, Asia, and Latin America) have provided important insights into the role of faith in health outcomes and the critical role of the faith healer in achieving positive health outcomes. Studies have shown positive relationships between religious/spiritual faith and positive health outcomes for different health conditions among different groups. More research is needed to better understand and document scientifically the contribution of faith healing to the mission of public health. There is a strong and growing partnership

between public health and the faith community, based on the increasing understanding of and appreciation for faith healing in improving the health of the public.

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(SEE ALSO: *Acculturation; Alternative, Complementary, and Integrative Medicine; Customs; Ethnocentrism; Folk Medicine; Immigrants, Immigration; Minority Rights*)

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FAITH-BASED ORGANIZATIONS

It has long been understood in public health that the way to solve health-related problems and improve the health of a community is to empower the people of that community. Lawrence Green and Judith Ottoson, in *Community and Population Health* (1999), state that improving the health of a community involves activating local organizations, groups, and individuals to cause changes in behavior or in rules or policies that influence health. Traditionally, empowering people has involved mobilizing schools, government agencies, health care professionals, and health-related organizations in communities. Faith-based organizations have often been left out of this process. Reasons for this omission range from the need for separation of church and state to the belief that religion and spirituality are not connected to health.

A faith-based organization may be defined as a group of individuals united on the basis of religious or spiritual beliefs. Traditionally, faith-based organizations have directed their efforts toward meeting the spiritual, social, and cultural needs of their members. However, when ministries promote physical and mental well-being, when they discourage illegal or reckless behavior, and when they advocate ethical conduct, they are also indirectly promoting members' health. Realizing that

there is a relationship between religious/spiritual beliefs and health, many faith-based organizations (such as churches, temples, synagogues, and mosques) are developing health ministries and extending those ministries beyond their own members to include entire communities.

Communities are also realizing the value of inviting faith-based organizations to the community health-planning table. Faith-based organizations are stable, enduring, and often the most trusted institutions in the community. They can be identified with almost every cultural and ethnic group and frequently serve as a point where large numbers of people regularly congregate. Finally, people often turn to their faith for strength in times of illness and stress.

The impact of faith-based organizations in African-American communities may be even greater than in other ethnic groups. The church has historically been the center of spiritual, social, and political life for African Americans. According to a 1997 study by Mary Sutherland et al, the church in an African-American community is an essential component in the success of any health-promotion program because of its impact on the lives of entire families. Increasing numbers of African Americans and African Canadians follow the Muslim faith, so the mosque replaces the church for them.

Many public health groups are beginning to develop policies that utilize the faith-based communities in promoting community health. The American Public Health Association has formed a new Caucus on Public Health and the Faith Community. The caucus will encourage health and faith partnerships that promote positive health behaviors among members of their congregations as well as individuals in the surrounding community. The World Health Organization held a meeting on tobacco and religion to explore this new type of partnership. Information was presented at that meeting on the spiritual dimensions of health and the ethical values underpinning public health actions.

Faith-based organizations that have developed health ministries are often very successful in providing community health programs. In an extensive review of the literature, Lynda Ransdell et al.

have studied the extent and success of church-based health-promotion programs. The researchers found eighteen frequently cited church-based health-promotion programs. Activities encompassed health screening, health-promotion and disease-prevention events, and risk-reduction programs. The African-American churches represented the largest number of churches included in the study. The church-based programs varied in their success. However, based on the diversity of programs offered and the number of people reached, most people would conclude that the church-based programs were successful. The study determined that health-promotion activities within faith-based settings are gaining broad-based support from representatives of religious institutions and public health officials.

The Partnership for a Healthy Mississippi is an example of the public-private partnership concept. The Partnership, funded by money from the Mississippi tobacco settlement, utilized a network of community-youth partnerships and faith-based organizations to help change the culture of Mississippi from one of acceptance of tobacco to one that protects youth from the detrimental effects of tobacco. The Partnership found that the faith-based organizations were excited about their role in promoting healthful behaviors, were able to reach a large number of youth who would not otherwise be reached, and were advocates for policy changes to benefit the health of their communities.

Faith-based organizations are essential in achieving the public health goals for healthier communities. The religious and spiritual connection with positive health behaviors makes faith-based organizations natural partners for planning and implementing health initiatives to improve the health of the community.

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(SEE ALSO: *African Americans; American Indians and Alaska Natives; Anthropology in Public Health; Black Magic and Evil Eye; Community Health; Customs; Faith Healers; Folk Medicine; Health Promotion and Education; Hispanic Cultures; Immigrants, Immigration; Medical Sociology; Shamanic Healing; Traditional Health Beliefs, Practices; Values in Health Education*)

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FAMILY HEALTH

Family health is a state in which the family is a resource for the day-to-day living and health of its members. A family provides its individual members with key resources for healthful living, including food, clothing, shelter, a sense of self-worth, and access to medical care. Further, family health is a socioeconomic process whereby the health of family members is mentioned.

As the basic socioeconomic unit of most societies, the family is the interface between societal and individual health, and the economic interface between the family and society determines what resources are available for a family's health. For example, in some families the father is the primary income earner, yet his skills are marketable only in remote, resource-based communities. In such families, members may have adequate financial resources for healthful living because of the father's stable employment, though their shared geographic location has the potential to negatively impact access to fresh foods, recreation facilities, and

quality health care. Here, the community plays a primary role in mitigating the effects of geographic location. In healthy communities, many families will benefit from resources available in the community and, in turn, will produce members who contribute in kind, with family dynamics mediating this reciprocal process.

While a family may have adequate resources to support its members' health-related decisions, family dynamics influence if, how, when, and by whom resources are accessed. For example, while the family may have adequate financial resources to support the regular physical activity of all members, female family members may be less apt to participate in such activities because of family expectations regarding traditional feminine behavior, such as caregiving and household management. Further, it is in families that individuals learn about, and are exposed to, behaviors and patterns of living that may be key to their own health. Such learned patterns may include diet, exercise patterns, orientation to social support, religious practices, substance use or abuse, and domestic violence. And, it is in families that individuals share a genetic makeup that may influence their individual and collective health-related decisions, such as those related to genetic screening.

Public health has a mandate to set norms and values for health behavior, establish policies that protect the health of the public, and set directions for advocacy initiatives to ensure that health-related resources are available to citizens. The family environment mediates between societal views of health, often set by public health initiatives, and individual health. That is, in the family unit the norms and values set by the public health agenda are interpreted in relation to the family's values and norms. These values are constructed through a complex process of interpretation, which is influenced by family history, cultural context, and popular science and culture. Thus, the family environment may be a primary determinant of the impact of public health policy on health-related behaviors such as exercise, diet, and smoking. For example, public health in a particular jurisdiction may establish a policy for nutritional labeling of packaged food. Parents in a family in that area who subscribe to the belief that a low-fat diet reduces risk for heart diseases may attempt to influence family members' health by selecting and serving food



Through families, individuals learn behaviors, such as diet, exercise, and social support, that may be key to their own health. (© Bob Krist/Corbis)

labeled “low fat,” a strategy that may lead to reduced incidence of heart disease in family members.

At the broad societal level, public health advocacy efforts at global, national, and community levels impact resources available to families. For example, health care reform in Canada in the 1960s established a system that ensures equitable access to medical care for all families—in contrast to the U.S. system of health care in which some families are unable to afford medical care for ill members, or such care devastates the financial resources of the family.

Family health-related research and scholarship is evident in a variety of disciplines, including family science, nursing, medicine, health promotion, social work, sociology, and psychology. Traditional family theorists focus on interpersonal family dynamics and how such dynamics contribute to or detract from family functioning. Located within a problem-orientated, “dis-ease” perspective (itself grounded in the practice of counseling),

authors have explored dimensions of family life that contribute to how well the family functions. The problem-orientation of family theories is an issue for those involved in family-health promotion who seek to build on the strengths and resiliencies of families. Emerging perspectives on family-health promotion explore the links between family life and individual members’ health, with individual health defined as more than the absence of disease. Feminist scholars contribute to understanding family health by exploring how family life affects the health of females, including the health-related effects of domestic violence and role strain, an area of research largely ignored or invisible prior to feminist inquiry.

While research on families beyond a problem/dis-ease orientation is in an early stage, evidence in diverse cultural contexts points to family practices and processes that foster and support the development of members’ health. Future research exploring the relationships between individual health, family, and social organizations has the

potential to uncover the reciprocity between individual health, family context, and society.

LYNNE E. YOUNG

(SEE ALSO: *Community Health; Family Planning Behavior; Health Promotion and Education; Preventive Health Behavior; Social Networks and Social Support; Women's Health*)

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FAMILY PLANNING BEHAVIOR

Reproductive health is defined in the *Programme of Action* of the International Conference on Population and Development (ICPD), held in Cairo, Egypt, in September 1994, as:

A state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity, in all matters relating to the reproductive system and to its functions and processes. Reproductive health therefore implies that people are able to have a satisfying and

safe sex life and that they have the capability to reproduce and the freedom to decide if, when, and how often to do so. Implicit in this last condition are the right of men and women to be informed and to have access to safe, effective, affordable and acceptable methods of family planning of their choice, as well as other methods of their choice for regulation of fertility which are not against the law, and the right of access to appropriate health care services that will enable women to go safely through pregnancy and childbirth and provide couples with the best chance of having a healthy infant.

Sexual health was also defined in this resolution, "the purpose of which is the enhancement of life and personal relations, and not merely counselling and care related to reproduction and sexually transmitted diseases." In 1999, the United Nations General Assembly adopted its *Key Actions for Further Implementation of the Programme of Action*. This document focused on population and development concerns; gender equality, equity and empowerment of women; reproductive rights and reproductive health; and partnerships and collaboration.

Reproductive health has widely been interpreted to focus more specifically on providing access and choice in family planning; caring for women before, during, and after pregnancy; preventing and controlling sexually transmitted infections, including HIV/AIDS (human immunodeficiency virus/acquired immunodeficiency syndrome); preventing and treating cervical cancer and breast disease; promoting the health of adolescents; promoting positive communication between sexual partners; promoting special services (i.e., counseling, care, and education) to women that decrease the disparity of services between genders; and supporting positive reproductive health-related practices. The *Programme of Action* has helped nations throughout the world to understand that, in the everyday lives of people, family planning is an integral part of daily living and overall health.

The World Health Organisation (WHO) has outlined four basic goals that should be met for people to achieve reproductive health. These goals were established in order to focus attention on the

community at large—how people live, work, and play—and to get people thinking more broadly about the treatment services available at health care delivery centers. These goals provide a basis for reproductive health promotion, prevention, and intervention initiatives. The overall design aspires to create a safe environment where people may: (1) be free from violence and other harmful practices related to sexuality and reproduction; (2) avoid illness, disease, and disability related to sexuality and reproduction, and receive appropriate care when needed; (3) achieve their desired number of children safely and healthily, when and if they decide to have them; and (4) experience healthy sexual development and maturation and have the capacity for equitable and responsible relationships and sexual fulfillment.

Implicit in these goals is the expectation that people should be safe from violations of their human rights, as well as from discrimination based on sex, race, religion, or culture. Women, in particular, should be free from all forms of sexual and physical violence. Both men and women should be seen as equal and responsible contributors to a healthy society.

Family planning enables couples and individuals to decide freely and responsibly the number and spacing of their children, and to have the information and means to do so. It also means that people have ongoing availability of a full range of safe and effective contraceptive methods that enable them to take action according to these decisions. This ability to take action is also based upon the cost of contraceptives, ideas (sometimes correct and sometimes erroneous) people have about the different methods, and the support or lack thereof of the partners, extended family members, and wider community. People are deciding to have families at both younger and older ages, and contraceptive technology is enabling them to do so. It is important that these decisions be made not only freely but also with full information about the long-term consequences for both the parents and the children. Unfortunately, there are still many women in the world who die each year from pregnancy-related services. A considerable number of these women want to limit or space their pregnancies but are without the means to do so effectively.

Reproductive rights include all the elements mentioned above related to family planning. They also include the rights of couples and individuals to make decisions about family size and spacing and about which contraceptives will be used, without being coerced or otherwise being subject to violence and other outside pressures to behave in ways contrary to what they would like. Implicit in these rights is the idea of gender equity in decision-making, including meeting the educational and service needs of both sexes, and addressing negative attitudes toward women and girls that often result in their having little control over their own sexual and reproductive lives.

FACTORS INFLUENCING REPRODUCTIVE HEALTH BEHAVIOR

In most countries of the world today, couples have concluded that it is in their best interest (and that of their children) to plan and limit the numbers of births. Most families are having fewer children than families did in the past. In industrialized countries this trend has been happening gradually since about 1900, while in developing countries, for the most part, the change has happened relatively swiftly beginning about 1970 and the average desired family size has dropped from six children to three. Unfortunately in some situations, particularly in sub-Saharan Africa, extreme poverty, profound inequalities between men and women, and early marriage severely limit women's ability to achieve their childbearing goals. A gap frequently exists between the number of children women say they want and the number they have. More than 50 percent of women in some countries report that they would have preferred to postpone their most recent birth or not have had it at all. More than 50 million of 190 million women who become pregnant each year have abortions, many of them clandestinely performed under unsafe conditions.

Identifying factors that affect family planning behaviors helps in understanding effective ways of promoting such behaviors. It is widely accepted that simply providing information to people does not make them change their behaviors. Information is only one of the factors that contribute to behavior change. Particularly in the complex area

of family planning, where there is a tremendous influence exerted by culture, tradition, taboos, sex-role definitions, and a reluctance to openly discuss these matters, it is important to understand contributing and inhibiting elements that will support or block healthy family planning behaviors.

In order to engage in safe family planning practices, individuals must feel that they are capable of what is needed. Self-efficacy, or having the appropriate skills, means, and confidence, is a critical factor in any person's decision to try to adopt a new behavior. To be effective in family planning, people need to know what contraceptives are available, how to use them, where to go to get them and how often they should be used. Being skilled, however, is only part of the process of developing capabilities for effective family planning behavior. Real or perceived barriers to obtaining contraceptives (including cost, accessibility, and lack of reinforcing and enabling support) can deter individuals. Some may find that despite their knowledge or skills, they may not be able to follow through on their desired practices due to the fact that there are elements of the system that block, deter, or discourage them. For example, some health policies may require that a woman have permission from her husband before she can be given contraceptives. Even though she may know that it is dangerous to her health to have more children, she may not seek family planning services for fear of a violent reaction from her spouse. Many people who go to health facilities are further discouraged because they feel that the health workers humiliate them, ask them difficult questions, and conduct unpleasant procedures. Costs, some of them recurring on a monthly basis, may be yet another deterrent.

Globally, and particularly in the United States, unwanted pregnancies and high levels of sexually transmitted diseases (STDs) are extremely prevalent in young people between the ages of ten and twenty-four. These are problems that are preventable through contraception and safe sexual practices. Therefore it is important to begin to reach young people early in their lives, when they are feeling the influence of many different pressures, to help them decide when and if they will have sexual intercourse, and, if so, whether they will

make it a point to protect themselves from unwanted pregnancy and STDs. In order that they may plan the size and timing of their families, it is also important for young people to understand the potential consequences of pregnancies that occur too early in their lives or are too closely spaced together.

In some situations, young girls think it would be wonderful to have a child, someone to care for and someone who will give love unconditionally. At one time, young girls who became pregnant and were not married were forced to either get married, not have the child, or not keep the child. In the United States today, with a prevailing culture and social support system that is supportive of single mothers, many young girls are looking forward to getting pregnant and having and keeping their children. What is important is that they understand the long-term consequences of making this decision—economically, socially, educationally, and in terms of their future opportunities.

Although some people do not believe that their family planning behaviors put them at risk, in other cases individuals will weigh the expected positive and negative outcomes. A woman who is considering using the female condom during each act of sexual intercourse may anticipate that she will have to choose between being embarrassed at having to discuss this with her partner and reducing her risk for unwanted pregnancy and diminishing her chance of contracting STDs. (Many women also have to take into account the possible harm her partner might inflict upon her in a violent attack.) Her decision may be based upon what she feels most comfortable doing.

The prevailing peer and social norms and expectations are also going to have an impact on whether or not a person decides to have a child or how early and how often to have children. Individuals will conform to different social norms depending on age, income, sex, experience, and culture. A very strong ethical or religious culture in the home will possibly exert greater influence on the decision whether to use contraceptives or not than will that of their peer group. In the end, individuals may act according to which pressures are dominant in their lives, and which ones they feel they are the most competent to resist.

Other factors that will influence a person's decision whether or not to use effective family

planning or STD protection include the media, current events, life events, social policy and legislation, and general information exchange. Private life events, such as supporting a friend through an abortion, may also produce a marked behavior change in the future decisions of an individual. Individuals are exposed to a considerable amount of information on a daily basis. Certain images and ideas may affect a behavior change, while others will be sifted and discarded by the end of the day. Repeated dissemination of information will have more of an impact than random images and messages. A well-publicized health campaign may influence an individual to adopt new behaviors, and repeated messages on public transport billboards, television, and radio may act to reinforce such a behavior change. When new behaviors are unfamiliar, other cues and associations can also act as reminders, or triggers, to individuals of their new or changed behavior. For example, if a woman associates taking a daily contraceptive pill with something she does as part of her daily routine, such as drinking orange juice or coffee in the morning, it will be a helpful reminder for her to continue this daily behavior. Behaviors can be reinforced when an individual receives positive feedback from someone whose opinion the person values. Reinforcement is a key element of behavior change and maintenance.

MARILYN RICE

(SEE ALSO: *Behavior, Health-Related; Contraception; Family Health; Planned Parenthood; Preventive Health Behavior; Women's Health*)

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FAMINE

Famine is defined as an extreme shortage of food or lack of access to food by a population, accompanied by an increase in death rates. Deaths during famine occur not only due to malnutrition, but also from infectious diseases to which malnutrition predisposes the population and from the social ills brought about by food shortage. Famine is a true public health emergency, and unfortunately has been a common human experience throughout history. The fundamental menace of famine is expressed in the Biblical reference to the "four horsemen of the apocalypse"—meaning famine, pestilence (disease), war, and death.

There have been thousands of famines over the last several centuries. The causes have included natural disasters such as droughts and floods; war, civil strife, and population displacement; and economic failure. In spite of the fact that worldwide food production has improved in the past several decades, and that global food supplies are sufficient to feed the world's current population, an estimated 20 percent of people in developing countries—more than 800 million people—lack access to enough food on a regular and predictable basis. The number of countries experiencing severe food shortages has almost tripled since 1990. Compared to poverty, which is the most common cause of malnutrition worldwide, famine is preventable. Access to food has been repeatedly recognized as a basic human right. Promotion of

this right requires international cooperation and a coordinated effort.

CAUSES OF FAMINE

The immediate causes of famine are inadequate food production or market availability, price fluctuations, and limited household assets. Underlying causes, however, almost always involve misguided or deliberate public policy, repressive political systems, or natural or human-caused disaster. In countries with preexisting widespread poverty, unemployment, or debt, natural and human-caused disasters are the most common causes of food shortages and famine. Additionally, hunger has been often used as a deliberate weapon. Access to food is such a basic human need that control of the food supply translates into direct political and economic power. Over and over again in history, specific populations have been the victims of an interruption of their food supply with the intent to subdue them or drive them away.

An example of the chain of events that leads to a “natural” famine (not the direct result of war or civil strife) is a poor harvest due to a drought or flood, resulting in reduced wages and rising food prices. The overall result is a decline in both food availability and food access.

Large famines caused millions of deaths in the early 1930s in the Ukraine, and in 1959–1961 in China; both occurred due to policies that resulted in reduced food availability. One of the most recent tragedies with regard to food shortage began in the mid-1990s in North Korea, where a steady economic decline and a series of floods, droughts, and failed harvests was superimposed on the economic blow brought about by the abrupt end of preferential trade with the former Soviet Union. A closed governmental system has limited humanitarian aid in this situation.

War and civil strife are two of the greatest causes of famine. Armies destroy crops and consume available food. Mass migration is also common for those living in war zones. Civil wars often cause famine, as everyone within the country is affected. Famines due to war occurred in Holland in 1945, the Sudan in 1988, Somalia in 1991, and a large famine in Zaire in 1991 was due to civil war. Severe food deprivation characterized the ethnic conflict in the Great Lakes region of Africa in the

late 1990s. The Bosnian war of 1998 included deliberate interruption of the flow of basic food supplies to the Kosovar population.

Finally, there are several parts of the world where famines occur on a regular basis. Much of Africa and Southeast Asia are subject to repeated food shortages. Nations in these areas are chronically vulnerable to changes in weather, or they have unstable political situations. India suffered recurrent famines up until the time of independence from colonial rule in the mid-twentieth century, but has not experienced a major famine since that time, illustrating that prevention is possible even in chronically famine-prone areas.

CONSEQUENCES OF FAMINE

The consequences of famine are physical, psychological, social, and economic. Malnutrition results from food shortage within weeks. Children fail to grow and cannot learn in school, and both adults and children experience weight loss, lack of energy, and decreased work ability. Permanent blindness can result from vitamin A deficiency that accompanies a deterioration of dietary quality. Malnutrition also puts people at a high risk of dying from common infectious illnesses. Diseases such as measles, malaria, pneumonia, and diarrhea are the most common causes of death during famine. Psychological impacts result from fear and uncertainty about having enough to eat or to feed one’s family. Socially, migration is a common occurrence during periods of famine, and resettling in other areas or in refugee camps disrupts social relationships and hierarchies. Lack of food also creates disharmony as people resort to desperate measures (such as stealing) in order to eat, or when old conflicts are renewed due to some groups having more food than others. Losing land ownership and selling valuable assets such as livestock, jewelry, or other goods can prevent families from recovering financially after a famine.

RESPONSES TO FAMINE

Responses to famine take place at the individual, governmental, and international level. At the individual level, families go through a series of progressively more drastic coping behaviors. First, food consumption becomes more restricted, and households attempt to generate more income to

purchase food. Adults will usually restrict their own food consumption in order to protect children. Typically, adults take on extra jobs and unemployed family members enter the labor force to earn additional money. If the stress continues, families borrow or accept donations from friends, relatives, or government agencies, and they may sell household items, livestock, or even vital assets such as seeds and land in order to obtain money to buy food. In extreme cases, people leave their homes and migrate to other areas in order to survive.

Responses at the government level depend upon how early an impending famine is detected and how prepared a government is to respond to the situation. For example, in Rajasthan, India, there is a governmental system of grain storage that can be distributed during periods of shortage. There are also programs in place for public works projects so that people can work for food during a crisis period. Furthermore, investment in roads, trains, and communications helps get food to people faster in times of need. In contrast, most of sub-Saharan Africa has little in the way of effective government antifamine plans and policies. Most of the sharing and distribution of food reserves takes place on an individual or community basis, and most countries do not have food stocks to distribute in case of emergency. Food must be imported, which is expensive, or countries are forced to rely on international food aid when famine threatens.

Many organizations provide food aid to countries and individuals during famines. The World Food Programme of the United Nations is the largest international mechanism for providing food aid where it is needed; up to date information can be found at the program's web site, <http://www.wfp.org>. The Hunger Site, at <http://www.thehungersite.com>, provides a world map where each click on a location is linked to donations from multiple donors to the World Food Programme. Many other governmental and nongovernmental organizations are also involved in responding to food emergencies as they arise.

PREVENTING FAMINE

Famine can be prevented in several ways. One strategy is to pay more attention to environmental issues, such as the rotation of crops to help to keep

the soil rich in nutrients or maintaining vegetative growth in fields year-round to keep soil from being blown or washed away. New agricultural technologies, including new fertilizers and pesticides and genetically improved crops, can also help avoid famine without harming the environment. Storing food during years of good harvest and redistribution of extra food and seeds to those who need them is another way of maintaining a food reserve. Finally, communication and coordination among communities and governments in need is essential to help prevent famine. Governments in famine-prone areas need to be able to predict in advance what areas may be vulnerable, assess needs, obtain food and necessary supplies, and transport these items to food-short areas in a timely manner. In Africa, a system called the Famine Early Warning System has had success in famine prevention. This program uses several methods to assess impending risks of famine. The program monitors weather in Africa and uses satellite photographs to see if plants are healthy or deteriorating. It also monitors crop growth, food availability, and prices in local markets.

Famines due to "natural" causes can be avoided through coordinated effort to keep governments and people alert and prepared and to provide mechanisms for people to get food when they need it. Food emergencies caused by war, civil strife, and political will depend on recognition of and respect for the fundamental right to food as a basic human right, and on enforcement of this principle in international law.

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(SEE ALSO: *International Health; Nutrition; Politics of Public Health; Poverty and Health; Refugee Communities; Right to Health; War*)

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FARM INJURIES

Agriculture is among the most hazardous occupations. It is, perhaps, the only industry where eight-year-olds and eighty-year-olds work in the same profession, side by side, operating large pieces of equipment. The death rate is four times that of all other industries combined. In 1993 there were 2,400 deaths, or 51 deaths per 100,000 farm residents. Typically, farm injuries are underreported. Farm vehicles account for half of the fatal farm injuries, the majority due to tractor accidents. Other problems include accidental amputation, hearing loss, respiratory diseases (including organic dust toxic syndrome, or ODTS), and higher incidences of some forms of cancer in the farm population. Farmers also suffer from high levels of stress. Farm work is difficult and demanding, and poor prices, weather conditions, and unstable markets all contribute to the stress level.

In 1991, 923,000 children under the age of 15 and 346,000 adolescents 15 to 19 years of age resided on U.S. farms and ranches. National Agricultural Worker's Survey data indicates that about 128,000 farmworkers between 14 and 17 years of age worked in crop production from 1993 to 1996, making up about 7 percent of all hired farmworkers.

It is estimated that 300 children younger than twenty years of age die of agricultural injuries on U.S. farms annually. This is a tragic statistic that is unique to agriculture. Approximately 32,800 agricultural-related injuries occurred among children and adolescents under the age of twenty who lived on, worked on, or visited a farm operation in 1998. The injuries occurred at a rate of 1.7 per every 100 farms. About 44 percent of the injuries that occurred to children were classified as work-related. Males are about four times more likely to suffer an injury than females. The most common types of nonfatal injuries include contusions, abrasions, and lacerations. Operating farm machinery, including vehicles, is the leading cause of farm deaths, and drowning is the second leading cause of death on farms.

There are an estimated 3 million to 4 million seasonal and migrant workers in the United

States, and 85 percent of all migrant workers are members of racial or ethnic minorities. Many of these workers are poorly paid and have very poor working conditions. Little data is available regarding their health status. The National Center for Farmworker Health estimates that the majority of farmworkers earn annual wages of less than \$7,500.

In the past, the U.S. Department of Agriculture's Cooperative Extension Service played a significant role in training farmers and their families about the risks associated with farming. These traditional programs were greatly enhanced with the establishment, in 1990, of the National Institute for Occupational Safety and Health (NIOSH) Agricultural Centers to conduct research, education, and prevention projects to address the nation's pressing agricultural health and safety problems. The centers are geographically distributed throughout the United States. Additionally, private organizations and farmer organizations have recognized the importance of injury-prevention programs.

MARK G. ROBSON

(SEE ALSO: *Immigrants, Immigration; Migrant Workers; National Institute for Occupational Safety and Health; Occupational Safety and Health; Safety*)

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FARR, WILLIAM

A British physician, William Farr (1807-1883), after statistical training in France, was appointed in 1839 as the compiler of abstracts in the newly established office of the Registrar of Births and Deaths in England and Wales, a position he held for over forty years. His tasks included the systematic review of tables compiled from the data contained in birth and death certificates. His *Annual Reports* set a pattern for the ideal in careful, critical analysis of and commentary on national tables of vital statistics that many other official statisticians have sought to emulate. Farr's eloquent and moving language, however, has rarely been equaled. In

his reports, columns and numbers came to life to tell a devastating story of suffering and premature death—a story that moved political leaders to take action.

Farr is justly honored as a founding father of vital statistics. As a vital statistician he made many significant contributions to the development of what was a primitive aspect of statistics when he started his career. His work was subsequently compiled in *Vital Statistics*, an 1885 anthology of his writings edited by his protegee Noel Humphreys.

Farr developed the first mathematical models of epidemic diseases, which were based on empirical observations and described the genesis, growth, and decline of epidemics. He identified the distinctions between “healthy” and “unhealthy” districts, discerned the relationship between incidence and prevalence, invented the concept of person-years, conceived the idea for retrospective and prospective methods of study, and, with his Swiss colleague Marc d’Espigne, invented the first workable nosology of disease, the precursor of the *International Classification of Diseases (ICD)* that is as of 2000 in its tenth revision. He was one of a small company of men and women that included Florence Nightingale, John Snow, John Simon, and others who met regularly at the London Epidemiological Society during the 1850s and who were, collectively, the leaders of the nineteenth-century Sanitary Revolution.

JOHN M. LAST

(SEE ALSO: *Statistics for Public Health; Vital Statistics*)

FATS

Fats, or lipids, are a group of chemical substances in food that are generally insoluble in water. There are several classes of fats. The triglycerides (triacylglycerols) are the predominant constituent of vegetable and animal fats and oils. They are composed of a 3-carbon glycerol backbone and three fatty acids of various types. The character of the fat is determined by these fatty acids. Saturated fatty acids tend to make the fat “hard” or solid at room temperature and are associated with an increased risk of heart disease. Monounsaturated fatty acids are prominent in olive and canola oils and do not

increase the risk of heart disease. The third group of fatty acids, the polyunsaturated fatty acids, are important components of omega-3 fish and plant oils. They play a role in blood clotting and in inflammatory responses in the body.

Phospholipids are closely related to triacylglycerols, except that one of the carbons on the glycerol contains one of several phosphate groups; the other two carbons have fatty acids. A third group, related to the first two, is the sphingomyelins and other complex brain lipids.

Cholesterol and its precursors are another group of fats that are essential for membranes; these are chemically composed of several 5- and 6-membered carbon rings. Steroids make up a fifth group of fats. Steroids are derived from cholesterol and include the androgens and estrogens, among others.

GEORGE A. BRAY

(SEE ALSO: *Blood Lipids; HDL Cholesterol; LDL Cholesterol; Lipoproteins; Triglycerides; VLDL Cholesterol*)

FECAL OCCULT BLOOD TEST

See Colorectal Cancer

FECUNDITY AND FERTILITY

Literally, “fecundity” means the ability to produce live offspring, and “fertility” means the actual production of live offspring. So fecundity refers to the potential production, and fertility to actual production, of live offspring. Fecundity cannot be measured, but it can be assessed clinically. Fertility and its impairments and aberrations are recorded for individuals in their medical charts and are measured in the population by routinely collected vital statistics about reproductive outcomes such as births, stillbirths, miscarriages, and so on. Fecundity and fertility are often confused. The confusion is further confounded by the fact that in French the meanings of the two similar-sounding words are reversed: *fécondité* means “fertility,” and *fertilité* means “fecundity.” Communication among demographers and others about these demographic

details therefore requires care and awareness of this fact.

JOHN M. LAST

(SEE ALSO: *Pregnancy; Reproduction*)

FERTILITY

See *Birthrate and Fecundity and Fertility*

FETAL ALCOHOL SYNDROME

Fetal alcohol syndrome, or FAS, refers to a consistent pattern of birth defects found in some individuals whose mothers drank alcohol during their pregnancy. It is the most devastating outcome of prenatal alcohol exposure. Fetal alcohol effects (FAE) refers to a condition in which fewer of the elements of FAS are present.

FAS is permanent and cannot be reversed or cured, although some aspects may change as a child grows or be ameliorated with proper environments. Small physical size often remains throughout life, beginning with low birth weight and short length at birth. Some characteristics may seem to change as the child grows; for example, some of the characteristic facial features of FAS can become less obvious. However, other problems worsen with age. For example, academic difficulties may not be noticeable until early school age, and some behavioral problems are manifested during the teenage years.

Multiple mechanisms may be involved in the way alcohol affects the fetus. Alcohol interferes with the development and function of nerve cells and can result in cell death. Alcohol consumption can act indirectly by affecting blood flow from the mother to the fetus. In that respect, acetaldehyde, a by-product of the metabolism of alcohol, may be a contributing factor to FAS, although alcohol is the primary cause. No single mechanism has been found to be the sole cause; instead, there appear to be numerous mechanisms, sites, and risk factors.

ETIOLOGY OF FAS

For well over a century, artists and popular writers have depicted disabilities among the children of

alcoholic mothers, but, until the 1960s, medical professionals believed that the placenta acted as natural barrier to toxic substances. It is now known that alcohol is a teratogen that is, it causes malformations in the developing embryo. Scientific knowledge changed when French (Lemoine et al., 1968) and American researchers (Jones and Smith, 1973; Ulleland, 1972) reported on patterns of malformations in infants born to mothers who drank excessively. Since then, over 6,000 journal articles have reported research describing the prenatal effects of alcohol, with the cumulative evidence leaving little doubt regarding the adverse outcomes of heavy alcohol exposure. Longitudinal studies following children and adults with FAS since the 1970s have been descriptive of the physical, cognitive, and behavioral characteristics. Other animal and human studies have examined specific aspects, such as precise areas of brain damage, and the effects of moderate alcohol use.

DIAGNOSIS AND DESCRIPTION OF FAS/FAE

FAS requires a medical diagnosis. Both Astley and Clarren (1997) and the Institute of Medicine (Stratton et al., 1996) have written criteria for diagnosis. Each includes as criteria: (1) known prenatal alcohol exposure; (2) growth deficiency; (3) characteristic facial features such as narrow upper lip, short palpebral fissures (eye openings), and indistinct philtrum (groove above upper lip); and (4) central nervous system involvement. The diagnosis of FAE requires confirmation of maternal alcohol use, along with fewer other criteria. Both sets of criteria also consider a diagnosis of FAS and FAE without confirmation of maternal alcohol use, which is less certain since many of these outcomes can have other causes. The term "partial FAS" has been suggested as a replacement of FAE, although others realize a continuum of effects, and prefer the term "FAS/FAE." Related terms are "alcohol-related birth defects" (ARBD), which refers to any defect caused by alcohol, and "alcohol-related neurodevelopmental disorder" (ARND), which refers to neurodevelopmental problems. These conditions may not warrant a diagnosis of either FAS or FAE.

FAE should not be considered less severe, since the behavioral or learning problems can

cause lifelong difficulties. FAE often goes undiagnosed in the absence of the more readily identifiable physical characteristics.

BEHAVIOR AND COGNITIVE OUTCOMES

Extensive and serious behavioral and cognitive abnormalities are associated with FAS/FAE. These characteristics result from prenatal brain damage and cannot be reversed, although with proper care many problems can be lessened. For example, many children with FAS/FAE become uncontrollable with too many audible and visual stimuli, including bright colors, competing noises, and many people around them. Altering the environment can help reduce these problems. Another common characteristic is the inability to learn from past experiences, and parents have found that pictorial reminders of daily routines help reduce frustrations for both the child and caregivers.

Some outcomes of prenatal heavy alcohol use are noticeable at infancy, including sleep disturbances and fine motor dysfunction. During preschool years, fitful sleeping and lack of coordination persist, and other problems develop, especially attention deficit disorder, hyperactivity, and impulsivity, which may result in an individual being more accident-prone. Hypersensitivity to touch is also common. Social problems often seen in children with FAS/FAE include an inability to distinguish friends from strangers, difficulty in forming friendships, and being overly friendly with adults. Overly talkative behavior is characteristic and is often confused with good language abilities, but there may be little meaningful content. Many children have low thresholds for frustration, have frequent temper tantrums, and demand constant attention and supervision. These characteristics, and others, are commonly described in children with FAS/FAE, although every child may not have these characteristics. For school-aged children, the most frequently reported and specifically studied behavioral characteristics are attention deficit, hyperactivity, and impulsivity, which Mattson and Riley (1998) have called the "hallmark features" of FAS/FAE.

Another serious consequence of prenatal heavy alcohol exposure is the very high prevalence of mental retardation. However, some children with

FAS/FAE have IQs within the normal range, although those with the most severe facial abnormalities and growth retardation are most likely to have learning problems. The range of IQ scores is higher amongst those with FAE than those with FAS. Many children have difficulties with language and mathematics. For adolescents and adults, the earlier cognitive and behavioral problems persist and new problems arise.

People with FAS/FAE are often accused of lying, although more often their stories change in order to please the listener. Typically, they seem unable to appreciate the consequences of their actions. They are often accused of behaviors such as stealing, although in reality they may take things because of an inability to see a connection between an item and its owner. Abstract reasoning and problem-solving skills also pose difficulties.

Understanding these common characteristics allows those working or living with people with FAS/FAE to realize that they are not necessarily prone to stealing or lying, but that they have problems with reasoning, understanding concepts, and language. Secondary problems arise from these difficulties. A U.S. study found that 60 percent of people with FAS over age eleven had been in trouble with the law, and a study of the Canadian criminal justice system found that 23 percent of youths remanded for forensic assessment were found to have FAS. These rates are well above the estimated worldwide incidence rates of FAS.

PUBLIC HEALTH BURDEN

The FAS incidence rate has been derived from a number of countries and is estimated to be 0.97 per 1,000 live births in the general population. The incidence of FAE is estimated to be ten times higher than FAS. The rates vary depending on the community, with some isolated, disadvantaged communities having much higher rates. FAS/FAE is a leading cause of birth defects, and may be the most common cause of mental disabilities, more common than Down syndrome (1 per 600 live births) and spina bifida (1 per 700 live births).

Beyond numbers of cases, there is a public health burden relating to cost. Estimates have been in the millions of dollars when health care, special schooling, and other costs are tallied in caring for children with FAS.

RISK FACTORS

Not all children whose mothers drank heavily during pregnancy have FAS. The extent and type of alcohol-related disabilities depend on the amount, pattern, and timing of exposure, the length of time during which the mother drank, nutrition, and other maternal health factors. Heavy alcohol exposure can come through daily drinking or drinking large amounts at one time. This refers to the pattern of drinking, and binge drinking (5 or more drinks at any occasion) is particularly risky for the fetus. Multiple maternal factors increase the likelihood of FAS, including older age, greater parity (having had previous children), and being a cigarette smoker. Poverty is considered to be a major determinant of the occurrence of FAS, and as Abel (1995) notes, "FAS is not an equal opportunity birth defect."

PUBLIC HEALTH MESSAGE

Various strategies have been used to decrease the use of alcohol during pregnancy, ranging from warning signs in places where alcohol is sold to midwives assisting those most at risk to improve health during pregnancy. Despite recognition of this serious birth outcome, many physicians still fail to recognize alcohol use in their patients and fail to diagnose FAS/FAE. Some medical professionals believe that until there are better treatment facilities for substance-abusing pregnant women, there is little value in identifying problem drinking. Public health messages note that women should either reduce heavy alcohol use during pregnancy or, if heavy drinking continues, delay becoming pregnant. The important aspect of FAS/FAE is that it is entirely preventable.

M. ANNE GEORGE

(SEE ALSO: *Alcohol Use and Abuse; Congenital Anomalies; Maternal and Child Health; Pregnancy; Prenatal Care*)

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FETAL DEATH

Fetal death, or stillbirth, means death of the product of conception before complete expulsion or extraction from its mother. Death is indicated by the absence of all signs of life, such as beating of the heart or pulsation of the umbilical cord. The term is statistically defined differently in various jurisdictions, but generally alludes to death after

either twenty or twenty-eight weeks gestation. Death of the fetus before this duration of pregnancy is referred to as miscarriage.

JOHN M. LAST

(SEE ALSO: *Fecundity and Fertility; Pregnancy; Reproduction*)

FIBER

Denis Burkitt (1911–1993), a British surgeon and medical researcher, is usually credited with popularizing the idea that dietary fiber may protect against the development of chronic diseases such as diabetes, hypercholesterolemia, heart disease, diverticular disease, and colon cancer that are prevalent in Western countries. Writing in the 1970s and 1980s, Burkitt described the relationship between large stools, which reflect a high intake of plant foods rich in dietary fiber, and a lack of “Western diseases,” as he called them.

Dietary fiber is plant cell material that resists digestion by the endogenous enzymes of humans. It is not really an accurate term, as many of its components are not fibrous. Gums and mucilages, for example, are classified as dietary fiber because mammalian enzymes or secretions do not digest them. Only one component of dietary fiber, cellulose, is truly fibrous; yet “dietary fiber” is the accepted term for describing the roughage in the human diet.

Dietary fiber is found only in plant products, including fruits, vegetables, nuts, and grains. The most concentrated sources of dietary fiber are the bran layers of grains, such as wheat bran. Because of their higher water content, fruits and vegetables provide less dietary fiber per gram of ingested material than grains and cereals.

Recommendations for adult dietary fiber intake generally fall in the range of 20 to 35 grams per day. For children, the general rule is to add five to a child’s age to determine the number of grams of fiber to be consumed daily. Thus, a ten-year-old child should consume 15 grams of dietary fiber a day. Usual intakes of dietary fiber in the United States average only 11 grams per day, so few people get the recommended amount. Most of the

popular foods Americans consume contain little dietary fiber. For example, most servings of grains, fruits, and vegetables contain 1 to 3 grams of dietary fiber. Thus, to get the recommended amounts of dietary fiber one would need to consume at least ten servings of fiber-containing foods per day. Dietary fiber content of foods is listed on the Nutrition Facts panel on food packages. Foods particularly high in dietary fiber include bran cereals, which contain up to 13 grams of dietary fiber per serving, and beans and legumes, which contain more than 5 grams of dietary fiber per serving.

Several epidemiologic studies indicate that a high intake of dietary fiber protects against most chronic diseases. This is true even when confounding variables such as fat and calorie intake are accounted for. Dietary fiber may protect against large bowel cancer by enhancing the environment of the large intestine. Dietary fiber escapes digestion in the small intestine and is fermented in the large intestine by intestinal microflora. This fermentation yields short-chain fatty acids and gases. Short-chain fatty acids, including butyrate and propionate, have interesting physiological properties. Butyrate is a preferred gut fuel for the cells in the colon. Additionally, propionate may be involved in the cholesterol-lowering effects of certain dietary fiber. Dietary fiber fermentation may also enhance the number of beneficial microflora, such as bifidobacteria and lactobacillus. However, two recent large intervention studies did not find any protection in polyp prevention, which has led to questions about whether fiber should be recommended to prevent colon cancer (Goodlad, 2001).

Dietary fiber is an accepted therapy for gastrointestinal disorders such as constipation and diarrhea, and is often consumed as bulk laxatives or high-fiber breakfast cereals. Fiber may also protect against other cancers. International comparisons show an inverse correlation between breast cancer death rates and consumption of fiber-rich foods.

Dietary fiber has also been shown to be effective in reducing serum cholesterol, and it may decrease the risk of coronary heart disease by decreasing serum lipids, lowering blood pressure, improving glucose metabolism, and aiding in weight control. Soluble fibers appear to be the most effective in lowering serum cholesterol. The U.S. Food and Drug Administration (FDA) has accepted health claims for the cholesterol-lowering ability

of oat bran and psyllium fiber. A significant reduction in serum cholesterol by soluble fiber was observed in sixty-eight of the seventy-seven human studies reviewed in a meta-analysis. Often, soluble fibers also decrease low-density lipoproteins (LDL) while maintaining high-density lipoproteins (HDL). Multiple mechanisms appear to be involved in the hypocholesterolemic response, and mechanisms for lowering cholesterol may vary considerably among the various sources of dietary fiber.

Some clinical research suggests that dietary fiber may also play a role in improving blood-sugar control in diabetes. Dietary fiber, especially soluble fiber, can delay glucose absorption and reduce insulin requirements in both insulin-dependent and non-insulin-dependent diabetes mellitus. Obese persons with diabetes often respond to a high-fiber diet with weight loss and decreased insulin requirements.

The best way to get dietary fiber in the diet is to consume a wide range of grains, legumes, fruits, and vegetables. Concentrated fiber sources such as bulk laxatives, fiber supplements, and foods fortified with fiber may be useful in the prevention and treatment of bowel disorders and as lipid-lowering therapies. Fiber supplements should be taken under medical supervision, since bowel obstructions, dehydration, and other medical contra-indicators have been reported with their use.

JOANNE SLAVIN

(SEE ALSO: *Chronic Illness; Coronary Artery Disease; Foods and Diets; HDL Cholesterol; LDL Cholesterol; Nutrition*)

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FIELD SURVEY

A field survey, or study, is an investigation, generally a descriptive study, done "in the field," usually with participants drawn from the general population of a community. The term applies to several varieties of epidemiological study, such as case-finding and contact-tracing in epidemics, or to household and community surveys, where the goal is to ascertain details about aspects of health status. Field studies may be small-scale, modest affairs, or large, comprehensive, communitywide studies in which large numbers of participants are engaged.

JOHN M. LAST

(SEE ALSO: *Community Health; Descriptive Study; Survey Research Methods; Surveys*)

FILTH DISEASES

The phrase "filth diseases" was coined in 1858 by British physician Charles Murchison to describe a class of conditions, mostly caused by infectious pathogens, that were associated with squalid living conditions—the overcrowded, unsanitary, and vermin-infested dwellings that were all too numerous in urban areas in the nineteenth century. It was an evocative phrase, popular with social reformers and pioneers of the Public Health movement and the Sanitary Revolution. It was not so much pejorative as accusatory, attributing blame for these diseases to the living conditions rather than to the people forced to live that way. Its use was a political lever that moved public opinion in favor of reforming the conditions that led to so much disease, disability, and premature death.

The filth diseases included infections of the gastrointestinal and respiratory tracts—diarrhea and dysentery, typhoid, croup, bronchitis, pneumonia, and tuberculosis—and skin diseases such as scabies and ringworm. Conditions associated with verminous bedding and clothing, such as louse-borne typhus, also turned out to be filth diseases although they may have not been identified as such at the time. Bubonic plague, long associated with rat-infested dwellings, was another filth disease, though fortunately its visitations were uncommon. One of the goals of nineteenth-century public health reformers was the eradication of filth

diseases, which meant improving the housing and living conditions of working people. This in turn depended on better wages and working conditions, so social and economic reform were inseparable from public health reform.

JOHN M. LAST

(SEE ALSO: *Communicable Disease Control; Environmental Determinants of Health; Poverty and Health; Social Determinants*)

FINANCE AS A CAREER

As the amount of money spent on public health continues to increase—from \$6.7 billion in 1980 to \$36.6 billion in 1998 in the United States, according to the Health Care Financing Administration—the role of the fiscal officer in not-for-profit public health programs and organizations becomes more demanding, more diverse, and more important. Concentrated in city and county health departments, the major responsibilities of fiscal officers are budgeting and grant reporting. New sources of funding and tighter standards for performance require that the fiscal officer be an integral part of management teams. Active participation in professional organizations such as the American Public Health Association is essential to the career development of fiscal officers working in public health. Training in government is a prerequisite for this career path.

ANDREW J. DOYLE

(SEE ALSO: *American Public Health Association; Benefit-Cost Analysis; Budget; Economics of Health*)

FINLAY, CARLOS

The importance of Carlos Finlay (1833–1915) in the discovery of the mosquito vector of yellow fever has often been overshadowed by the fame of his American colleague and friend, Walter Reed. A Cuban physician of Scottish ancestry, Finlay trained in France and at Jefferson Medical College in Philadelphia. In 1881, he published his theory that a microbial agent transmitted from person to person by mosquito bites was the cause of yellow fever. Isolated in his views for the rest of the

century, Finlay performed careful mosquito breeding experiments and identified the correct yellow fever vector, *Aedes aegypti* (then called *Stegomyia fasciata* or *Culex fasciatus*). However, he failed to produce experimental yellow fever in human volunteers by exposing them to mosquitoes fed on yellow fever patients, possibly because he did not recognize the long incubation period of the yellow fever agent inside the mosquito.

Finlay was also one of several nineteenth-century bacteriologists who mistakenly believed that they had isolated a specific microbial cause of yellow fever (shown, in the 1930s by Max Theiler, to be a virus), but Finlay's *tetragenus*, like Guiseppe Sanarelli's *Bacillus Icteroides* and Domingo Freire's *micrococcus*, proved to be a harmless contaminant. The experimental proof of the mosquito transmission pathway was obtained in Walter Reed's experiments with U.S. Army volunteers near Havana in the summer of 1900. Finlay supplied the eggs from which the mosquitoes used in the experiments were hatched, and Reed was careful to credit the importance of Finlay's work in each of his publications describing his experiments. Finlay served as president of the Cuban Board of Health for several years in the early twentieth century.

NIGEL PANETH

(SEE ALSO: *Reed, Walter; Yellow Fever; Vector-Borne Diseases*)

FLOODS

See Natural Disasters

FLUORESCENT TREPONEMAL ANTIBODY ABSORPTION

The fluorescent treponemal antibody absorption (FTA-ABS) test measures a specific antibody made against *Treponema pallidum*, the bacterium that causes syphilis. The test is reserved for confirmation of a positive screening test for syphilis and distinguishes patients with true infection from those with a false positive result of a screening test. Once a person tests positive, he or she will usually test positive for life. Therefore, the test cannot be used to measure disease activity or differentiate past from present infection.

The FTA-ABS is performed by first heating a patient's serum and mixing it in an extract of nonpathogenic treponemes called "sorberent." This step removes any cross-reacting antibodies that may have developed against treponemes that naturally reside in the human mouth or genital tract. The serum is then layered onto slides containing *T. pallidum*. Anti-human antibodies labeled with a fluorescent indicator are added, and the slides are examined under a fluorescent microscope. The intensity of fluorescence is quantified using a one (weakly positive) to four (strongly positive) scale. Though very sensitive and highly specific for syphilis, this test tends to be expensive, subjective, and time-consuming, as it requires interpretation by an experienced technician.

JUDITH E. WOLF

(SEE ALSO: *Antibody, Antigen; RPR Test; Syphilis; VDRL Test*)

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FLUORIDATION

See Community Water Fluoridation

FLUOROSIS

See Dental Fluorosis

FOLIC ACID

Folic acid, one of the B vitamins, is necessary to make DNA and is, thus, essential for cell division. Folate deficiency causes serious birth defects and anemia, and it increases the risk for heart attacks and strokes. The United States Public Health Service, in 1992, and the Institute of Medicine, in 1998, recommended that all women of reproductive age consume 400 micrograms of synthetic folic acid to prevent birth defects. Most people are folate-deficient unless they eat approximately 400 micrograms of synthetic folic acid per day, either from a vitamin pill or from foods sufficiently

fortified with synthetic folic acid. Governments that require adding a sufficient amount of folic acid to centrally processed and commonly eaten foods, such as flour and cornmeal, can eliminate folate deficiency.

GODFREY P. OAKLEY, JR.

(SEE ALSO: *Foods and Diets; Micronutrient Malnutrition; Nutrition; Prenatal Care;*)

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FOLK MEDICINE

Folk medicine has existed for as long as human beings have existed. In an effort to cope with an environment that was often dangerous, humans, and their ancestors, began to develop ways of lessening pain and treating physical and mental problems. At first, many of the ways of treating these problems undoubtedly came through trial and error, using various plants and other methods derived from observation of how animals reacted to and treated illnesses and injuries. Over time, individuals within family and tribal groups became more skilled at helping the sick and injured, and some of these became responsible for carrying out healing ceremonies, religious rituals, and other rites designed to ensure the safety and health of their communities.

Many of the methods for treating injuries and diseases have been passed down through families for generations, and some of these have been adopted for use by the medical profession. Those treatments not commonly believed to fit within the framework of modern medical practice are commonly identified as folk medicine. Illnesses whose etiologies are not recognized by Western medical practice are known as folk illnesses. Folk illnesses are shaped by the cultural and ethnic groups from which they emerge. They are specific to the cosmology of the cultural and ethnic group

to which they belong and they have specific causative, diagnostic, preventative, and healing/curing practices that may vary significantly from how they may be viewed by modern medical practitioners. For example, liver grown is a folk illness found among Pennsylvania Germans. This illness is believed to occur when the liver has become attached to the ribs or some other part of the body cavity. The illness is thought to be more common among children and caused by exposure to a strong wind. It may also be the result of staying outside too long or from being shaken up while traveling. In the American South, the most common symptom in a child is failure to thrive in the child. The illness is diagnosed by feeling the lower chest and seeking to find the flesh pulled inward. Treatment may involve stretching the child's arms and legs behind them to loosen the liver or by passing them through a warm horse collar, bramble bush, or other similar process.

It is important to understand that some folk illnesses have common symptoms that are treated by Western medical practitioners, while other symptoms may not be understood by Western medicine to mean the same sort of thing. In the previous example, failure to thrive has a specific Western medical connotation and treatment approach that is different from that employed by those believing in liver grown.

In attempting to understand folk medicine, a number of researchers have noted that these remedies are often learned and passed down from parent to child, and the explanations for illness causation and treatment go hand in hand with this learning process. They have come to classify folk medicine into four major categories: the patient world, the natural world, the social world, and the supernatural world. The patient world is concerned with illnesses caused by factors that the patient has some control over, such as diet, smoking, drinking, and other lifestyle behaviors. The natural world includes problems related to animate and inanimate factors, including those caused by microorganisms and viruses; animal bites; and environmental factors such as pollution, pollens, poisons, and natural disasters. The social world covers interpersonal conflicts, including conditions caused by physical injury inflicted by one person on another, the stresses of daily living, and witchcraft and sorcery. The supernatural world includes illnesses caused by spirits, ancestors, or gods who

have been offended through sinful behavior, the breaking of taboos, or other breaches of proper behavior.

Folk medicine practitioners use a variety of methods to treat illnesses. These practitioners go by many names, including shaman, curandero, root doctor, spirit medium, herbalist, native healer, medicine man, kahuna, and other related terms. Each has specific treatment approaches, which may include prayer, dancing, medicinal herbs, massage, sweat baths, coining (a process of rubbing the skin with a metal coin), cupping (a treatment used to draw blood to the surface of the skin by means of a small heated vessel made of horn, ceramic, or bamboo), hot and cold foods, and other practices not normally considered in modern biomedicine. Often these practitioners are the first to be consulted when a family member becomes ill. They are easy to access, tend to share the same illness causality beliefs, will come to the home day or night, and are much less expensive than a clinic, hospital, or doctor's office visit. Folk medicine practitioners are also often consulted when home remedies fail. If the practitioner also fails, then consultation with the biomedical community may occur.

In addition to the medical practices employed by traditional healers, there has also evolved a profusion of folk healing practices that are not seen by either the folk healer or modern health practitioner. These home healing practices are handed down by word of mouth and are used to treat a variety of illnesses, including anxiety and depression, coughs and colds, burns and sunburns, bladder and kidney infections, bedwetting, bites and stings, asthma, arthritis, birthing problems, bleeding, diarrhea, fever, infertility, insomnia, skin problems, and mouth and gum disorders. Almost every family has some specific home remedy that has been learned and passed down by older family members, and even in the face of more modern health beliefs they will continue to use these folk remedies before seeking other biomedical treatment methods. For instance, in many families an aloe leaf is used to treat a burn, rather than a burn ointment or spray from the pharmacy. Other examples of folk medical treatments include the use of American ginseng as a sedative or tonic in the Appalachian Mountains; celery seeds to help treat rheumatism among British and German immigrants to the United States; and ginger to treat gas

or nausea in New England. In addition to these historical practices, the spectrum of folk medicine in the United States has been extended by the influx of new immigrant groups.

Magic animals have also been used in folk medical practices. Animal parts and by-products are used to treat certain illnesses or conditions—bird nests are used to prevent headaches, the tooth of a mole may be worn around the neck to prevent toothache, and fresh muskrat skin is used to prevent colds. Other animals thought to have healing properties include toads, snakes, eels, and earthworms.

Prayers are also used in folk medicine. In Appalachian and southern culture, “fire doctors” use prayer to alleviate the pain of burns. In Native-American and Asian cultures, prayer is used to cure soul-loss or ghost sickness. Prayer has been scientifically studied to determine its effects in helping people to get well or to feel better, and there is some evidence that it does have value in the treatment of illness and disease.

Other folk medicine remedies have been shown to be effective. One such remedy is the eating of live-culture yogurt to reduce vaginal yeast infections.

The placebo effect can, however, play a part in the efficacy of a treatment. A strong belief in a certain treatment can yield a positive outcome, even with a treatment that has been shown scientifically not to work. At the same time, some folk remedies, like modern medicines, can have serious, and sometimes fatal, side effects. Plants gathered to treat an illness may have been prepared improperly, or the wrong plant may have been picked along with the correct one, tainting the remedy. Some preparations may be too strong for some patients, particularly infants or those weakened by serious illness. The use of any herbal preparation should therefore be approached with great caution, even if purchased at a health-food store or other commercial outlet. Herbal remedies are not well regulated and may be dangerous to take.

Folk medicine exists side by side with modern medical practices, and is often at odds with it. This is primarily because it very often does not conform with what is scientifically known about the causes of illness and disease and what are thought to be the most effective medical treatments. For those who use and believe in folk medical practices, their

knowledge has been acquired from generations of others that have used the treatments. Folk medicine traditions stress the importance of balance and harmony within the body. A sense that each person is connected to the earth and the cosmos is very important, as is the belief that an illness should be treated with every resource available. Herbal preparations, prayer, magic, diet, exercise, and proper social relations are all viable tools in the effort to maintain health. For public health practitioners, an awareness of the diversity of health beliefs and practices that may be encountered among those who use more traditional folk medicine approaches, and the ability to suspend judgment about those who use them, is an important step in learning to work more effectively with the diverse folk medicine traditions they encounter in their practice.

ROBERT M. HUFF

(SEE ALSO: *Alternative, Complementary, and Integrative Medicine; Chinese Traditional Medicine; Cultural Identity; Customs; Faith Healers; Lifestyle; Shamanic Healing*)

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FOOD AND DRUG ADMINISTRATION

The U.S. Food and Drug Administration (FDA), an agency of the U.S. Department of Health and Human Services, advances the nation's welfare by

protecting consumers against health hazards that usually are beyond an individual's control. The agency's origins go back to the 1906 publication of Upton Sinclair's best-selling novel *The Jungle*, which described in graphic detail the filth and unsanitary practices then prevailing at the Chicago stockyards. The public's outraged response prompted the Congress to pass the Food and Drugs Act of 1906, the first federal law aimed at preventing interstate commerce in misbranded and adulterated foods, beverages, and drugs. Enforcement of this rather limited act was entrusted to the U.S. Department of Agriculture's (USDA) Bureau of Chemistry, which in 1930 became the FDA.

The weakness of the law was fully revealed in 1937, when a widely marketed toxic elixir of sulfanilamide killed 107 people, mostly children. Following another storm of public indignation, Congress passed the Federal Food, Drug, and Cosmetic Act of 1938 (FFDCA), which completely overhauled and greatly broadened the FDA's powers and responsibilities. The law's key provisions required new drugs to be shown to be safe before they could be marketed; defined adulterated and misbranded food; authorized standards of identity, quality, and fill-of-container for foods; and authorized the FDA to inspect facilities producing regulated products.

Even these sweeping provisions have failed at times to protect the public against new hazards, and Congress has strengthened the FFDCA by passing more than 200 amendments. Landmark additions to the act include the Kefauver-Harris Drug Amendments of 1962, which required manufacturers to prove that their medicines are effective as well as safe; the Medical Device Amendments of 1976, which extended similar requirements to medical equipment; and the FDA Modernization Act of 1997, which directed the agency to carry out its mission in close cooperation with other public health groups, both in the United States and abroad.

At the end of the twentieth century, the FDA's mandated responsibilities included ensuring the safety of the entire food supply (except for meat and poultry, which remained under the USDA's purview); making certain that all drugs, medical devices, vaccines, blood products, tissues for transplantation, and animal drugs and feeds are safe and effective when properly used; and assuring that cosmetics and devices that emit radiation do

no harm. All of these products, which are manufactured, transported, warehoused, and retailed by more than 110,000 establishments, are worth about \$1 trillion a year, or a fifth of all consumer expenditures. In 2000, the per capita cost of this protection was less than two cents a day.

The head of the FDA is the Commissioner of Food and Drugs, a presidential appointee who is confirmed by the Senate. About two-thirds of the FDA's 9,000 employees work in five product-focused centers. The FDA's Center for Food Safety and Applied Nutrition primarily ensures that food products do not contain hazardous pesticides or other contaminants, and that they are truthfully labeled. This center also works with producers to ascertain that genetically modified foods do not present a health risk. The other four centers—Evaluation and Research; Biologics Evaluation and Research; Devices and Radiological Health; and Veterinary Medicine—develop standards for product safety and effectiveness and make sure that the standards are met by reviewing the manufacturers' applications before allowing new health care products on the market.

In general, the application data must be derived from rigorously designed and controlled clinical trials that, for most drugs, include toxicity tests in animals, safety tests in healthy subjects, and studies of safety and effectiveness in large groups of patients. For the most complex drugs and devices, the FDA also relies on the recommendations of advisory panels of outside specialists who evaluate the products in public meetings. To be approved, each product's benefits must outweigh the risks of its use. Continued compliance of marketed products with FDA standards is ensured by the agency's inspectors, investigators, and food safety officers that are located in 174 communities from coast to coast and in Puerto Rico and by twelve national FDA laboratories.

The fast-growing U.S. dependence on imported food and health care products; the global spread of AIDS (acquired immunodeficiency syndrome); mushrooming international tourism; and the development of new, highly sophisticated food, pharmaceutical, and device technologies in the late 1900s greatly increased the complexity of the FDA's mission. To meet the new challenges, the FDA has developed strong scientific ties with academia and the private sector and worked closely with foreign

governments to enhance public health standards around the globe. By the onset of the twenty-first century, the FDA's role had expanded from protecting hygiene at Chicago stockyards to promoting cooperation with product regulators all over the world.

LAWRENCE BACHORIK

(SEE ALSO: *Benefits, Ethics, and Risks; Foods and Diets; Pharmaceutical Industry; United States Public Health Service [USPHS]*)

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FOOD-BORNE DISEASES

Defined by the World Health Organization (WHO) as diseases “of an infectious or toxic nature caused by, or thought to be caused by, the consumption of food or water,” food-borne diseases are an important cause of morbidity and economic loss worldwide. Countries that keep statistics (usually industrialized countries), may record tens of thousands of cases annually, but it is acknowledged that only a small proportion are reported centrally (see Table 1). A study in the early 1990s in England, for example, reported that only one in 136 cases of infectious intestinal diseases was recorded.

CAUSES OF FOOD-BORNE DISEASES

The agents that cause food-borne diseases include microorganisms, natural toxins, and chemical residues. Microorganisms, including bacteria, viruses,

Table 1

Reported and estimated annual cases and costs of food-borne disease in North America

Country	Reported Cases	Estimated Cases	Annual Cost
Canada	6 – 10 thousand	2 million	\$1 billion
United States	30 – 50 thousand	6 – 12 million	\$6 – 11 billion

SOURCE: Buzby et al.

parasitic protozoa, and worms, are the most commonly reported causes.

The list of food-borne disease agents is expanding; the last years of the twentieth century saw the emergence of *Campylobacter*, now a commonly reported causes of diarrhea; verotoxin-producing *Escherichia coli* (VTEC), initially linked to undercooked hamburgers and a cause of hemolytic uremic syndrome (HUS) in children; the protozoa *Cryptosporidium*, which is often linked to consumption of contaminated water, and *Cyclospora*, which has caused diarrhea in consumers of soft fruit from Central America. The most significant new agents may be “prions,” which have been linked to transmissible spongiform encephalopathies.

Bacteria. The mechanisms by which food-borne bacteria cause illness include the production of toxin in food before it is eaten or the production of toxin in the intestine, which is usually linked to multiplication of the organism in that environment. Illness is usually characterized by rapid onset, within hours or days, of vomiting and diarrhea, which may last a few hours or days in healthy people. Some pathogens, or their toxins, may escape the digestive tract and cause septicemia, meningitis, or localized internal infection. For example, the toxins of VTEC damage the tissues of the intestines and kidneys, causing hemorrhagic colitis and HUS, potentially leading to kidney failure. Common food-borne bacteria, their mode of action, and symptoms are listed in Table 2.

Viruses. Food and drink can also transport viruses, which replicate in living cells. The symptoms of viral infection reflect the tissues (organ) infected and the degree of damage caused. For example, enteric viruses (e.g., Norwalk virus) cause

Table 2

Common Bacteria Causing Food-Borne Illness		
Bacteria	Main Symptoms	Incubation
Produce toxins in food:		
<i>Staphylococcus aureus</i>	Vomiting	2 – 6 hours
<i>Bacillus cereus</i>	Vomiting or diarrhea	1 – 16 hours
<i>Clostridium botulinum</i> (botulism)	Headache, double vision, paralysis, death	12 – 96 hours
Release toxins in intestines:		
<i>Clostridium perfringens</i>	Diarrhea, stomach pains	8 – 22 hours
Rapid multiplication in intestine:		
<i>Salmonella</i> species	Diarrhea, fever, headache, some vomiting	6 – 48 hours
<i>Campylobacter</i> species	Fever, headache, diarrhea, stomach pains, nausea	2 – 8 days
<i>Escherichia coli</i> – VTEC	Cramps, vomiting, fever, bloody diarrhea, hemolytic uremic syndrome (HUS)	1 – 5 days
<i>Shigella</i> species	Diarrhea, vomiting, fever, cramps	1 – 7 days
<i>Vibrio cholera</i> 01	Profuse diarrhea, dehydration	1 – 3 days
<i>Yersinia enterocolitica</i>	Diarrhea, fever, severe abdominal and joint pain	1 – 7 days
<i>Vibrio parahaemolyticus</i>	Watery diarrhea, cramps, fever, vomiting	4 – 30 hours
Extraintestinal infection:		
<i>Brucella abortus</i> (brucellosis)	Fever, joint pains, weight loss, depression	5 – 60 days*
<i>Listeria monocytogenes</i> (listeriosis)	Fever, vomiting, diarrhea, headache, constipation, meningitis, septicemia	1 – 8 weeks† about 3 weeks
<i>Salmonella typhi</i> (1/c t) and (typhoid fever)	Fever, constipation, headache	1 – 4 weeks

* Can last as long as several months.
† Can be as short as one day.

SOURCE: Courtesy of author.

acute vomiting and diarrhea twenty-four to forty-eight hours after infection. In comparison, Hepatitis A virus targets the liver, resulting in fever and jaundice two to eight weeks after infection. Food contaminated by infected human feces is the likely source of these viruses. Outbreaks are associated with filter-feeding mollusks (e.g., oysters) harvested from sewage-contaminated seawater, infected food handlers, and fresh produce (e.g., salads and soft fruit) infected by contaminated irrigation or rinse water or during handling.

Parasites. Many parasites, including protozoa and worms, are transmitted by contaminated food or water. The risk of infection exists wherever standards of sanitation, hygiene, drinking water quality, and meat inspection are suspect. The protozoa *Giardia* and *Cryptosporidium* are important causes of diarrhea in developing and industrialized countries, and are linked particularly to contaminated water. More recently, *Cyclospora* has caused outbreaks of diarrhea in North America linked to contaminated berries.

Tapeworms (e.g., *Taenia*) and the nematode *Trichinella spiralis*, which causes trichinosis, are among the commonly reported food-borne worms. These parasites have complicated life cycles, and human infection usually occurs when meat containing parasite cysts or eggs is consumed. Developing larvae then migrate from the intestines to other tissues. Symptoms vary with the infecting agent, from inapparent to fatal illness, and include gastrointestinal symptoms, muscle pain, and neurological and cardiac symptoms.

Prions. In 1986, “mad cow disease” or bovine spongiform encephalopathy (BSE) was first identified in the United Kingdom. The disease spread rapidly in cattle and is characterized by behavioral changes, lack of coordination, weakness, and death. BSE was thought to infect only bovines, but increasing numbers of human cases of a variant of Creutzfeldt-Jakob disease (vCJD), first recognized in the UK in 1996, have been linked to eating meat from BSE-infected cattle in Europe, particularly in the United Kingdom. Approaches to reduce the

Table 3

Factor contributing to outbreaks	Food-handling practices commonly linked to outbreaks of bacterial food-borne disease			
	Salmonella	Clostridium Perfringens	Staphylococcus Aureus	Bacillus Cereus
Food prepared too early	✓	✓✓	✓	✓✓
Stored at room temperature	✓	✓✓	✓	✓✓
Not properly cooked	✓	✓✓		✓
Not properly reheated	✓	✓✓		✓✓
Undercooked	✓			
Contaminated canned food			✓	
Not properly thawed	✓			
Cross contamination	✓			
Improper warm holding		✓		✓
Infected food handler			✓	

Based on analysis of 1,479 outbreaks in England and Wales, 1970 - 1982, by Diane Roberts.
 ✓ = reported in 10% - 49% of outbreaks
 ✓✓ = reported in 50% or more of outbreaks

SOURCE: Roberts, D. (1982). "Factors Contributing to Outbreaks of Food Poisoning in England and Wales 1970-1979. *Journal of Hygiene* 89 (3) 491-498.

risk of human infection have included depopulation of infected herds and rigid controls on the movement of cattle and bovine products. The effectiveness of these measures in limiting the spread of disease is unclear.

Natural Toxins. Toxins exist naturally in plants (e.g., haemagglutinins in haricot beans), fungi, including mushrooms and moulds (e.g., aflatoxins produced by the mold *Aspergillus flavus*); and animals (e.g., tetrodotoxin, a neurotoxin present in puffer fish and some amphibians). Toxic substances may result from natural decomposition processes; for example, scombrottoxins (histamines) released during decomposition of scombroid (e.g., tuna) and other fish cause flushing, sweating, headache, nausea, dizziness, and a peppery taste within minutes of consumption.

Normally safe plants and animals can pick up natural toxins, chemicals, and pollutants from their environment. Potent neurotoxins produced by algae (e.g., *Gonyaulax*, *Pyrodinium*, *Gymnodinium* species) accumulate in filter-feeding mollusks. Human intoxication usually coincides with algal blooms in harvesting areas, and results in sporadic cases and outbreaks of, for example, paralytic shellfish poisoning and other types of diarrhetic or neurotoxic poisoning. For example, an outbreak of amnesiac shellfish poisoning traced to mussels affected over one hundred people and caused three deaths, in Canada in 1987; memory problems and other neurologic symptoms were prolonged in severe cases. Incidents of human disease due to contaminated shellfish are reduced by regular monitoring of harvesting areas during high-risk periods. A further example, ciguatera fish poisoning, is common in tropical areas, such as the Caribbean and Pacific Islands. Algal toxins accumulate in reef fish, particularly large predators. Early gastrointestinal symptoms are followed one to two days later by neurologic symptoms.

Chemical Poisoning. Food-borne illness may result from chemical contamination of food or drink due to inappropriate use of pesticides and herbicides, contamination by cleaning agents during food preparation, leaching of chemicals from containers or the environment, or accidental or deliberate adulteration during food processing or preparation.

A devastating example of chemical poisoning followed deliberate adulteration of cooking oil in Spain in 1981 and 1982. An estimated 20,000 people were affected, about 350 died, and others suffered serious long-term illness.

PREVENTION OF FOOD-BORNE DISEASES

Food-borne diseases present public health challenges related to food-handling practices, as described by Diane Roberts, who analyzed causal factors in over 1,400 outbreaks (see Table 3). Other important factors include:

- Globalization of the food supply, resulting in rapid, international distribution of raw and processed foods and exposure to

foods produced in less well-regulated environments.

- Economic pressures to provide products as cheaply as possible, requiring large scale production and distribution processes.
- Traditional food production and handling practices that may be inappropriate in the modern production and retailing environment.
- Public and political expectations about the safety of the food supply.
- Population-health factors that may increase risk of illness, including age (the young and elderly), existing illness (e.g., cancer), inherited traits (e.g., sickle cell disease; HLA B-27 susceptibility to reactive arthritis), and depressed immunity (from AIDS, cancer treatment, transplants, pregnancy, and poor nutrition).
- New pathogens and antibiotic-resistant strains possibly related to environmental factors and changes in farming and husbandry practices.

The response to these challenges involves government, the food industry, the public health community, and the public.

Government action encompasses legislation to regulate the conditions under which foods are produced, distributed, and retailed, and the development of codes of good practice. Governments may collect statistics to monitor the incidence and causes of food-borne disease, and they may act to protect the public by investigating disease outbreaks and withdrawing unsafe products from sale.

Modern processors and manufacturers generally adopt procedures to minimize risks of contamination, (e.g., the Hazard Analysis Critical Control Point [HACCP] approach) and to ensure product quality and safety through quality control procedures. The public health community is concerned with the development and enforcement of standards in manufacturing, processing, and retailing. Finally, the public, by becoming educated about food safety, can protect themselves by adopting appropriate hygiene practices in food preparation, and by ensuring food retailers maintain high

standards of hygiene by reporting poor practices to public health authorities.

PAUL N. SOCKETT

(SEE ALSO: *Bovine Spongiform Encephalopathy; Campylobacter Infection; Cryptosporidiosis; E. Coli; Foods and Diets; Pathogenic Organisms; Prions; Trichinosis; Waterborne Diseases*)

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FOODS AND DIETS

Humans have evolved to depend on a continuous supply of energy (calories) and nutrients from edible plants and animals. From the dawn of civilization, humans have been omnivores. Early humans hunted or gathered whatever foods were available in the immediate environment, as determined by geography, climate, and season. The precise number of foods eaten by humans is uncertain; scientists estimate that at least twenty thousand plants have edible parts. To these must be added fungi and algae, as well as foods derived from mammals, fish, seafood, birds, eggs, milk, and exotic animals. Among food plants, about 150 have been domesticated and are cultivated on a large scale, but only about twenty constitute principal energy sources, and just three—wheat, corn, and rice—dominate world markets. What people choose to eat depends largely on culture and economics. Cultural factors explain why Asians eat rice or noodles, whereas Mediterraneans consider no meal complete without bread. There are also religious prohibitions, such as those against consuming beef, pork, or alcoholic beverages. People can choose freely from available foods only if they can afford them; without an adequate income, food choices are limited.

Foods vary in quality as well as variety. Their composition is exceedingly complex; foods contain hundreds of chemical components—including the familiar nutrients and energy sources, but also fiber, phytochemicals, and other substances that may affect health. As recently as the mid-twentieth century, most foods were produced and eaten locally. As transportation improved, production became increasingly centralized and foods were processed to permit transport and storage. Processing removed essential vitamins, minerals, and other nutritious components and added preservatives, texturizers, flavors, and colors. While highly efficient, centralized production permitted biological and other contaminants to affect larger numbers of people. Increased efficiency led to cheaper food, but it also led to other, less desirable effects of overproduction.

The food systems of industrialized countries produce more food than their population can consume. As a result, they compete for consumer

food dollars. About 80 percent of every food dollar is spent for processing beyond the food itself, including transportation, packaging, and advertising. Potatoes are cheap; it is much more profitable to sell potato chips. Food companies introduce more than twelve thousand new food products—many of them candy, snacks, soft drinks, and desserts—into the American food supply each year. A typical supermarket stocks more than thirty thousand different food items, and manufacturers market them with about \$30 billion worth of annual advertising. Marketing affects dietary choices. Thus, the changing food supply favors consumption of processed foods higher in energy and relatively lower in nutritional value than the basic foods from which they were derived.

OPTIMAL DIETS

An optimal diet, by definition, is one that maximizes health and longevity, prevents nutrient deficiencies, reduces risks for diet-related chronic diseases, and is obtained from foods that are available, affordable, safe, and palatable. Throughout human history, societies have developed a variety of dietary food patterns that take advantage of the foods available. Ancestral diets of societies surviving to the present must have been sufficient enough to support growth and reproduction, even if they did not promote optimal adult health.

At issue is how to select a health-promoting diet from the array of possible choices. When the leading causes of illness and death were infectious diseases made worse by inadequate diets, health officials advised people to eat more foods from specific groups such as dairy, meat, fruits and vegetables, and grains. As diseases such as coronary heart disease, certain cancers, diabetes, and stroke overtook infectious diseases as the leading causes of death, new recommendations were needed to address these chronic conditions. A large body of biochemical, animal, epidemiologic, and clinical research indicated that diets high in energy, saturated fat, cholesterol, sugar, salt, and alcohol raise risks for multiple chronic diseases, whereas diets high in fruits, vegetables, and whole grains reduce chronic-disease risk factors such as obesity, high blood cholesterol, and high blood pressure. This evidence established the basis for new dietary recommendations.

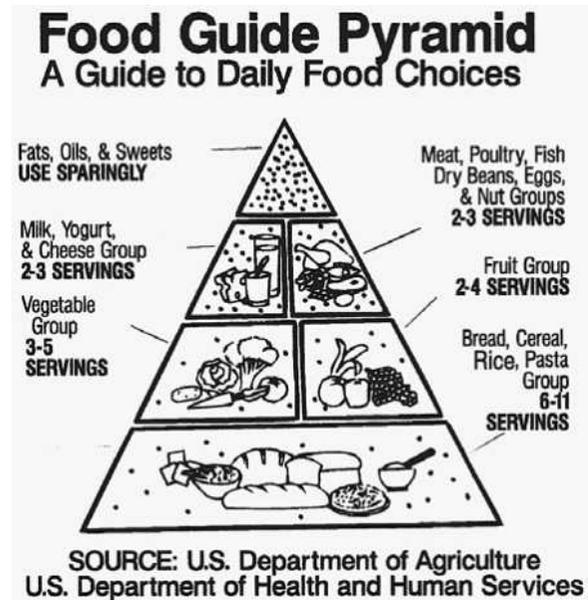
DIETARY GUIDELINES

Throughout the world, governments issue dietary guidelines to help their populations make healthful food choices. Guidelines may be quantitative (“Reduce fat intake to 30 percent of energy or less”) or qualitative (“If you drink alcoholic beverages, do so in moderation”). They may focus on food, nutrients, dietary behavior, or other issues. A typical food-based guideline is, “Eat more fruits and vegetables every day.” Nutrient-based guidelines suggest choosing foods low in saturated fat, cholesterol, sugar, or salt. Because obesity has emerged as a major health problem among people in industrialized countries and is increasingly a problem in developing countries, guidelines focus on behavioral changes to reduce energy intake (“eat less”) and increase energy expenditure (“move more”). Finally, guidelines address the need to “eat a variety of foods,” or to “keep foods safe to eat.”

In the United States, collections of such precepts are published as the *Dietary Guidelines for Americans*. Issued every five years since 1980, and required by Congress since 1990, the *Guidelines* document is a policy statement that governs federal nutrition programs and educational activities. The separate guidelines are meant to be followed as a whole, and they define a distinct dietary pattern. When translated into food choices, this pattern derives most daily energy from grains, vegetables, and fruits, with less from meat and dairy foods, and even less from fats and sweets. To help the public translate this advice into healthful food choices, the U.S. Department of Agriculture (USDA), with the assistance of the U.S. Department of Health and Human Services, developed the food guide pyramid. The pyramid suggests that people consume specified numbers of daily servings of certain food groups. Its design indicates that the foods are hierarchical. People are supposed to eat more foods from the base of the pyramid (the plant food groups) but to eat fewer servings from the upper sections (meat, dairy, and processed foods). In contrast to earlier advice to “eat more,” this pattern demands “eat less” in order to prevent chronic diseases.

DIETARY CONTROVERSIES

Recommendations to limit intake of fat, saturated fat, and cholesterol mean eating less of the food



The food pyramid indicates recommended daily servings of certain food groups.

sources of these nutrients: meat, dairy, eggs, and processed foods high in fat. Eating less salt and sugar means less snack foods, soft drinks, and desserts. Although the first such recommendations appeared in the mid-1950s and have hardly changed since, they consistently have elicited controversy. Groups have argued that “eat less” advice is unjustified by the evidence, inappropriate for the general public, and economically unsound. Scientific concerns derive from the difficulties inherent in conducting studies that meet rigorous standards of proof among diverse populations who consume varied diets and develop diseases with multiple causes. Dietary recommendations apply to all individuals over the age of two years, but some people will benefit more from the advice than others. Some authorities argue that public health guidelines are unnecessary because individuals with chronic-disease risk factors can be identified and treated, and because young and old individuals may not be helped by such advice. But high-risk individuals cannot always be identified before they develop symptoms, and health care systems do not reach everyone who is at risk. Because similar recommendations apply to so many chronic diseases, most health officials believe that the advice in the dietary guidelines and food pyramid is prudent.

Economic concerns about guidelines derive from their impact on food producers. Meat and dairy foods together account for about 40 percent of the total fat, 60 percent of the saturated fat, and all of the cholesterol in the food supply, and processed foods are often high in energy, salt, and sugar. Soft drinks, for example, are a leading source of added sugars in American diets. Dietary recommendations to reduce such nutrients necessarily translate into decreased intake of meat, dairy, and processed foods. Since 1977, any federal recommendation to “eat less” has been strongly—and often effectively—protested by interested commodity groups. In 1992, objections of meat producers to the location of their products on the pyramid led the USDA to suspend publication until additional research confirmed its effectiveness. Given such considerations, government advice about healthful diets elicits more attention than might be expected for messages that have not changed in years.

Virtually every government or health organization—national and international—that has examined research linking diet to health has issued similar dietary guidelines. This international policy consensus, based on research that is uncertain, incomplete, sometimes contradictory, and endlessly debated, can be explained by the fact that scientific arguments usually focus on the role of single nutrients such as fat, specific fatty acids, cholesterol, fiber, sugar, or sodium. But individuals do not eat single nutrients; they eat food. Evidence for the substantial health benefits of dietary patterns that follow recommendations has remained constant, despite debates over nutritional details. If this point is not widely recognized, it may be because the underlying message to “eat your vegetables” is not headline news, is difficult to follow in societies where meals are increasingly consumed outside the home, and is likely to lead to politically unpopular changes in food patterns. From the standpoint of health, pyramid-like diets make sense. In the light of current societal pressures that encourage people to eat more, not less, the challenge is to find ways to make it easier to follow the pyramid’s recommendations.

MARION NESTLE

(SEE ALSO: *Nutrition; Nutrition in Health Departments; United States Department of Agriculture [USDA]*)

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FOOT AND MOUTH DISEASE

See United States Department of Agriculture (USDA)

FORMALDEHYDE

Formaldehyde is a simple, highly reactive hydrocarbon that is used as a fixative in the pathology laboratory, as a fumigant, and in the manufacture of foam insulation, cosmetics, drugs, clothing, and furniture. It is also a major toxic component of photochemical smog. Formaldehyde is a strong allergen and irritant to which humans have a very low odor threshold (less than 1 ppm), and it is carcinogenic in the rat bioassay via the inhalation

route. Formaldehyde increases airway resistance when inhaled, probably because of local irritation and release of inflammatory mediators. Additionally, formaldehyde is a strong contact allergen. Both pulmonary changes and dermatologic symptoms have been reported in the occupational setting. Acute and chronic dermatitis was once a common complaint in the beauty parlor industry because of using formaldehyde in fingernail finishes. Histology and pathology laboratories were common sites of high levels of exposure. However, after the report of nasal tumors in rats, industrial hygiene measures were instituted to minimize exposure. This was also true in the garment industry, where formaldehyde was used in the manufacture of permanent press fabrics.

Formaldehyde residues are major constituents of smog. An overwhelming percentage of the aldehyde in smog is formaldehyde. It is through smog that the general population is most broadly exposed. Because of its irritant and allergenic properties, formaldehyde is considered one of the possible etiologic agents involved in the well-documented asthma incidents that have occurred in relation to moderate to severe smog events. Another source of exposure to the general public in indoor air is off-gassing from fabrics and foam materials. These levels are considerably lower than photochemical smog concentrations, but they are more insidious because of the ambient nature of the exposure. In house fires, formaldehyde residues in fabrics and foams play a major role in the toxicity of smoke.

The greatest risk for injury from formaldehyde is in a workplace with minimal industrial hygiene measures. The greatest danger of formaldehyde is to those individuals who have compromised pulmonary function.

MICHAEL GALLO

(SEE ALSO: *Ambient Air Quality [Air Pollution]; Asthma; Occupational Safety and Health*)

FRACASTORO, GIROLAMO

The scholarship and erudition of the Veronese physician Girolamo Fracastoro (1483–1553) were

recognized early—he was appointed to the chair of logic and philosophy at the University of Padua at the tender age of nineteen. Also known by his Latin name, Hieronymus Fracastorius, he is best known for two works. The first, *Syphilidis sive Morbi Gallici* (Syphilis, or the French disease, 1530), is a description in verse of the then relatively new (to Europe) epidemic disease known, from that point on, as syphilis. The disease is named after Fracastoro's protagonist, the shepherd Syphilis, who offended the sun god and whose people (residents of an unidentified island in the Caribbean) were punished with the disease, which they transmitted to Spanish sailors, and, thereby, to the inhabitants of Europe. In his poem, Fracastoro provided a graphic description of the secondary and tertiary phases of the disease, recognized its venereal origin and its transmission by breast-feeding (though he did not seem to believe it was exclusively transmitted by contact) and suggested treatment with mercury.

Fracastoro is equally famous for his prose treatise on communicable diseases, *De Contagionibus et Contagiosis Morbis et Earum Curatione* (*On contagion and contagious diseases*, 1546), one of the earliest theoretical conceptualizations of something approximating germ theory. Fracastoro attributed epidemic diseases to living agents too small to see that were transmitted by physical touch or contagion. Plague was viewed by Fracastoro as contagious, as was smallpox. Contagion via microscopic agents was not returned to as a major explanatory theme in medicine until the work of Athanasius Kircher (1602–1680) in the seventeenth century. Fracastoro was an astrologer, and he embellished his theory of contagion with a strong belief in the powerful influence of the stars on the progress of epidemic diseases.

NIGEL PANETH

(SEE ALSO: *Communicable Disease Control; Contagion; History of Public Health; Syphilis; Theories of Health and Illness*)

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FRAMINGHAM STUDY

The Framingham Heart Study is a longitudinal study of a defined population in Massachusetts, initiated in 1948. The Framingham Study was conceived by Joseph Mountin, Assistant Surgeon General and head of the Division of Chronic Diseases of the U.S. Public Health Service. Mountin saw that cardiovascular diseases were replacing infectious diseases as the major cause of mortality in the United States. He responded to the suggestion of David Rutstein of Harvard University that the study be set up in Framingham, Massachusetts, a Boston suburb. The study was soon incorporated into the newly established National Heart Institute (NHI), part of the National Institutes of Health (NIH), by NHI director C. J. Van Slyke. Felix Moore, the chief of biometrics at NHI, was charged with estimating the required sample size for a definitive epidemiological study that had a reasonable likelihood of establishing, during a twenty-year period, the relationship between given characteristics and the risk of death from heart attack. This resulted in a study sample of 5,209 Framingham men and women between the ages of thirty and sixty.

Early opposition to epidemiological studies at NIH was overcome, in part due to the arguments of Van Slyke's chief cardiologist advisor, Boston cardiologist Paul Dudley White, who had become interested in the natural history of heart diseases as a student in England. Dr. Thomas Dawber was appointed director of the study, and he brought his own ideas to what was to become the best-known cohort study of all time. In his book, *The Framingham Study* (1980), Dawber wrote:

The task of epidemiology . . . is to determine to what degree an observed relationship may be the result of chance and at what point the relationship is sufficiently strong that it may well be involved in causality (p. 5).

The characteristics of persons who already have the disease are not necessarily the same as those that predispose to the disease. Observations of population characteristics must be made well before disease becomes overt if the relationship of these characteristics to the development of the disease is to be established with reasonable certainty (p. 11).

If the relationship is one that fits what is known about the disease and has a logical explanation, it is worth exploring further, regardless of the strength of the relationship. If, however, the relationship is very powerful, it deserves careful scrutiny even though the alleged relationship may be unexplained at the time (p. 4).

The ongoing Framingham Study has remained the responsibility of the NHI, which was renamed the National Heart, Lung, and Blood Institute (NHLBI) in 1976, and it is carried out under contract by researchers at the Boston University School of Medicine. It has been enlarged twice, in 1971 with the "Offspring Study," which added 5,124 children (and their spouses), to the original study participants, and in the late 1990s with the "Omni Study" of minorities. Every other year, after an extensive baseline examination, subjects undergo testing that includes a medical history, blood profile, echocardiogram, and bone, eye, and other specialized tests.

The Framingham Study produced a landmark report on the predictive power of blood pressure, blood cholesterol level, and cigarette smoking for heart and blood vessel diseases (Dowbar et al., 1957). The term "risk factor" is, in fact, attributed to the investigators of Framingham, who have also gone on to elaborate many central concepts and practical tools in the identification and prevention of elevated cardiovascular risk. Among their discoveries are:

- Knowledge about the relationship between blood vessel diseases and blood cholesterol fractions, LDL ("bad") cholesterol and HDL ("good") cholesterol.
- "Multivariate risk"—the more-than-additive contribution to risk of multiple factors present together.
- The greater predictive precision of systolic, rather than diastolic, blood pressure levels.
- Discounting the "common wisdom" that high blood pressure is less dangerous in women and the elderly.
- The rising risk of cardiovascular diseases among women after menopause.

- The halving of heart attack risk within a few years after stopping smoking.

The Framingham Study, with congruent findings from other studies in the United States and abroad, sparked a revolution in understanding the individual and the mass causes, as well as the preventability, of heart attack and stroke. It provided a sound basis for successful medical action and health-promotion policies to reduce the death rate from these diseases.

Under the leadership of William Kannel, in recent years the Framingham researchers have also studied the risk of particular disease manifestations such as heart failure, peripheral artery disease, stroke types, and arrhythmias. New risk characteristics such as the apolipoproteins and their regulating genes, homocysteine, blood clotting factors, and inflammation have also been examined. The scope of the study has widened to include chronic conditions such as obesity, diabetes, cardiac enlargement, osteoporosis, cancer, and Alzheimer's disease.

HENRY BLACKBURN

(SEE ALSO: *Behavior, Health-Related; Cardiovascular Diseases; Chronic Illness; Cohort Study; Coronary Artery Disease; Epidemiologic Transition; Multifactorial Diseases; National Institutes of Health; Noncommunicable Disease Control; Observational Studies; Risk Assessment, Risk Management*)

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FRANK, JOHANN PETER

The German physician, Johann Peter Frank (1745-1821) studied at Heidelberg and Strasburg,

was a professor at Göttingen and Pavia, and eventually became director of the Allgemeines Krankenhaus and a professor of medicine in Vienna. He also taught in many other European cities, including St. Petersburg, and was physician to Czar Alexander I from 1805 to 1808. Early in his career he began working on a massive treatise, *System einer vollständigen medicinischen Polizey* (A complete system of medical policy). This occupied him throughout his life and was published in nine volumes from 1779 to 1827. It was the first thorough treatise on all aspects of public health and hygiene, covering in detail the principals and practice of an orderly method to keep human settlements clean. In addition, the treatise documented existing laws and proposed further regulations regarding conduct that affected people's health.

Frank's *System* dealt with water supply and sanitation, food safety, school health, sexual hygiene, maternal and child welfare, regulation of aspects of public behavior such as the conduct of teachers and prostitutes, and the compiling of statistical records of hospitals. Hospital records that were compiled using Frank's methods enabled the Hungarian obstetrician Ignaz Semmelweis (1818-1865) to demonstrate the relationship of puerperal sepsis to a lack of adequate personal hygiene by birth attendants.

Frank is without doubt one of the most influential figures in the early history of public health and community medicine. In addition to his *System*, Frank wrote a seven-volume textbook of internal medicine and made important clinical discoveries, including the distinction between diabetes mellitus and diabetes insipidus.

JOHN M. LAST

(SEE ALSO: *Community Health; History of Public Health; Social Medicine*)

FRAUD AND MISREPRESENTATION

The intentional distortion of the truth, for whatever purpose, is contrary to most conceptions of morality, as well as to codes of practice and codes of ethics in the professions. To alter or distort the

truth is also the antithesis of appropriate scientific conduct. Science is dependent upon certain principles, including integrity of character, honesty, and objectivity, in the pursuit of truth. Being in a position of trust places on the professional an additional expectation to tell the truth. Public health, as well as the health of individuals, is dependent on the ability to gather full and accurate information on any health-related topic. To minimize the likelihood of fraud, ethics guidelines exist and health professionals are expected to abide by them. Ethical conduct is ensured by peer oversight and is perpetuated through role models. In teaching settings, supervisors serve as ethical mentors in the apprenticeship of aspiring professionals.

In spite of this value system and need for the truth, fraud and misrepresentation are not uncommon in science and public health. Instances of fraud range from plagiarism and the fabrication and falsification of scientific data to practicing medicine without a license. In public health, where much harm could result from such practices, penalties exist as disincentives. Penalties for scientific misconduct include being barred from the scientific community, expulsion from professional organizations, and the suspension or loss of a license to practice. Minimally, a period of exclusion from professional activity would be ordered if some degree of rehabilitation could be expected. However, in practice, people have deceived not only their peers, but also the public. The promotion of tobacco products provides one example of a deception that has resulted in untold public harm over many decades. Indeed, at the end of the twentieth century after some fifty years of avoidance, the tobacco industry was being called to task for its deceptive actions. Substantial financial penalties have been ordered by the courts.

COLIN L. SOSKOLNE

(SEE ALSO: *Accountability; Codes of Conduct and Ethics Guidelines*)

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FROST, WADE HAMPTON

Wade Hampton Frost (1880–1938) was the seventh of eight children born to a country doctor in Virginia. He graduated in medicine from the Medical College of Virginia in 1903, and after two years of hospital internship he entered the Marine Medical Service and was posted to New Orleans, where yellow fever was a persistent public health problem. His interest in epidemiology was aroused by this work, and by contact with some of the eminent medical scientists and public health specialists who were dealing with this and other problems.

When he returned from New Orleans to Baltimore, Frost began working in the Hygiene Laboratory under the direction of Milton Rosenau, where he met and worked with Joseph Goldberger, Charles Nicolle, and other leading epidemiologists of the time. For several years he worked on river and stream pollution and their relationship to outbreaks of typhoid. Then, in 1918, he began working with Edgar Sydenstricker on a statistical and epidemiological study of influenza. When Johns Hopkins University opened its School of Hygiene and Public Health in 1919, Frost was the obvious choice as "resident lecturer," and he soon was elevated to the status of professor of epidemiology. He devoted the rest of his professional life to developing an outstanding educational program in epidemiology at the Johns Hopkins School of Hygiene and Public Health, and he was a major influence on epidemiological teaching and research throughout the United States and beyond.

Frost became increasingly involved in international health and in the administration of the School of Hygiene and Public Health, of which he became dean in 1930. Frost published many important original articles and was responsible for several innovative epidemiological and statistical methods. His papers were collected and published in a widely consulted monograph published soon after his death.

JOHN M. LAST

(SEE ALSO: *Goldberger, Joseph; Sydenstricker, Edgar*)

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FUEL ADDITIVES

Gasoline is one of the most widely used and highest volume chemical mixture to which the public is exposed, which justifies intense public health scrutiny of its composition. The widespread and inherently dispersive use of fuel additives has resulted in significant global contamination, as well as occupational and environmental exposures. Fuel additives are used to improve gasoline performance in vehicles and to reduce specific emissions. They include octane enhancers, antiknock compounds and oxygenates, as well as corrosion inhibitors, detergents, and dyes. Notable in terms of public health are the antiknock additives tetra-ethyl lead (TEL) and the oxygenate MTBE—both of which have been added to gasoline and later banned or restricted because of their adverse health effects—and MMT, which has been the subject of controversy, especially in Canada.

Tetra-ethyl lead, which prevents precombustion in higher compression-ratio engines, was introduced in the United States in the 1920s and adopted worldwide by the 1950s. Although the toxic effects of lead exposure were well known by the 1920s, the potential for exposure and toxicity from this new use was not generally understood, although public health experts, including Alice Hamilton and Yandell Henderson, argued against the initial approval of TEL. By the early 1970s, when the U.S. Clean Air Act was passed, lead additives were increasingly recognized as a problem for two reasons. First, the catalytic converters adopted in the United States to reduce automotive emissions of CO, NO_x, and VOCs were damaged by lead. Second, blood lead levels were found to be associated with lead in air, and a growing biomedical literature demonstrated that even low levels of lead adversely affected growth as well as neurobehavioral and intelligence development in children and increased risks of hypertension in adults. As a consequence, unleaded gasoline was introduced in the United States and the amount of lead in leaded gasoline was reduced in a series of steps during the 1970s and 1980s. Lead was finally eliminated from motor gasoline in the United States in 1995.

This phaseout revealed the true impact of lead in gasoline on public health. In the United States, population blood lead levels fell from about 15 micrograms per deciliter (mg/dL) in 1976 to about

9 mg/dL in 1980, and to about 3 mg/dL in 1990. Much of this decrease has been attributed to the elimination of lead from gasoline. By 1991, scientific consensus established that blood lead levels as low as 5 to 10 mg/dL have a range of health impacts, including detrimental effects on fetal and child development.

Lead additives were replaced by new gasoline mixtures, some with a higher content of the carcinogen benzene and by the additive MTBE (methyl tertiary butyl ether). In addition to its antiknock properties, MTBE is also an oxygenate—an oxygen-containing compound intended to reduce emissions of carbon monoxide and ozone-forming compounds. MTBE use in the United States increased greatly after 1990 to meet mandates to reduce carbon monoxide and ozone air pollution. However, data soon demonstrated that oxygenates are not very effective in reducing ozone. Moreover, MTBE, which is highly soluble in water, has been found to have contaminated drinking water supplies. In animals, MTBE causes cancer, and even at very low concentrations MTBE affects the taste of water. As of 2001, a number of states were acting to ban MTBE and the U.S. Environmental Protection Agency (EPA) had urged a substantial reduction in its use.

MMT (methyl cyclopentadienyl manganese tricarbonyl), another organometallic antiknock additive, has been widely used in Canada since 1978. Levels of manganese in urban air in Canada have increased as a consequence. Similar to lead, manganese is highly neurotoxic at high levels of exposure, but the effects of the long-term low-level exposures that would result from widespread use in gasoline are incompletely understood. In 1996, Canada banned MMT, but lifted its ban in 1998 after a challenge to its risk assessment. The EPA effectively prevented the introduction of MMT in the United States from the late 1970s through the mid-1990s, but it was overruled by the U.S. courts in 1995. As of 2000, MMT is used in less than 1 percent of U.S. gasoline; the automobile industry opposes its use because it could damage vehicle engines and emissions control systems.

The history of fuel additive use in the twentieth century reflects the interplay between engine and fuel technologies and public health concerns related to air pollution. Often, decisions to utilize

specific additives have been made in the absence of sufficient information on health effects or exposure. The impact of these national decisions has extended globally, and the effects of dangerous additives persist for decades after the removal of these additives.

ELLEN SILBERGELD
VALERIE THOMAS

(SEE ALSO: *Ambient Air Quality [Air Pollution]; Automotive Emissions; Blood Lead; Cancer; Carcinogen; Clean Air Act; Drinking Water; Lead; Public Health and the Law*)

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FUNCTIONAL CAPACITY

Functional capacity refers to the capability of performing tasks and activities that people find necessary or desirable in their lives. One way of examining the effects of disease on people and communities is through mortality and morbidity (illness) statistics. But another way, which took on increased significance in the last decades of the twentieth century, is through examining functional status or functional capacity. Whereas mortality and morbidity tends to be examined relative to specific diseases or conditions, functional capacity tends

to be considered over and above the various combinations of diseases a person has that might contribute to functional difficulties.

Functional capability is most appropriately examined with reference to particular life-cycle tasks that an individual may need to perform. For children, functional requirements include learning at school, participating in play, and involvement in family life. For adults, functional abilities in the labor force are important, as well as (in many cases), activities related to rearing and interacting with their children. Some assessment tools examine the ability to perform such age-related tasks in some detail. Other assessment tools, especially those used in large-scale research, attempt to use questions that work for all age groups. An example of a general questions about functional capacity would be: "How often are you unable to perform your usual activities because of illness or disability?" This approach would be less than optimal for persons of retirement age, who may not have a wide range of "usual activities." A narrower, more general approach is to ask how many days an individual has been in bed because of illness or disability in a particular time period. The most common approach is to consider ability to perform each in a list of specific tasks or activities.

Functional capacity measures have particularly been emphasized for people who need long-term care, which disproportionately includes elderly people. In fact, the need for long-term care services, as well as eligibility for services under public funding or insurance programs, tends to be measured by an individual's inability to perform various functional activities. With reference to older people and others needing long-term care, two common terms have emerged to characterize functional capacity: ability to perform "activities of daily living" (ADLs) and ability to perform "instrumental activities of daily living" (IADLs).

ADLs are the most basic of self-care functions. In the 1960s, Dr. Sydney Katz evolved the art of ADL measurement based on his work in the rehabilitation of people with hip fractures and strokes. He developed a simple measure that classified people as independent or dependent on each of six ADL functions: bathing, dressing, using the toilet, transferring in and out of beds or chairs, continence, and eating (continence is now usually

removed from ADL measures because it is more indicative of a physiological state than a function). When ADL is measured dichotomously, people are usually considered independent if they can do the function without help (even if they depend on equipment) and dependent if they need human help. Depending on the level of detail sought, some ADL measures use a more graduated scale to measure degrees of dependency; some break down the tasks (e.g., dressing can include upper body, lower body, putting on shoes); and some add tasks (e.g., walking a certain number of feet, climbing stairs). IADLs are functions that may be needed for independence depending on task allocation in a family unit and demands made by a person's life. They include cooking, cleaning, laundry, shopping, making and receiving telephone calls, driving or using public transportation, and taking medicines.

Lack of functional capacity in each ADL or IADL task can result from any combination of physical problems, memory loss, lack of social resources, or lack of motivation (e.g., because of depression). Thus, when trying to improve someone's functional ability in, say, cooking, one could attempt to change any of these parameters. If memory loss is the reason for functional impairment, some people might be able to perform the function with cueing and reminders. Sometimes people become more functional when a task is simplified. Sometimes physical rehabilitation or provision of a wide range of prosthetic aides (dentures, hearing aides, canes, or specialized equipment) improves functional abilities. The variation in the amount of human help needed to become functional on any given task can be considerable, ranging from just stand-by assistance for safety to the physical help of two or more people.

Functional capability can be measured by questions about what a person *can* do, or by demonstrations of actual ability (e.g., getting up from a chair, demonstrating ability to hold food on a spoon and bring it to one's mouth, opening a medicine bottle and taking out the correct number of pills). It can also be measured by questions about what a person actually *does* do. The measurement strategy should be tailored to the purpose of getting the information. Rehabilitation programs need to know about capacity, and often in considerable detail. For program evaluation and quality assurance,

actual functioning may be more important than capacity. For example, a person may be capable of bathing without help, but may never do it because of rules in the nursing home in which he or she resides. Some would argue that the actual independence exercised is what matters in terms of quality of life.

ROSALIE A. KANE

(SEE ALSO: *Geriatrics; Gerontology; Health; Health Measurement Scales; Health Outcomes; Quality of Life*)

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FUNGAL INFECTIONS

Fungal infections of the skin are among today's most common infectious diseases, and they occur worldwide. Superficial fungus infections fall into three broad categories: the dermatophytes (ringworm), tinea versicolor, and cutaneous candidiasis (yeast infection).

Tinea Corporis (Ringworm of the Skin). The typical lesion is an itchy, round or oval patch of skin with central clearing and a red scaly margin—hence the name "ringworm." If it occurs in the groin, it is called "jock itch" or "tinea cruris." If there are only two or three rings of infection, topical therapy with antifungal creams will be sufficient. For widespread infection, oral antifungal pills may be necessary.

Tinea Capitis (Fungal Infection of the Hair). Fungal infections of the scalp are most common in children. The infection presents as round scaly patches of hair loss, often with broken-off stubby hairs. The infection must be treated with oral antifungal therapies. The prognosis is excellent and shaving the scalp is not necessary.

Tinea Pedis (Fungus of the Feet, or Athlete’s Foot). Tinea pedis is the most common type of fungal infection, presenting as itchy, scaling, and/or macerated webspaces. There may be a powdery white scaling of the bottom of the feet. Sometimes the infection presents as blisters on the bottom of the feet. The infection can spread to the groin (tinea cruris). Topical antifungals will cure the webspace infections but oral antifungals are necessary to treat the blistering infections. Afflicted individuals should keep their feet dry and spray their shoes with antifungal sprays.

Tinea of the Nails (Onychomycosis). Toenails are more commonly affected than fingernails. The nail becomes opaque, yellowish, thickened, and crumbly with the accumulation of material under the nail. There may be an associated athlete’s foot infection. Oral antifungals are necessary to cure the problem.

Candidiasis (Yeast Infections). Yeast infections occur in closed spaces on the skin, such as the corner of the mouth, under breasts, in armpits, and in the groin. It is a red, moist, and often odorous tender rash, and is more severe in patients taking antibiotics or who have systemic diseases such as diabetes. Heat and sweat aggravate the problem. Candidiasis can also occur in the mouth (oral thrush) or as a yeast vaginitis. Treatment is with topical antiyeast creams and/or oral medication. To prevent recurrence, the area must be kept dry.

Tinea Versicolor. Tinea versicolor presents on the upper trunk—as brown spots in the winter and white spots in the summer. It is easily treated by washing the area with antidandruff shampoos, but the therapy must be repeated monthly to prevent recurrence.

SUSAN SWIGGUM
JOHN ADAM

FUNGICIDES

Fungicides are a class of pesticides that are marketed specifically for the purpose of killing or inhibiting the growth of fungus. Fungus are defined under the Federal Insecticide, Fungicide, and Rodenticide Act as “any non-chlorophyll-bearing thallophyte (that is, any non-chlorophyll-bearing plant of a lower order than mosses and

Table 1

Classes of Fungicides, with Examples	
Class of Fungicide	Examples
Substituted Benzenes	Chloroneb, chlorothalanil, Hexachlorobenzene, pentachloronitrobenzene
Thiocarbamates	Ferbam, metam sodium, thiram, ziram
Ethylene Bis Dithiocarbamates (EBDC’s)	Mancozeb, maneb, nabam, zineb
Thiophthalimides	Captan, captafol, folpet
Copper compounds	
Organomercury compounds	Ethyl mercury, methyl mercury, phenyl mercuric acetate
Organotin compounds	Fentin, triphenyl tin
Cadmium compounds	
Miscellaneous organic fungicides	Benomyl, cyclohexamide, iprodione, metalaxyl, thiabendazole, triadimefon

SOURCE: Courtesy of author.

liverworts), as, for example, rust, smut, mildew, mold, yeast, and bacteria, except those on or in living man or other animals and those on or in processed food, beverages, or pharmaceuticals.” Although the United States statutory definition excludes fungi that would grow on food, beverages, and pharmaceuticals, biologically these are fungi. Thus, in the United States, products designed to kill fungi are regulated by the U.S. Environmental Protection Agency as pesticides and/or by the Food and Drug Administration under food and drug law (a chemical may fall under the purview of both agencies).

The benefits of fungicide use have been many. In agriculture, fungicides control pests that may rob water and nutrients from crop plants or may cause food spoilage as the products are brought to market. Fungicides may also prevent the growth of fungi that produce toxins, such as aflatoxins. Fungicides also have important industrial applications and are important in preserving the purity and safety of certain pharmaceutical agents.

In 1997 there were an estimated \$0.8 billion in sales of fungicides in the United States, about 7 percent of the total pesticide market. In 1997, worldwide, 5.7 billion pounds of pesticides were used, of which 0.5 billion were fungicides. Of the 1.2 billion pounds of conventional pesticides used

in the United States in 1997, a total of 81 million pounds of fungicides were used; 79 percent of the use was in agriculture. Generally, the United States has experienced a downward trend in total fungicide use since 1970.

There are numerous classes of fungicides, with different modes of action as well as different potentials for adverse effect on health and the environment (see Table 1). Most fungicides can cause acute toxicity, and some cause chronic toxicity as well. Hexachlorobenzene, now banned or severely restricted in most parts of the world, has been associated with human poisoning from contaminated seed grain and poisoning of infants from misuse in laundry solutions. Metam sodium and other thiocarbamates are skin irritants that can cause reactive airway disease at low doses and severe toxicity and even death at high doses. The ethylene bis dithiocarbamates (EBCDs) are suspected human carcinogens and are tightly regulated in the United States.

Organic mercurials have caused severe acute and chronic toxicity. Worldwide, there have been a number of incidents of treated seed grain fed to people, with disastrous consequences in terms of acute poisoning and damage to fetuses. Phenyl mercuric acetate is no longer used as a paint preservative in the United States because it off-gases elemental mercury into the air, with the potential for causing toxicity to young children. Organotin compounds also have serious human toxicity and are very toxic to the environment; their use is banned or severely restricted in most of the world. Likewise, due to human toxicity concerns, cadmium is no longer used as a fungicide in the United States.

LYNN R. GOLDMAN

(SEE ALSO: *Mercury; Pesticides; Toxic Substances Control Act; Toxicology*)

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Table 1

Life Expectancy at Birth and at 65 Years of Age, United States, Selected Years, 1900-1997

	At Birth	Gain	At 65 Years	Gain
1900	47.3		11.9	
1960	69.7		14.3	
1900-1960		22.4 years		2.4 years
1997	76.5		17.7	
1960-1997		6.8 years		3.4 years

SOURCE: NCHS (1999). *Health, United States, 1999*. Hyattsville, MD.

FUTURE OF PUBLIC HEALTH

Contemplating the future of public health entails noting the historical nature of the field. From time immemorial, public health has embraced determining and analyzing a community’s health problems, formulating strategies to deal with them, and implementing social means of attending to those problems. The Institute of Medicine has expressed the public health mission as “fulfilling society’s interest in assuring conditions in which people can be healthy.”

In the immediate future, public health must be concerned with both communicable and non-communicable disease control issues. These include the prospect of eradicating poliomyelitis and measles; dealing with the HIV/AIDS (human immunodeficiency virus/acquired immunodeficiency syndrome) pandemic; expanding immunization programs against influenza and pneumonia; and using sociobehavioral approaches and screening programs to curtail the major highly fatal conditions that currently prevail in the industrialized world—particularly cardiovascular disease and cancer. Critical to the success of these efforts will be overcoming the health disparities that exist between different racial and ethnic groups and between socioeconomic groups.

In the longer term, public health will have to be concerned with changes in the concept of health and with demographic trends and conditions of life that determine health problems. Up until the latter part of the twentieth century, health was generally regarded as the absence of disease. New

views are now emerging, however. The World Health Organization defines health as “a state of complete physical, mental, and social well-being, and not merely the absence of disease or infirmity,” and the Ottawa Charter for Health Promotion calls health “a resource for everyday life.” These ideas reflect the fact that people are living into their eighties and nineties and are increasingly free of major diseases during most of their lives. For many people, ideas of achieving health in a positive sense are supplementing ideas of disease avoidance.

In addition to this concept’s challenge to public health, the field must attend to health problems arising from major population dynamics, particularly aging and migration. Longevity in the United States increased more than 50 percent during the twentieth century, and life expectancy is advancing after sixty-five years of age as much as in all the years of life up to sixty-five (see Table 1). Public health will hence be shifting its age focus. It will also be necessary to respond to the huge migrations of people from one part of the world to another. These migrations cause health problems associated with changes in both physical and social living conditions.

Public health activity emanates from the ways in which society organizes to protect and advance community health. It has included governmental functions that improve and maintain environmental conditions for health; provide certain medical services that are essential to health (such as immunizations and prenatal care); and promote healthful personal behavior. These governmental activities will evolve in accordance with epidemiological findings and political decisions concerning what should be done about health problems. Formulating policies and proposals for such decisions is a significant component of public health leadership.

In the United States, nongovernmental public health activity has long included work by voluntary health organizations that deal with particular diseases, such as the American Cancer Society, the American Lung Association, and the American Heart Association. During recent years an upsurge of community-based organizations (CBOs) has focused to a considerable extent on health improvement. It appears that neighborhood groups, church-sponsored programs, school-affiliated programs,

and other types of community organizational health efforts will constitute an increasingly important aspect of public health. This reflects a growing willingness to improve local health conditions at the grassroots level, beyond what government typically undertakes.

Another boost to public health is coming from the trend to set objectives for achievement within a specific time period. An example is the decennial series *Healthy People*, established by the U.S. Department of Health and Human Services.

Public health leadership in the future should include not only a delineation of health problems and the formulation and advocacy of means of solving them, but also the development of community consensus regarding objectives and strategies. This should further lead to a genuine partnership with other social agencies and organizations to improve the environmental, medical, and sociobehavioral conditions that affect health.

LESTER BRESLOW

(SEE ALSO: *Access to Health Services; Aging of Population; Communicable Disease Control; Community Health; Demography; Economics of Health; Genetics and Health; Health; Healthy People 2010; History of Public Health; Immigrants, Immigration; Leadership; Life Expectancy and Life Tables; Noncommunicable Disease Control; International Nongovernmental Organizations; Nongovernmental Organizations, United States; World Health Organization*)

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G

GALLSTONES

Gallstones form in the gallbladder when there is an excessive increase in the concentration of cholesterol in bile. (Bile is a secretion of the liver that aids in fat emulsification.) In the United States, 20 percent of women and 10 percent of men have cholesterol gallstones by age sixty-five. Less common are pigment stones, which form when bilirubin, a bile pigment, precipitates in bile following an increase in the breakdown of red blood cells, as in sickle cell anemia. Risk factors for cholesterol gallstones include heredity (Native Americans are at increased risk), obesity, rapid weight loss, physical inactivity, pregnancy, and diabetes. Episodic abdominal pain (biliary colic) or inflammation of the gallbladder (cholecystitis) occur in 25 percent of persons with gallstones. A stone may pass from the gallbladder and block the bile duct or cause pancreatitis. Symptomatic stones are generally treated by surgical removal of the gall bladder (cholecystectomy) or, occasionally, chemical dissolution of the stones by oral administration of bile acids.

LAWRENCE S. FRIEDMAN

(SEE ALSO: *Cholesterol Test; Nutrition; Physical Activity; Sickle Cell Disease*)

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GAME THEORY

Game theory is a way of reasoning through problems. Although its use can be found throughout history, it was only formally stylized by the economists John von Neumann and Oskar Morganstern in the 1940s. Game theory takes the logic behind complex strategic situations and simplifies them into models that can be used to explain how individuals reach decisions to act in the real world. Game theory models attempt to abstract from personal, interpersonal, and institutional details of problems how individuals or groups may behave given a set of given conditions. This modeling allows a researcher or planner to get at the root of complex human interactions. The major assumption underlying most game theory is that people and groups tend to work toward goals that benefit them. That is, they have ends in mind when they take actions.

The most important application of game theory to public health occurs when the actions of individuals or groups affect the health of others. On some occasions, individual or group strategies for betterment lead to inferior outcomes for the greater population.

Using game theory to model public health problems is not different from using it to model any other type of problem or decision-making

scenario. One particularly illustrative game is called the Prisoners' Dilemma, illustrated below. This game is often used to show the need for public resources and services. That is, sometimes individuals who choose certain strategies end up with an inferior outcome because of the incentives they were presented with. In public health, the problem becomes apparent quickly.

In order to place these events into a context in which game theory can be employed, four commonly defined criteria are used:

- *Players* are the decision makers in the game; a player can be an individual, group, or population that must decide how to use the resources available within given constraints.
- *Rules* are the constraints; all activity is defined by rules and gives the model an analytical credence to be tested for validity in the real world.
- *Strategies* are the courses of action open to the players in a game; players may choose their action dependent upon different situations they are presented with.
- *Payoffs* are the final returns to players, which are usually stated in terms that are objectively understood by each player of the game.

Consider a situation in which two groups of people border a malarial swamp. One group is named Alpha and the other is Beta. The swamp causes both groups to be plagued by malaria and other diseases. The problem could easily be remedied by draining the swampland. However, neither group is willing to act first because no incentives exist to take on the hard labor of draining the swamp alone. The greater utility that would be conveyed to both groups is lost because there is no incentive for either individual group to act.

THE SWAMP: A PRISONERS' DILEMMA

The game called Prisoners' Dilemma can be modeled using game theory. The game matrix shown in Table I is an example of a common tool in game theory modeling. The players are named in the

Table 1

The Swamp: A Prisoner's Dilemma					
		Beta			
		Contribute		Not Contribute	
Alpha	Contribute	Alpha	1	Alpha	-1
		Beta	1	Beta	2
	Not Contribute	Alpha	2	Alpha	0
		Beta	-1	Beta	0

SOURCE: Courtesy of author.

outer boxes, the rule is that the players may not communicate before simultaneously acting, the strategies are to contribute or not contribute, and the payoffs are in the innermost boxes.

Look at the situation as it is presented to the Alpha group. They realize that the outcome depends on the action the Beta group takes. If Beta contributes, it pays Alpha to avoid contributing, for in that instance, Alpha will benefit twice as much as if they worked with Beta to drain the swamp (2 points rather than 1). The reason the payoff for not contributing is greater is that Alpha will receive the benefit of draining the swamp without doing any of the work. However, if Beta does not contribute, Alpha still benefits by not contributing rather than contributing alone (the payoff is 0 instead of -1). That is, Alpha will choose not to bear the costs of draining the swamp alone.

The Alpha group reasons that regardless of Beta's action, their own best action is to not help drain the swamp. Because Beta's options are symmetric to Alpha's, they also reason that they benefit most through inaction. As a result, the swamp does not get drained, and both groups end up with an inferior outcome. This game leads to a special equilibrium called a Nash equilibrium, which means both players' strategies will lead them to the same payoff regardless of the strategy chosen by the opposing player.

PUBLIC HEALTH IMPLICATIONS

The implication for public health is that the best strategies for individuals or groups are sometimes not the best strategies for everyone taken as a

whole. Public health professionals need to be vigilant to these special circumstances and use interventions to create better incentive systems. For example, Alpha and Beta could each be levied a tax, by some authority over both, to pay for the draining of the swamp. The disincentives for progress would then be circumvented and both groups would benefit.

Game theory has been used to model a number of subjects important to public health, including organ donation, ethics, and the patient-provider relationship. Game theory provides a strong modeling device for public health professionals and illustrates the need of public intervention when the incentives of individuals impede progress for the group.

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(SEE ALSO: *Community Health; Community Organization; Ethics of Public Health*)

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GANGS

See *Adolescent Violence and Street Violence*

GASTRIC AND DUODENAL ULCERS

Gastric and duodenal ulcers are defects in the lining of the stomach or duodenum that form when gastric acid overwhelms the normal protective mechanisms. Most ulcers are caused by the bacteria *Helicobacter pylori* or by aspirin and similar drugs, which impair the stomach's defenses against gastric acid. Some rare ulcers are caused by tumors that produce gastrin, a hormone that stimulates gastric acid secretion. The lifetime prevalence of ulcers in the United States is 6 to 10 percent. Affected persons often experience indigestion, and about 20 percent have a complication, such as bleeding. Ulcers can be cured with drugs that suppress gastric acid secretion or eradicate *Helicobacter pylori*.

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GATEWAY DRUG THEORY

The "gateway drug theory" describes the phenomenon in which an introduction to drug-using behavior through the use of tobacco, alcohol, or marijuana is related to subsequent use of other illicit drugs. The theory suggests that, all other things being equal, an adolescent who uses any one drug is more likely to use another drug. In practice, early introduction to substance use for adolescents is often through tobacco and/or alcohol. These two drugs are considered the first "gate" for most adolescents. Under this hypothesis, tobacco, alcohol, and marijuana are all considered "gateway drugs," preceding the use of one another and of illicit drugs.

The National Center on Addiction and Substance Abuse (CASA) provides the following illustrations:

- Among 12- to 17-year-olds with no other problem behaviors, those who drank alcohol and smoked cigarettes at least once in the past month are 30 times likelier to smoke marijuana than those who didn't. These correlations are more pronounced for girls than boys: for girls, 36 times likelier; for boys, 27 times likelier.
- Among 12- to 17-year-olds with no other problem behaviors, those who used all three gateway drugs (cigarettes, alcohol, marijuana) in the past month are almost 17 times likelier to use another drug like cocaine, heroin, or LSD. These correlations are stronger for boys than girls: for boys, 29 times likelier; for girls, 11 times likelier.

These gates are prime targets for early intervention and prevention strategies. There is also a clear dose-response relationship between the quality and frequency of use of gateway drugs and the likelihood of subsequent illicit drug use.

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(SEE ALSO: *Alcohol Use and Abuse; Adolescent Smoking; Drug Abuse Resistance Education [DARE]; Marijuana; Smoking Behavior; Tobacco Control*)

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GENDER AND HEALTH

Women's health differs from men's health, and not just with respect to reproduction. To understand and examine these differences appropriately, the variables of sex and gender are each relevant.

In general, *sex* refers to biological, anatomical, physiological, and hormonal variations that, on average, distinguish females and males. By contrast, *gender* refers to the differences between men and women, boys and girls, that stem from how behaviors, abilities, responsibilities, and overall values are ascribed differentially to males and to females in a society. Sometimes separately, but more often through their interactions, sex and gender are important determinants of health.

For instance, there are sex-linked diseases (e.g., hemophilia) that only rarely and under exceptional circumstances affect women. There are also sex-specific cancers (e.g., of the prostate [men] and of the ovaries [women]), as well as specific conditions that, because of their biological exclusivity to males or females, can only occur in one or other sex (e.g., pregnancy-related conditions in women; testicular disorders in men). Generally, however, observed differences in the frequency of some health outcome between women and men do not reflect a sex (biologic) difference. Rather, most differences derive from a complex set of interactions between sex (biology) and gender (roles and expectations).

Every society has its own economic, social, cultural, and political arrangements that make being a woman different from being a man. The gender norms and expectations applied to women and to men that derive from these arrangements vary from place to place, change overtime, and are always affected by other features (e.g., age, class, ethnicity, sexual orientation, ability) that are attached to an individual. As a result of the gender differences assigned to them, individuals will experience their lives differently according to whether they are defined as male or female. Accordingly, women and men will have different exposures to different risks, different responses to the same exposures, different patterns to seeking treatment, and different needs for and responses to public

health programs. These all contribute to differences in the frequency and distribution of diseases between them.

Consequently, to understand and respond to most human health and sickness issues, clarifying the interaction between sex-linked factors and gender-based factors is critical; the expectations, norms, and stereotypes associated with the roles of men and women play out in their health, strongly influencing symptoms, treatments, and policies.

As an example, consider the relation of work to health. Much research has shown that underemployment and lack of control over work situations or job demands are associated with increased levels of stress and poor health. These employment and working conditions differ according to gender, and women in the paid workforce in North America are more likely than men to have undervalued and underpaid jobs in the service sector, to work part-time, to have interruptions of their careers because of family responsibilities, and to experience high-demand, low-control conditions at work. All these factors influence their risks for (exposure to) disease, what they do when ill, how health care professionals respond to and treat them, and what public policies of work-related health promotion and health protection are developed.

Thus, to examine the relation of work to health without accounting for the influence of gender would be to ignore how women may be exposed to health-damaging agents unlike those their male colleagues face; how they may have less access to private health care (United States) or necessary medications that must be paid for out-of-pocket (United States and Canada); and how they may have reduced opportunities to attend health programs, such as screening programs, because after-work hours are filled with child-care duties more often for women than for men. Furthermore, to the extent that work in the home is still more likely to be defined as “women’s work,” her gender, and not her biology, means that a woman may be more exposed to harmful household cleaning agents and neighborhood environmental contaminants, to the stresses that come from trying to balance child and elder-parent care with paid employment, and to reduced (if any) time for recreational exercise and other health-promoting activities.

Until the early 1990s, most health research was conducted on men on the assumption that the information gained could be applied simply and straightforwardly to women. The major exceptions were diseases and conditions that occurred only (e.g., pregnancy) or primarily (e.g., breast cancer) in women. Yet, what is learned from studying males may not apply to the health of women.

Similarly, in developing public health policies and interventions, there has been an assumption of “gender neutrality,” that is, not taking account of whether men or women were the subjects. It is now apparent that this approach is not only an oversimplification, but actually incorrect. The options that women and men have, and the decisions they are able to make, including their employment, smoking behavior, and sexual and other activities, will generally, if not always, be constrained by how male and female roles are defined in any society.

For example, consideration of the role of gender is essential to understand infection with HIV (human immunodeficiency virus). Males and females may have some biological differences in the probability of contracting the virus following exposure, but their risks of exposure are more than biological. For instance, if women in a society are dependent on men for economic security, their ability to demand safer sex practices will be limited; if they are seen as the primary child-care providers, their parenting roles, not those of their male partners, may be proscribed and/or constrained by law.

Neither sex nor gender can, on its own, provide complete understanding of most matters of health and disease. Sex differences (deriving from hormonal and/or anatomical variations) may affect the ways in which men and women experience the symptoms of a heart attack, but gender-related factors will influence whether or not medical treatment is sought by the individual and how a health professional responds to the person presenting these symptoms. Similarly, while sex differences (as in metabolism) may affect the efficacy of drug treatment for a heart problem, gender-related factors may influence whether or not the costs of the medication can be afforded, whether or not the medication can be taken on the schedule prescribed, and whether social interventions (e.g., stress reduction, exercise, and dietary changes)

can be adopted to complement the drug treatment. Society and biology influence health, and reducing complex explanations to only one or the other set of determinants may impede, not advance, the well-being of women and of men.

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(SEE ALSO: *Biological Determinants; Women's Health*)

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GENES

In the early 1860s, Gregor Mendel developed the concept of the gene to help explain results obtained while crossbreeding strains of garden peas. He identified physical characteristics (phenotypes), such as plant height and seed color, that could be passed on, unchanged, from one generation to the next. The hereditary factor that predicted the phenotype was termed a "gene." Mendel hypothesized that genes were inherited in pairs, one from the male and one from the female parent. Plants that bred true (homozygotes) had inherited identical genes from their parents, whereas plants that did not breed true (hybrids, or heterozygotes) inherited alternative copies of the genes (alleles)

from one parent that were similar, but not identical, to those from the other parent.

Some of these alleles had a greater effect on the phenotypes of hybrids than others. For example, if a single copy of a given allele was sufficient to produce the same phenotype seen in homozygous organisms, that gene was termed a "dominant." Conversely, if the allele could only be detected in the minority of the offspring of hybrid parents that were homozygous for that "weaker" allele, the gene was termed a "recessive." Based on these observations, Mendel formulated a series of laws that are the basis of what we now term "Mendelian" inheritance patterns.

The "law of unit inheritance" holds that factors retain their identity from generation to generation and do not blend in the hybrid. The "law of segregation" states that two members (alleles) of a single pair of genes are never found in the same mature sperm or ovum (gamete) but always separate out (segregate). Finally, the "law of independent assortment" holds that members of different pairs of genes (nonalleles) are sorted out (assort) independently to different gametes.

Almost a century later, in 1953, Watson and Crick solved the structure of the DNA molecule and helped explain how this genetic information could be encoded in a polymer, deoxyribonucleic acid (DNA), which was found in the nucleus of the cell. They demonstrated that DNA is a double-stranded polymer consisting of two linear arrays of diverse purine (adenine [A] and guanine [G]) and pyrimidine (thymine [T] and cytosine [C]) bases. Each purine or pyrimidine on one strand pairs with a complementary base (A:T and G:C) on the other strand. Each strand is thus complementary to the other. The two antiparallel polynucleotide strands are gently twisted to form what is termed a "double helix."

In humans, the nucleus of each somatic cell contains twenty-three pairs of chromosomes, which are formed by tightly coiled DNA strands. Twenty-two pairs of the chromosome pairs are found in the cells of both men and women. These chromosomes are termed "autosomes," and they are numbered by size from 1 (the largest) to 22 (the smallest). The twenty-third pair of chromosomes determine the sex of the individual, and these two chromosomes are thus termed the "sex chromosomes." Women have a pair of X chromosomes,

whereas men have a single X chromosome, which they inherit from their mother, and a single Y chromosome, which they inherit from their father. The Y chromosome is dominant for maleness.

During “mitosis,” the DNA double strand is unwound and split apart. Each individual strand is then duplicated. By making copies of each DNA strand, a parental cell can transmit a complete set of genetic information into each of its two daughter cells.

Gametes result from “meiosis,” which differs from mitosis in two ways. First, allelic chromosomes are paired prior to their duplication. Second, there are two sets of divisions before the final product, the gamete, is created. In the first set of divisions after DNA duplication, allelic chromosomes, rather than chromatids, segregate into the daughter cells. In the second set of divisions, the chromatids separate and segregate into the gamete. Thus, one and only one copy of each allelic pair is contributed to the gamete. In this way, a “diploid” germ cell gives rise to a “haploid” sperm or egg that contains an assortment of one of each of the twenty-three pairs of allelic chromosomes in the parental cell. During fertilization, a sperm and an egg unite to create a zygote with a newly constituted complete set of forty-six chromosomes. These fundamental properties of DNA and cell division are the basis of Mendel’s laws of unit inheritance, segregation, and independent assortment.

The central dogma of molecular genetics holds that each gene encodes one polypeptide, forming a monomeric protein. The portion of the gene that specifies the polypeptide sequence is termed “coding” DNA. Each human cell contains approximately 3.9×10^9 base pairs of DNA per haploid genome, which is enough to encode about 1 million polypeptides of average length. However, there are approximately 35,000 structural genes—possibly in the range of 30,000—in humans; thus more than 90 percent of DNA does not encode peptide sequences. The DNA that does not code for protein, termed “noncoding” DNA, is often involved in the regulation of gene expression. Noncoding DNA can also play a structural role. Structural functions include providing structural stability for the chromosome (e.g., matrix-associated regions, or MARs), providing the specialized sequences that define the ends of the chromosome (telomeres), and providing a site to

which the cellular cytoskeleton can be attached in order to allow the movement of chromosomes during meiosis and mitosis (centromeres). Approximately 10 percent of cellular DNA consists of a repetitive sequence that has been randomly inserted throughout the genome. Although the function of this repetitive DNA is unknown, its presence has proven useful for gene mapping studies.

Genetic information proceeds in a stepwise fashion from the sequence of a gene to the synthesis of a polypeptide. Located near the coding sequence of the gene are sequences, called DNA control regions, that identify the transcription start site (promoters), mark the tissue in which it will be expressed (enhancers), and control the use of batteries of genes during ontogeny (locus control regions). The regions of DNA that specify the sequence of a polypeptide chain, or structural genes, are organized into discrete units (exons) that are separated by noncoding sequences (introns). The first step in synthesizing a new protein occurs in the nucleus, where the sequence of the coding DNA is copied (transcribed) into ribonucleic acid (RNA), a less stable nucleic acid that can be rapidly degraded. The ends of the RNA are modified to help stabilize the final product and the introns are removed, or spliced out, generating messenger ribonucleic acid (mRNA). The mRNA is transported from the nucleus to the cytoplasm, where it is translated by ribosomes into polypeptide strands.

Ribosomes read the sequence of the mRNA in sequential groups of three, or triplets, termed a codon. There are sixty-four different combinations (e.g., AAA, TTT, CAC), all but three of which specify a specific amino acid. Each codon specifies a single amino acid, but amino acids can be encoded by more than one codon, thus there is considerable degeneracy in the code. Translation begins when the mRNA is bound to the ribosome. Transfer RNA (tRNA), an adapter molecule, contains a complementary triplet anticodon at one end, and an amino acid bound to the other end. The tRNA anticodon binds to the mRNA codon and helps stabilize the interaction with the ribosome. Each ribosome has two sites where the tRNA can bind. Binding of the downstream tRNA, which contains sequence complementary to the next three nucleotide codon on the RNA, brings its amino acid next to the end of the growing polypeptide strand. Formation of a peptide bond

allows the ribosome to shift down the mRNA, providing a site for the next amino acid and its adapter to bind. Step by step, the protein is allowed to grow until the mRNA brings one of the three remaining codons into the ribosome. These codons do not have tRNA partners, and they function to terminate translation and allow the release from the ribosome of the mRNA and its protein product.

Many genes are composed of a series of structural or functional domains, with each exon specifying part or all of the sequence of a single structural domain. Each domain can endow the protein with a different property. For example, a protein may have one or more extracellular domains that allow it to bind to a specific soluble ligand, a transmembrane domain that allows it to be anchored in the cell membrane, and one or more intracellular domains that allow it to signal inside the cell. These types of proteins are the product of mixing and matching different types of domains during evolution, a process that is facilitated by the exon/intron structure of the gene. By changing the extracellular domains while maintaining the rest of the molecule relatively intact, for example, a similar signal can be elicited by the binding of several different types of ligands. Conversely, the presence or absence of a transmembrane domain can allow the protein to be tethered to the cell or to exist as a soluble factor. The function of an unknown protein can often be guessed by analyzing its complement of domains.

At first glance, the linking of genes in chromosomal units and their transmission as a unit to daughter cells would seem to violate Mendel's laws of independent assortment and segregation, because effectively one might expect genes to be inherited as part of only 23 sets of genes. However, when allelic chromosomes are brought into close juxtaposition during the process of meiosis, breaks occur in the chromosomes and allow bridges, or *chiasmata*, to form between homologous portions of the chromosomes. This crossing over of DNA strands allows allelic chromosomes to recombine, forming patchwork or chimeric chromosomes that contain portions of each of the parental chromosomes. Although recombination can occur anywhere in the chromosome, only a limited number of chiasmata form during each meiosis. Two genes that are on opposite ends of the chromosome may

thus behave as if they were on different chromosomes, whereas recombination is less likely between genes that are very close to each other in their primary sequence. The increased frequency of the joint inheritance of two genes that are closely physically linked on a chromosome is termed "linkage disequilibrium."

Distances between genes on a chromosome are quantified by either their physical distance from each other in millions of base pairs (megabases), or by their genetic distance, as measured by the frequency of recombination between the two genes per generation. One percent of genetic recombination is termed a "centimorgan," after the geneticist Thomas Hunt Morgan, whose studies of the common fruitfly, *Drosophila*, in the first half of the twentieth century helped elucidate the properties of recombination. As a rough guide, one centimorgan covers approximately one megabase of DNA. However, the relationship between linear and genetic distance is not absolute. The frequency of recombination, and thus the genetic distance between genes in specific regions of the genome, may differ depending on the sequence or the nonhistone proteins that cover the DNA. Recombination frequencies in selected regions of the genome may differ in male and female gametes, implying that segments of chromosomes can be handled differently by spermatogonia and oocytes. This disparity in how DNA is treated by male and female gametes can lead to differences in the function of alleles, depending on whether they have been inherited from the mother or the father, a process termed "imprinting."

A "mutation" is defined as a stable, heritable alteration in the DNA sequence that can be passed from a parental cell to at least one its daughters. From the standpoint of evolution, mutations are required to generate the genetic diversity that is needed to permit species to adapt to a changing environment. The normal rate of mutation is approximately one base pair change per generation per 10^7 base pairs; thus, on average, each child differs from its parent by approximately 390 base pairs as a result of mutations in the gametes. Mutations in the nonreproductive cells of the body are termed "somatic" mutations. Although by definition these alterations are not transmitted to the gametes, the mutations are passed on to the daughter cells of the mutated parent. Somatic mutations

in oncogenes, for example, foster the development of many cancers.

Mutations can involve an entire human genome, as in triploidy, in which a third copy of the entire chromosomal complement occurs. Mutations may involve all or part of a single chromosome, including duplications, deletions, and translocations of a portion of one chromosome to another. At the other extreme, a mutation can be minute and involve a small deletion or insertion, or a replacement of only a single base pair (point mutation). Deletions or insertions that occur in a coding region can alter the reading frame distal to the mutation (frameshift mutations). Frameshift mutations frequently alter the protein sequence and can lead to premature peptide termination by generating a stop codon, one of the three triplet sequences that does not encode an amino acid. Point mutations in coding regions may be of three types: (1) a nonsense mutation (about 4% of base substitutions in coding regions), in which the base change generates one of the three termination codons; (2) a missense, or replacement, mutation (about 73% of base substitutions in coding regions), in which the base change results in substitution of one amino acid for another; and (3) a synonymous, or silent, mutation (about 23% of random base substitutions in coding regions), in which the base replacement does not lead to a change in the amino acid but only to a different codon for the same amino acid. Even synonymous mutations can have deleterious effects, however. A change in the coding sequence of a given gene may alter splicing patterns or diminish mRNA stability, reducing protein production.

The consequences of a single-point mutation to the function of a given protein can vary greatly. Enzymes, for example, exhibit a hierarchy of resistance to mutation. Portions of the hydrophilic exterior may serve primarily to allow the protein to be soluble in an aqueous solution, hence changes in the amino acid sequence that preserve hydrophobicity may have little or no effect on the function of the protein. The hydrophobic core provides structural stability for the molecule, and amino acid changes may result in an unstable protein product that is temperature sensitive (e.g., falling apart at high temperature). Finally, the catalytic site is exquisitely sensitive, and a single mutation may completely abolish function.

Large deletions may interrupt a coding region and cause an absence of one or more closely linked protein products. If the deletion removes a bridge between two coding regions, the result may be a fusion or hybrid protein containing the initial sequence of one protein and the terminal portion of the other. Such deletions can also result from unequal crossing-over between homologous genes. Finally, alterations of the DNA in the surrounding regions may lead to changes in RNA splicing, transcriptional efficiency, or control of tissue expression.

The Human Genome Project began in 1990 with the goals of developing genetic and physical maps and determining the complete DNA sequence of the human genome. The ultimate goal is to use this mapping and sequence information to isolate and study the structure and function of genes that can contribute to the development of disease. Knowledge of the genetic basis of susceptibility for specific diseases is likely to aid in disease prevention as well as therapy. Associated with these benefits, however, is the risk of discrimination against healthy at-risk individuals that may never develop a disorder. Thus, in addition to learning how to use this new knowledge, we must gain the wisdom to use genetic information appropriately.

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(SEE ALSO: *Genetic Disorders; Genetics and Health; Human Genome Project; Medical Genetics*)

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GENETIC DISORDERS

The traditional method used to study an inherited disease is to observe the pattern of its distribution in families through examination of a pedigree, the construction of which begins with the individual first known to have the disease. The pedigree pattern allows one to judge whether or not the distribution conforms to Mendelian principles of segregation and assortment, and thus represents single-factor inheritance. Patterns that do not conform to Mendelian principles may represent polygenic traits, which represent the cumulative effects of a number of different genes. These complex patterns underlie the vast majority of human diseases.

Disorders caused by single mutant genes show one of four simple (Mendelian) patterns of inheritance: (1) autosomal dominant, (2) autosomal recessive, (3) X-linked dominant, or (4) X-linked recessive. A dominant trait is one that is expressed in the heterozygote (as well as in the homozygote or hemizygote). A recessive trait is one that is expressed in a homozygote (or a hemizygote), but silent in the heterozygote. The terms "dominant" and "recessive" refer to the phenotypic expression of a trait, not to the expression of the gene. Thus it is incorrect to speak of a dominant or recessive gene. A gene is either expressed or not expressed. Whether the trait is considered dominant or recessive often depends upon the level of observation.

Sickle cell anemia is a recessive trait—it requires a double dose of the abnormal gene for expression at the clinical level. Nevertheless, the sickle gene can be expressed in single dose as well, giving rise to carriers with SA hemoglobin. In a state of reduced oxygen tension, red cells in SA carriers may sickle. Recessive traits may thus be *codominant* when viewed biochemically at the level of the gene product, or dominant in an altered environment.

AUTOSOMAL DOMINANT TRAITS

By definition, genes that are situated on chromosomes other than the X or Y sex chromosomes are autosomal. Dominant traits are fully evident when only one abnormal gene (mutant allele) is present and the corresponding partner allele on the homologous chromosome is normal (a heterozygous state). The representative initial for the dominant gene is typically capitalized, and the recessive gene is placed in lower case. Thus, if there are two alleles of a given gene that are referred to as "A" and "a," three possible genotypes exist: AA, Aa, and aa. Genotypes AA and aa are homozygotes; Aa is a heterozygote.

Autosomal dominant traits bear the following characteristic features: (1) an affected individual usually bears an equal number of affected and unaffected offspring; (2) unless the condition arose by a new mutation in a germ cell that formed the individual, each affected individual has an affected parent; (3) males and females are affected in equal numbers; (4) each gender can transmit the trait to male and female; (5) normal children of an affected individual have only normal offspring; and (6) when the trait does not impair viability or reproductive capacity, vertical transmission of the trait occurs through successive generations. The best evidence of a dominant trait is three or more generations of male-to-male transmission.

Autosomal dominant disorders often show two additional characteristics that are rarely seen in recessive disorders: (1) marked variability in the severity, or expressivity, of the disorder and (2) delayed age of onset. In heterozygotes the expression of the abnormal gene can be so weak that a generation appears to be skipped because the carrier of the abnormal gene is clinically normal. In such fortunate individuals, the trait is said to be "nonpenetrant." In some diseases, such as Huntington's disease and adult polycystic kidney

disease, the disorder may not become manifest clinically until adult life, even though the mutant gene has been present since conception.

In every autosomal dominant disease, some affected persons owe their disorder to a new mutation rather than to an inherited allele. A reasonable estimate of the frequency of mutation is on the order of 5×10^{-6} mutations per allele per generation. Because a dominant trait requires a mutation in only one of the parental gametes, the expected frequency for a new autosomal dominant disease in any given gene is one in 100,000 newborns.

A classic example of a dominant trait in humans is familial hypercholesterolemia, an autosomal dominant disorder characterized by elevation of serum cholesterol bound to low-density lipoprotein (LDL). Mutations in the LDL receptor (LDLR) gene on chromosome 19 cause the disorder. Heterozygotes develop fatty collections on their tendons, a corneal arc, and, of greatest concern, coronary artery disease, which typically presents in the fourth or fifth decade of life. Homozygotes develop these features at an accelerated rate. In the United States, the frequency of homozygotes is approximately one in a million, and the frequency of heterozygotes is approximately one in five hundred. However, among patients with a history of myocardial infarction (heart attacks), the heterozygote frequency is about one in twenty.

AUTOSOMAL RECESSIVE DISORDERS

Autosomal recessive conditions are clinically apparent only in the homozygous state—when both alleles at a particular genetic locus are deleterious. In most autosomal recessive disorders the clinical presentation tends to be more uniform than in dominant diseases, and the onset is often early in life. The following features are characteristic: (1) on average, male and female siblings are affected in equal proportions; (2) the parents are clinically normal; (3) all of the children of the union between an affected individual and a homozygous normal individual are heterozygous carriers, but none will be affected; (4) on average, half of the children are affected when an affected individual mates with a heterozygous carrier (a *pseudo-dominant* pedigree); (5) all of the children of a union between two individuals homozygous for the same mutant gene will be affected; (6) on average, if

both parents are heterozygous at the same genetic locus, one-fourth of their children are homozygous affected, one-fourth are homozygous normal, and half are heterozygous carriers of the same mutant gene; and (7) the less frequent the mutant gene is in the population, the greater the likelihood that the affected individual is the product of consanguineous parents.

Consanguinity increases the likelihood of a child presenting with a recessive disease because the likelihood of inheriting the same rare mutation from a distant common ancestor, or “founder” increases. First cousins share, on the average, one-eighth of their genes. When two first cousins marry, an offspring has, on average, one-sixteenth of the loci homozygous for a gene derived from a common ancestor. In general, offspring of first cousins are slightly more likely to have congenital malformations, as well as mental defects and metabolic diseases, than are children born to unrelated parents.

Increased frequency of consanguinity is not observed if the recessive disease is common. Cystic fibrosis exemplifies an autosomal recessive disorder that is common among individuals of Northern European descent. In the United States, the frequency of individuals heterozygous for a mutation in the cystic fibrosis conductance regulator gene (CFTR) is quoted as one in twenty-five. Inheritance of two malfunctioning genes leads to the disruption of pancreatic exocrine function and chronic bronchitis with emphysema, as well as biliary cirrhosis, meconium ileus, and an enhanced loss of salt through the skin, which is the basis of the “sweat test” used for screening purposes. The frequency of individuals affected with cystic fibrosis is one in 2,500, and typically the parents are unrelated.

X-LINKED INHERITANCE

Diseases or traits that result from genes located on the X chromosome are termed “X-linked.” Because the female has two X chromosomes, she may be either heterozygous or homozygous for the mutant gene, and the trait may exhibit recessive or dominant expression. The terms “X-linked dominant” and “X-linked recessive” refer only to expression of the trait in females. The male has only one X chromosome and therefore is hemizygous

for X-linked traits. Males can be expected to express X-linked traits regardless of their recessive or dominant behavior in the female. This accounts for the large numbers of X-linked diseases. Affected males do not transmit an X chromosome to their sons; thus an important feature of X-linked inheritance is the absence of male-to-male transmission. In contrast, since all females inherit their fathers' single X chromosomes, their daughters are all obligate carriers.

Although genotypically females have two X chromosomes, functionally they behave as though they only have one X chromosome, like their brothers. This is due to the process of X-inactivation, which was first proposed by Mary Lyon and is termed "lyonization" in her honor. During ontogeny, one of the X chromosomes becomes inactive, condensing to form a "Barr body." Inactivation is random, so each cell has an equal probability that the paternally or maternally derived X chromosome will be inactivated. Once one of the two X chromosomes is inactivated, the same X chromosome remains inactive throughout all subsequent cell divisions. Thus, on average, half of the cells of a female express the X chromosome of her father and half of her mother.

For the vast majority of genes on the X chromosome, the normal female is a mosaic, with her cells expressing one or the other X chromosome, but not necessarily a 50–50 mosaic. Inactivation of one of the X chromosomes occurs early in development and is random; hence many females may, by chance, have many more cells that carry an active X chromosome derived from one parent than from the other. Similarly, if one of the X chromosomes carries a mutant gene that confers a metabolic disadvantage upon cells with that mutation, these cells may survive less frequently during development, and the female offspring may have cells that carry predominantly or exclusively the active X chromosome without the mutation.

X-linked dominant traits are uncommon. The characteristic features are as follows: (1) females are affected about twice as often as males; (2) heterozygous females transmit the trait to both genders with a frequency of 50 percent; (3) hemizygous affected males transmit the trait to all of their daughters and none of their sons; and (4) the expression is more variable and generally less

severe in heterozygous females than in hemizygous affected males. Some rare X-linked dominant disorders occur only in the heterozygous female, because the condition is lethal in the hemizygous affected male. Additional characteristics of this form of inheritance are as follows: (1) an affected mother transmits the trait to half of her daughters (heterozygotes), and (2) an increased frequency of abortions occurs in affected women, the abortions representing affected male fetuses.

X-linked recessive traits are relatively common. The characteristic features are as follows: (1) the disorder is fully expressed only in the hemizygous affected male; (2) heterozygous females are usually normal, although occasionally they may exhibit mild features of the disorder, and in females who have unfortunately inactivated the wrong X chromosome may be almost as severely affected as the hemizygous affected male; (3) on average, a heterozygous female transmits the trait to half of her sons (hemizygous affected), but the other half are normal; (4) on average, half of the daughters of a heterozygous female are carriers and half are normal; (5) all daughters of an affected male and a normal female are carriers, and no sons of such a union are affected (no father-to-son transmission); (6) in the rare event of the union of an affected male and a heterozygous female, half of the daughters are homozygous affected and half are heterozygous carriers; while half of the sons are hemizygous affected (maternal inheritance) and half are normal; (7) if the trait is rare, parents and relatives are normal except for male relatives in the female line (e.g., on average, half of maternal uncles are affected). This "uncle and nephew" pattern gives rise to an oblique pedigree pattern, in contrast to the horizontal pattern of autosomal recessive conditions and the vertical pattern of autosomal dominant conditions.

Duchenne muscular dystrophy (DMD) and the milder Becker muscular dystrophy (BMD) are the product of mutations in the dystrophin gene on the X chromosome. The most distinctive feature of Duchenne muscular dystrophy is a progressive proximal muscular dystrophy with characteristic pseudohypertrophy of the calves. On average, a typical patient with DMD is diagnosed around the age of five, is wheelchair dependent at twelve years of age, and is dead before the age of twenty. One-third of cases represent new mutations.

POLYGENIC TRAITS AND MULTIFACTORIAL GENETIC DISEASES

Most phenotypic traits are determined by many genes collaborating at different loci (polygenic) rather than by single gene effects. Parents and offspring, and usually siblings, have 50 percent of their genes in common. Second-degree relatives share, on average, one-fourth of all genes, and third-degree relatives (cousins) share one-eighth. As the degree of relation becomes more distant, the probability of inheriting the same combination of genes is reduced, and the degree of resemblance is likely to be less.

Many common chronic diseases (e.g., essential hypertension, coronary artery disease, and schizophrenia) and the common birth defects of children (e.g., cleft palate, cleft lip, and neural tube defects) that tend to run in families fit best into the category of multifactorial genetic diseases. Multifactorial genetic diseases have both a polygenic component and an environmental component of causative factors. Susceptibility, or risk, genes are present in low frequency in the population at large. However, if any one individual has a particularly large number of such genes, the disease may manifest. When an individual is unfortunate enough to have inherited just the right (or wrong) combination of risk genes, he or she passes beyond a "risk threshold" at which environmental factors may determine the expression and severity of disease. In order for another family member to develop the same disease, that individual would have to inherit the same, or a very similar, combination of genes. The likelihood of such an occurrence is clearly greater in first-degree than in more distant relatives. The chances of another relative inheriting the right combination of risk genes decreases as the number of genes required to express a given trait increases. For example, the recurrence risk for siblings in neural tube defects is almost 4 percent, or ten times greater than the risk in the population as a whole.

CHROMOSOMAL DISORDERS

Failure of appropriate segregation (nondisjunction) during meiosis by allelic chromosomes or by sister chromatids can lead to an imbalance in the number of chromosomes present in a gamete. The

frequency of chromosomal nondisjunction increases with increasing maternal age, with up to 1 percent of the offspring of mothers aged thirty-five and 10 percent of the offspring of mothers aged forty-five or older exhibiting such abnormalities. A zygote with only one copy (monosomy) of any one autosome is nonviable, and three (trisomy) or more copies of any one type of autosomal chromosome are also typically lethal. Exceptions do occur, the most common of which is trisomy 21, or Down syndrome.

Due to lyonization, nondisjunction of the X chromosome is better tolerated. XO individuals (Turner's syndrome) are phenotypically female, but are typically sterile. The Y chromosome is dominant, hence XXY individuals (Klinefelter's syndrome) are phenotypically male. However, affected men are also commonly sterile. Rare individuals with apparent Klinefelter's syndrome have been fertile, but these individuals are typically mosaics, with a sufficient population of chromosomally normal cells to yield viable gametes.

HARRY W. SCHROEDER, JR.

(SEE ALSO: *Congenital Anomalies; Genes; Genetics and Health; Human Genome Project; Medical Genetics*)

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GENETICS AND HEALTH

The role of genetics in medicine and public health came to broad public consciousness quite dramatically in June 2000, when President Bill Clinton and Prime Minister Tony Blair jointly sponsored the announcement by government, academic, and industrial scientists that a "first draft" of the human genome sequence had been completed. Then, in early 2001, the announcement of the full sequencing and a revised estimate of the number of genes in the human genome was released. No doubt many people were mystified by the term "genome," even if they had some idea about what genes and proteins are. The genome is the complete set of genes of each individual in any species. In humans, there are an estimated 30,000 to 100,000 genes in the forty-six chromosomes of, essentially, all human cells. In early 2001, the same scientific groups reported a nearly complete sequence for the human genome, with an estimated 30,000 to 40,000 genes distributed on twenty-three pairs of chromosomes.

THE MOLECULAR NATURE OF GENES

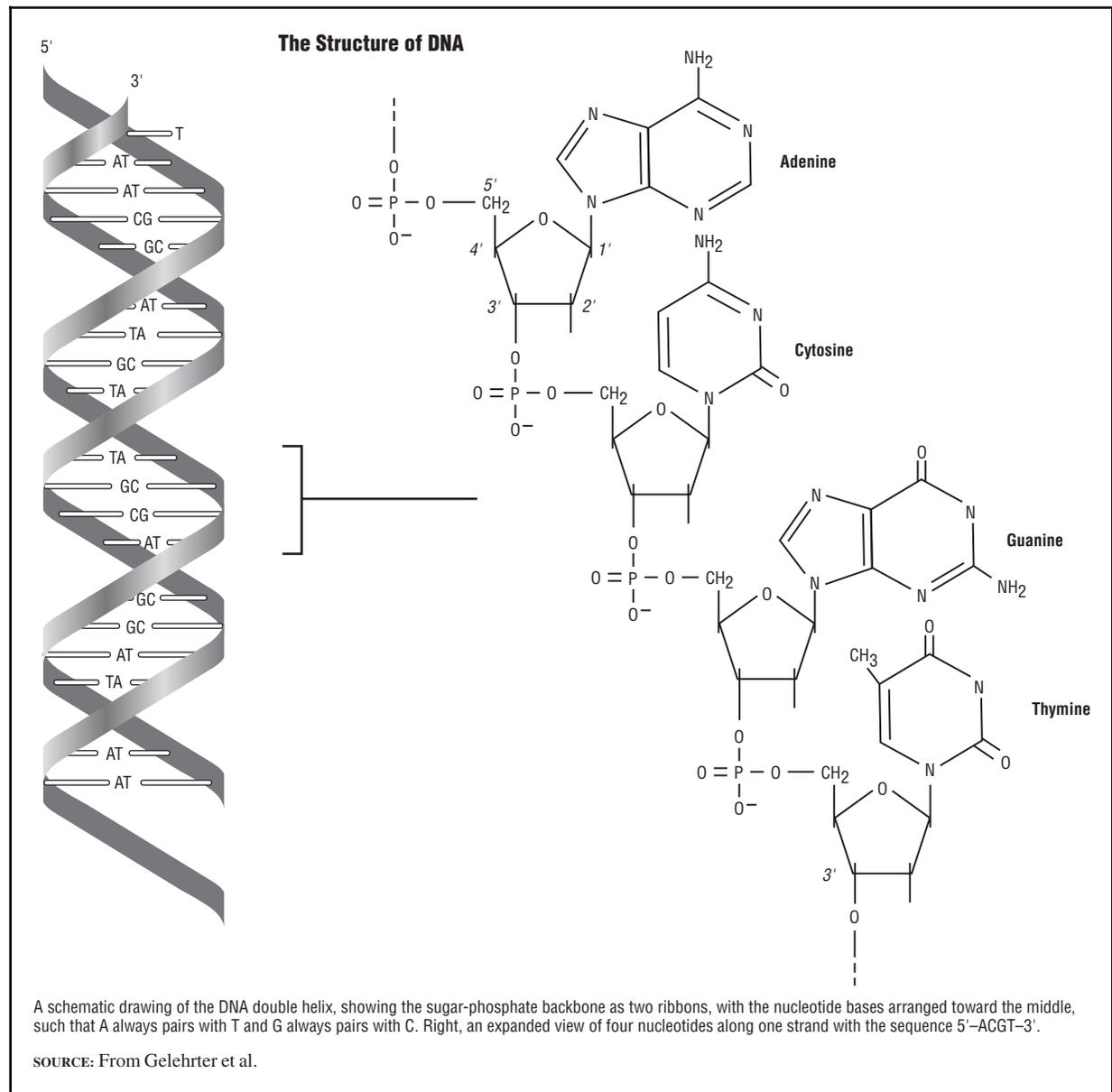
DNA (deoxyribonucleic acid) molecules carry the code for genetic information and its transmission from one generation to the next. For decades it

was thought that DNA was a most unlikely candidate for this role, due to its presumed simplicity (compared with proteins). DNA consists of a string of just four different nucleotide bases (A,T,G,C— for adenine, thymine, guanine, cytosine) held together by a sugar (deoxyribose)—phosphate backbone. In contrast, proteins are polypeptide chains of twenty different amino acids, offering much more variation for coding. In a classic experiment in 1944, scientists at the Rockefeller Institute in New York City working with bacteria that cause pneumococcal pneumonia showed that inherited transformation of the surface characteristics of the bacteria could be accomplished with DNA and not with protein.

In 1953, James Watson and Francis Crick, at Cambridge University in England, published the stunning hypothesis that two intertwined strands of DNA, running in opposite directions, could be joined in a double helix through hydrogen bonds linking the nucleotide bases in the specific combinations of A-T and G-C (see Figure 1). This model was justified by available X-ray pictures of the molecular patterns of DNA. Linear sets of three nucleotide bases generate a "triplet code," with sixty-four combinations, more than enough to code for the twenty amino acids. We now know that the double helix of DNA can separate, through actions of enzymes that facilitate unwinding, so that one strand of the double-stranded DNA can be transcribed into messenger RNA (mRNA) molecules. The mRNA is then translated into polypeptides, which assume highly folded three-dimensional structures to function as enzymes, antibodies, and structural components of cells. Other RNA molecules are involved in supporting the formation of the polypeptides and in delivering the right amino acid to the growing polypeptide chain as directed by the triplet code in the mRNA.

This flow of information from DNA to RNA to protein is a general phenomenon throughout living organisms. There are exceptions, such as viruses (including HIV/AIDS [human immunodeficiency virus/acquired immunodeficiency syndrome]) which use RNA as their genetic material. When these viruses infect human (or plant or animal) cells, they must first convert their RNA message into DNA to join the flow of information in the cell from DNA to RNA to protein. Similar "reverse transcription" can occur in cancer cells and during

Figure 1

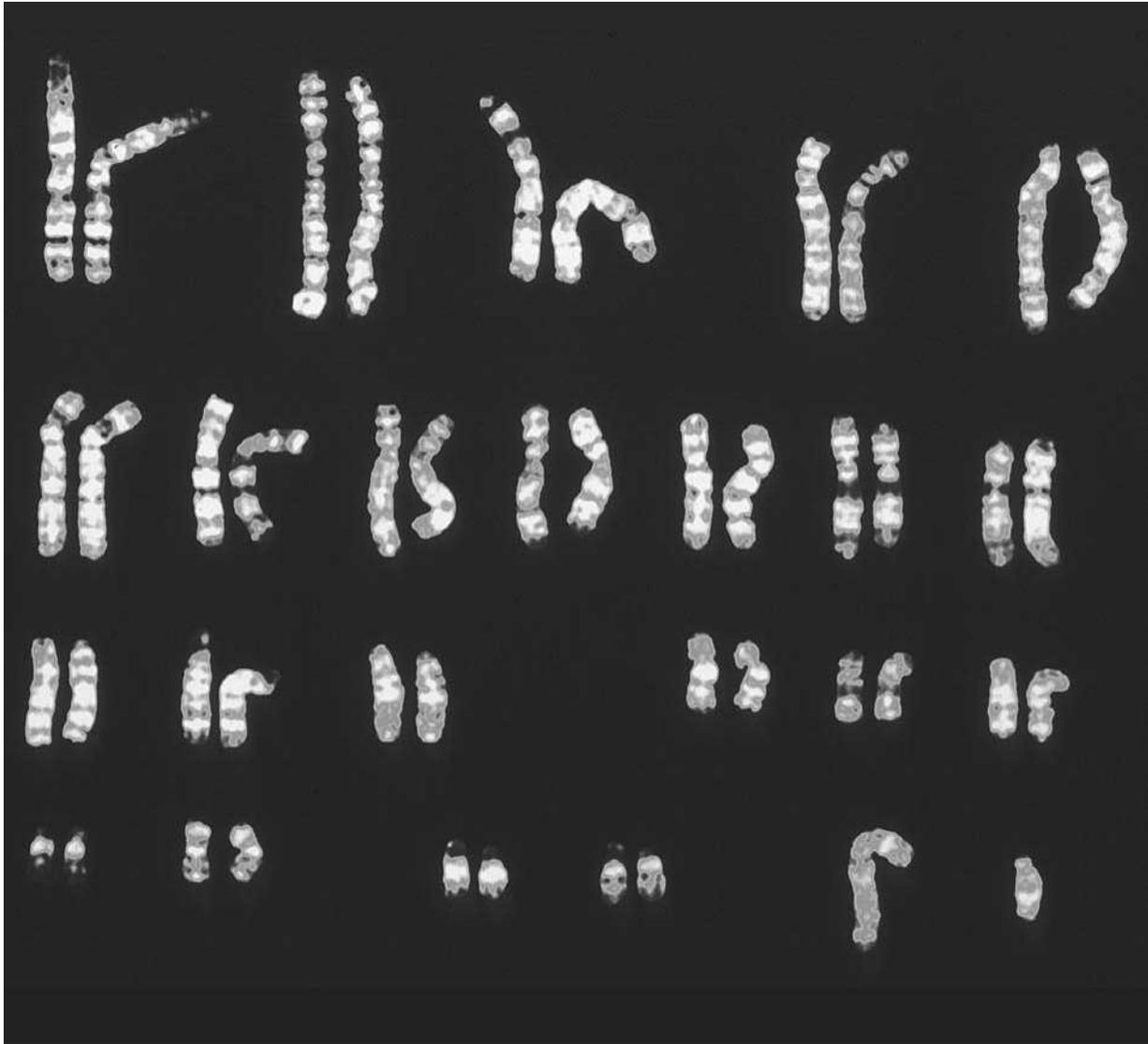


embryological development. Experimental conversion of mRNA to DNA is utilized very extensively to clone and sequence individual genes, key techniques in the field of biotechnology.

THE BASIS FOR INHERITANCE

Long DNA molecules are carried on structures called chromosomes in the nucleus inside each

cell. Human chromosomes occur in pairs, one derived from the mother and one from the father in sexual reproduction. Humans have twenty-three pairs of chromosomes, of which twenty-two are similar in males and females. These are numbered 1 through 22, according to chromosome size (1 is the largest). One chromosome pair is different between females and males: XX in females (one X from each parent) and XY in males (X from the mother and Y from the father).



A micrograph of the full complement of male chromosomes. (Photo Researchers Inc.)

When ordinary cells divide (during fetal development, normal growth, and the regeneration of skin, other organs, and cells lining the lung, intestine, and uterus), the chromosomes must be duplicated and then be distributed to daughter cells so that every cell gets a full set of twenty-three pairs of chromosomes. When the chromosomes are duplicated, the DNA must be replicated, as well.

Egg-forming cells in the ovary and sperm-forming cells in the testes are unique. They are duplicated in a more complex pattern so that they contain only one each of the twenty-three pairs of

chromosomes; when egg and sperm then combine, their aggregate of chromosomes is the expected twenty-three pairs.

Something else important can happen during duplication of chromosomes and replication of DNA. There may be recombination across the pairs of chromosomes between the DNA strands, so that genes (information) from the mother are combined at the molecular level with information from the father, and vice versa. Also, there may be mistakes. Mistakes in an individual gene occurring during replication, or when triggered by X-rays,

ultraviolet radiation, or chemical reactions, are called “mutations.” The complementary double-stranded structure of DNA is a defense against loss of information when DNA is damaged or broken; the damaged strand is repaired using the complementary strand to direct the repair. Mistakes that occur when chromosomes are duplicated can lead to translocations of part of one chromosome onto another, loss of a chromosome or part of a chromosome, or failure of separation of duplicated chromosomes (gaining a third copy of that chromosome, as in Down syndrome, where there are three copies of chromosome 21). In addition, some genes are actually carried outside the nucleus in the energy factories called mitochondria; these can be passed on only by the mother, in the egg cell, and are associated with certain diseases of muscle and brain.

MAPPING GENES ON CHROMOSOMES

Very effective methods have been developed to identify which genes for specific traits or diseases are located on which chromosomes, and to pinpoint the location on the relevant chromosome. The smallest genes consist of only a few hundred bases of DNA; the largest known human gene, which is mutated in Duchenne muscular dystrophy, is 2 million base pairs in length. A surprising feature of all nonbacterial genes is their organization into “introns” and “exons.” Introns are noncoding stretches of DNA within the gene which are transcribed into RNA but then spliced out before the RNA is translated into protein. There are also untranslated noncoding regions at each end of the gene. There are lots of signals built into the sequence of the DNA—for initiation, stopping, splicing, and other functions crucial to defining the genes in the lengthy DNA molecules; for regulating their expression as mRNA and proteins; and for coordinating regulation of related genes. Some genes have only a single exon; others have up to one hundred interruptions with introns. The reasons are still quite obscure.

Gene mapping before 1950 was limited to the X chromosome, deduced by mother-to-son transmission in pedigrees (diagrams of family histories) for X-linked diseases (e.g., hemophilia) or traits (e.g., color blindness). A few genes were located

on abnormal chromosomes by careful clinical correlations. Improved chromosomal analyses permitted formation of double-stranded DNA between fluorescent-labeled probe DNA and the DNA in a particular chromosome. Another method used mouse/human hybrid cells with one each of the different human chromosomes—if a human gene could be detected in the presence of the mouse genes, that gene must be coded for on the single human chromosome present. Once one gene is located, another gene which is *linked* in transmission from generation to generation can be deduced to be on the same chromosome. For example, the gene for cystic fibrosis was placed near linked markers on chromosome 7. This is truly a needle-in-the-haystack approach, since there are some 30,000 to 40,000 genes, distributed on the 23 pairs of chromosomes.

Everything changed with the new methods of recombinant DNA and the polymerase chain reaction—a way to produce millions of copies of a particular DNA molecule isolated or synthesized in tiny amounts. Increasingly, genes are being identified without the benefit of an initial chromosomal localization. A scan of the entire genome (across all chromosomes) is performed in a search for linkage to fairly common variants of genes that serve as well-spaced markers, even without knowing their function. Many steps in this approach are now automated, thousands of samples can be processed, and powerful computer programs sift through hundreds or thousands of markers to find clues for localization of the presumed gene or genes for a disease. Segments of DNA from the suspected chromosomal region can be cloned into specialized vectors. Linking together all such fragments permits scientists to assemble the genome sequence of humans or of many other organisms (e.g., yeast, fruitfly, bacteria, earthworm, mouse). A much more complicated mapping process is helpful in locating multiple genes for complex diseases like diabetes, high blood pressure, or depression.

THE HUMAN GENOME PROJECT

According to Francis Collins, director of the National Human Genome Research Institute, “mapping the human genetic terrain may rank with the great expeditions of Lewis and Clark, Sir Edmund Hillary, and the Apollo Program.” In the early

1970s, obtaining sequence information on DNA or RNA was arduous, typically requiring an entire year to deduce about fifteen nucleotides. Advances in laboratory methods triggered hope in the mid-1980s that a massive scale-up could eventually sequence the entire 3 billion base pairs of human DNA. The project was officially launched in October 1990 in the United States and soon became international, with major efforts in Britain, France, Scandinavia, and Japan. Specific goals, by chromosome, were set to achieve the mapping of genes to chromosomes, the physical map of DNA fragments, and then the DNA sequence. By 1994 there were 5,000 highly useful markers for the genetic map, and overlapping cloned fragments of DNA to create physical maps, using various techniques. Many clever schemes have been put to use to assure sufficient overlaps to orient the location and direction of DNA sequence fragments. Powerful sequencing methods accelerated the target completion date from 2005 to 2003, and then to 2001. Work to “clean-up” the sequence is ongoing.

Nevertheless, having the entire sequence has been likened to having the complete works of William Shakespeare as a sequence of the twenty-six English letters with no punctuation of any kind. Figuring out where the genes are and how they are turned on and off, or up and down, during life’s events is a huge remaining task. In reality, the work of understanding the genome has only just begun. Computer algorithms, including one called “GRAIL,” have been designed to find and use characteristics that may distinguish coding regions from the other 95 percent of the DNA sequence. Working backward from the mRNA molecules by forming double-stranded complementary DNA with the enzyme reverse transcriptase, and then sequencing the cDNA or even partial cDNA as expressed sequence tags, has accelerated this work.

Another powerful approach has utilized the theme of “unity in diversity” that characterizes all living things. There are amazing homologies between genes in humans and genes for similar functions in mice, earthworms, fruitflies, and even yeast cells, all of which have smaller genomes than humans. Computer databases available to scientists throughout the world permit “virtual experiments” using knowledge of a disease-related gene in the mouse, for example, to deduce what gene might account for a similar disease in humans.

Regulation of gene expression is a crucial feature of differentiated cells in complex organisms and of development from the single fertilized egg cell. Except for red blood cells, which have no nucleus, all other cells in any individual have a nucleus, chromosomes, and DNA—the same DNA. So the information content is essentially the same in all cells, yet quite different sets of genes are active in the blood, liver, kidney, brain, heart, and other organs and in cancer cells. Much is being learned about the ways in which genes are regulated in health and disease.

INTERACTION OF GENES AND ENVIRONMENTAL FACTORS

For many decades there were disputes about whether inheritance or environment were more important in determining health status. The debate was framed as genetics versus environment, or nature versus nurture. That kind of thinking is no longer appropriate. It is firmly established that genes act by generating a molecular framework in cells and organisms, including people, that environmental factors act upon. Thus, people are exposed to many kinds of radiation; noise; chemicals and infectious agents in air, water, food, consumer products, cigarettes, alcohol, and drugs; as well as to physical and psychosocial stresses—all of which may interfere with normal cellular functioning. For example, chemicals called polycyclic aromatic hydrocarbons are produced in the combustion of gasoline, oil, cigarettes, and various industrial processes; these chemicals are breathed in through the lungs, enter the circulating blood, are activated in the liver and other organs into very reactive intermediates, and attack the DNA, forming chemical adducts with the DNA. These adducts cause the DNA code letters to be misread, generating mutations in the genetic information of these cells and increasing the risk that these cells will evade normal growth controls and become cancers. Behavioral follow-up studies in Scandinavia of adults who were adopted as infants have provided potent evidence that genetics and biology are crucial to future risks for alcoholism, depression, schizophrenia, and even criminal actions. There is now evidence of relevant inherited variation in dopamine receptors in depression, cigarette-smoking behaviors, and dysfunctional alcoholic intake. Such genetic variation may account for

predisposition or resistance to these behavioral disorders.

Many pharmaceutical agents have variable therapeutic effects and variable adverse effects in different patients. In many cases we understand the reason: the drugs are metabolized (changed by enzyme action) into more active, or less active, molecules, depending on the inherited form of the gene coding for that particular metabolizing enzyme. Other chemicals from the external environment may undergo similar variable steps due to the same genes. Interactions of infectious agents with their "hosts," like infected people, may vary with genetic variation in the microbe and genetic variation in the infected person. Responses to high cholesterol foods or to cigarette smoking are subject to marked variation in people with different patterns of relevant genes. The study of these genetic-environmental interactions is called "ecogenetics."

SIGNIFICANCE OF GENETICS IN CLINICAL MEDICINE

There are well-recognized patterns of inheritance involving particular disease genes. If a disorder occurs in a grandparent, parent, and child, such vertical transmission in the pedigree is called dominant (caused by an abnormal gene from just one of the grandparents), and can involve either the X chromosome or any of the twenty-two autosomal chromosomes. Examples are Marfan's syndrome and Huntington's disease. If both parents appear normal, yet carry a recessive mutation, disease may occur when a child receives the mutant gene from each parent; examples include sickle-cell anemia and cystic fibrosis. Finally, the recessive gene may be carried on the X chromosome without manifestation in the female, but with full manifestation in the XY male, who has no normal second X gene; examples are hemophilia and Duchenne muscular dystrophy.

For common diseases like coronary heart disease, diabetes mellitus, breast cancers, depression, cleft lip and palate, and high blood pressure, multiple genes are involved; the heterogeneous causes vary within any group of diagnosed patients. Identical twins are much more likely than nonidentical (fraternal) twins to have the same disease; siblings and other close relatives have higher risks than unrelated individuals. In all cases,

environmental factors, maturation factors, and other genes influence the age of onset of disease and the specific manifestations.

It is quite miraculous that such a high proportion of babies appears to be "normal"—within the broad range of normal physical and mental development. Nevertheless, about 3 percent of newborns have major malformations affecting the heart, colon, bones, or other organs. Some 2 to 5 percent have severe or moderate mental retardation or developmental disabilities. Chromosomal abnormalities account for many of the malformations, and various gene mutations contribute to the disabilities. Major chromosomal abnormalities are particularly common in spontaneously aborted fetuses (up to 50%). Variations within the normal range influence height, body habitus, propensity to weight gain, and mental development and temperament.

One of the important concepts in genetic medicine is "inborn errors of metabolism," a phrase introduced by Sir Archibald Garrod in 1908. Specific mutations, usually involving both the maternal and the paternal forms of the gene (autosomal recessive pattern of inheritance, with 25% risk for each offspring), cause deficiency of a key enzyme—as in mental retardation due to a block in the metabolism of the amino acid phenylalanine, which becomes toxic to the developing brain. The effects of this disorder (phenylketonuria, or PKU) can be prevented by diagnosing the condition at birth through newborn screening of a heel-stick blood sample and putting the child on a diet low in phenylalanine for the first five years of life, while the brain is growing rapidly. The special diet can be less stringent (but should, it now seems, be sustained) during childhood and adolescence. For women, it is crucial that they be back on a stringent low-phenylalanine diet during pregnancy; otherwise, the high circulating levels will definitely damage the fetus (100% risk of mental retardation).

Autosomal dominant diseases, like those which affect collagen in bone, cartilage, skin, and teeth, typically distort key proteins that have two or more polypeptides, such that a mutation in one makes the whole protein complex malfunction.

Knowledge from the Human Genome Project should allow identification of susceptibility genes for a broad array of diseases, thereby permitting testing before symptoms become manifest. If a

single gene is responsible, testing during pregnancy or at any other appropriate time of life for the particular disease may predict a high risk or eliminate worry about that specific disease. For example, a person found to carry an inherited mutation in one of the colon cancer mutation repair genes could benefit from annual colonoscopy beginning at age thirty, so that any polyps would be detected and removed long before they progress to a potentially invasive cancer. In more complicated inherited conditions, multiple genes will be tested using new microarray and protein expression methods, answers will be couched in terms of increased or decreased risk and the likelihood of favorable responses to treatment. In other situations, the value of testing is limited due to lack of effective treatments, as for Huntington's disease. Of course, it is hoped that research will lead to effective therapies and preventive interventions and patients and families do value having the correct diagnosis, even if therapy is not (yet) available.

THE HUMAN GENOME PROJECT ELSI PROGRAM

One of the distinctive and important features of the Human Genome Project is its Ethical, Legal, and Social Implications (ELSI) program. James Watson committed a part of the annual appropriation from Congress to such matters from the start of the project. Three major categories of issues that have been examined in conferences, workshops, commissioned papers, and surveys are fairness, privacy, and safety.

Fairness. In the use of genetic information, fairness is especially important in preventing discrimination in access to affordable health care and life insurance and in employment. Many Americans fear genetic testing will identify a predisposition that will be (unfairly) considered a "preexisting condition" by insurance companies. As a result, genetic counselors advise that patients and families have good insurance in place before seeking counseling and testing. Even so, many individuals seek to be tested anonymously.

Privacy. Medical records and insurance health exams are not secure. In the state of Michigan, a 1999 report from the Governor's Commission on Genetic Privacy and Progress led to enactment of

seven model statutes in 2000. Federal legislation is pending.

Safety and Efficacy of the Tests. Many new tests emerging from research labs need to be converted to high throughput, less expensive methods, with reliable quality-assurance programs. In general, people will be tested only once, and the test results carry implications for relatives. Autonomy of the individual has been the explicit policy for genetic counseling and informed participation in genetic screening for many years; testing must be conducted with similar respect for individual preferences and decisions.

SIGNIFICANCE OF GENETICS IN PUBLIC HEALTH

The sequencing of the human genome and the subsequent demonstration of variation in numerous genes in health and disease will surely stimulate a golden age for the public health sciences. It will be essential to investigate and link data about microbial, chemical, and physical exposures; about nutrition, metabolism, growth, and development; about lifestyle behaviors; and about diagnoses, medications, and health care utilization to information about genetic variation. Such studies must be conducted on a population basis in order to interpret the significance of the genetic variation. Laboratory scientists, clinician-investigators, and health care professionals will rely upon epidemiologists, biostatisticians, environmental health scientists, behavioral scientists, health economists, and health-policy analysts for the collaborative research that will inform evidence-based, cost-effective medical care and public health interventions.

In research, practice, and policy, both genetics and public health focus on populations. Both are interested in clinical preventive services and in prevention of environmental and behavioral risks. Both fields explicitly recognize cultural, societal, ethnic, and racial contexts. Geneticists are particularly sensitive to the legacy of the eugenics movement of several decades ago and to the conundrum of making medical decisions when no treatment or preventive intervention is yet known. So long as the United States lacks universal health insurance, discriminatory use of genetic information by insurers and by employers must be guarded against, as noted above.

More knowledge is needed about the heterogeneity of genetic predispositions, environmental exposures, and disease risks. Unfortunately, most public health research on infectious disease and environmental chemical risks has paid little attention to inherited susceptibility in people, focusing only on the environmental-disease agents. Similarly, heterogeneity of study populations has often been neglected in epidemiologic studies in the effort to generate sufficient numbers to justify the analysis statistically. For quantitative traits, pharmacologists, toxicologists, and psychologists have generally emphasized means and standard errors of the means, and neglected potentially informative people with values outside two standard deviations from the mean. Nevertheless, genetics is now at the core of research on cancers, coronary heart disease, high blood pressure, neurological and psychiatric conditions, and a host of other common conditions.

Complete genome sequences are now available for *Mycobacterium tuberculosis*, HIV, and hepatitis B virus; sequences will soon be available for cholera, malaria, and other agents. The ability to promptly identify disease-causing strains of these infectious agents has been a boon to epidemiologic surveillance in the community and to clinical management of patients. Genetic variation in both the agents and exposed persons interact. For both HIV and malaria, there are cell-surface variants of blood cells in humans that protect some people from infection. These host-parasite relationships will be a fertile area for new knowledge in public health and for drug development.

Nutrition and genetics interact extensively. Individuals with similar elevated levels of cholesterol have a variety of underlying conditions for which different dietary and pharmacologic approaches are needed. Another important risk factor for coronary heart disease is the amino acid homocysteine, whose level is greatly influenced by folic acids and vitamins B12 and B6, as well as genetic variation in enzymes metabolizing these vitamins. One common disorder, hereditary hemochromatosis, results from an overload of iron from the diet, leading to damage from iron deposition in the heart, liver, pancreas (diabetes), testes (infertility), skin, and joints (arthritis). Simple blood donation can reduce iron burdens in the body and prevent these serious complications. It is easy to test for elevated iron levels and for the gene

mutations that predispose to the retention of excess iron. Unfortunately, the American Red Cross refuses to accept blood from these otherwise normal potential donors, and the Centers for Disease Control has been extremely cautious about undertaking screening programs on a population basis.

In the arena of environmental health, variation in susceptibility has been recognized as one of the three key components in assessment of risks, together with the dose-response relationship and the levels of exposure in relevant settings. The U.S. government has mounted an Environmental Genome Initiative to direct emerging knowledge of genes and genetic variation from the Human Genome Project and develop powerful new methods of chip technology for testing lots of genes simultaneously as an aid in identifying and preventing health risks from environmental exposures.

Across all of these fields, genetics will surely contribute to a scientifically sound strategy for improving health, preventing disease, and reducing disparities, the overarching missions of public health.

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(SEE ALSO: *Autonomy; Environmental Determinants of Health; Eugenics; Genes; Genetic Disorders; Human Genome Project; Medical Genetics; Nutrition; Retrovirus; and articles on specific diseases mentioned herein*)

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GENITAL HERPES

Genital herpes is a recurrent, incurable sexually transmitted disease (STD) caused by one of two types of the herpes simplex virus (HSV): HSV type-1 or HSV type-2. Persons infected with HSV remain infected for life and can transmit the virus to others during vaginal, anal, or oral sex. Each year, as many as 1 million Americans contract genital herpes. Some infected persons have outbreaks of sores and can transmit the virus when the sores touch a mucous membrane or small break in the skin of an uninfected person. Persons with no symptoms can also transmit HSV. All infected

persons periodically reproduce HSV and silently shed virus in their genital tracts. During these shedding episodes, they can transmit HSV to a sex partner.

Most persons infected with HSV are not aware of their infection. If symptoms occur during a first episode of genital herpes, however, they can be quite severe and prolonged. Most persons who suffer a symptomatic first episode have several recurrences per year. Genital herpes can also reactivate without causing any visible symptoms. At these times, small amounts of virus are shed at or near sites of the original infection, in genital or oral fluids, or from nonvisible sores. This asymptomatic shedding usually lasts only a day but is enough to infect a sex partner.

Herpes is not curable, but antiviral drugs can partially control the duration and severity of episodes. Genital herpes rarely has serious physical consequences, except for newborns and persons with weakened immune systems. A pregnant woman who develops a first episode of genital herpes close to delivery can pass the virus to her newborn during childbirth. Herpes infection in a newborn can be fatal.

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(SEE ALSO: *Sexually Transmitted Diseases*)

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GENITOURINARY DISEASE

Genitourinary disease involves disorders of the genital and urinary organs. These organs are involved in reproduction and urination, and include the external genitalia, kidney, bladder, ureter, and urethra in both sexes; the prostate in males; and internal genitalia, including the ovaries and the uterus in females. Genitourinary diseases can be

classified as either benign or malignant. This division has important prognostic and therapeutic implications.

Benign diseases of the genitourinary system can be divided into developmental (genetic or congenital) and acquired disorders. Developmental disorders usually present in childhood, and, if not treated promptly, they may result in permanent damage. Examples include congenital obstruction of the urinary organs, defects of the bladder wall or the genital tract, and abnormal sexual differentiation. In most circumstances, early recognition and treatment in childhood is associated with normal lifestyle and social development. The advent of routine prenatal ultrasound has revolutionized the opportunities for intervention, and most disorders are now diagnosed and treated earlier than in the past.

Acquired disorders can be subdivided into benign tumors, stones of the urinary system, obstruction of the genitourinary system, infectious and inflammatory processes, traumatic disorders, and iatrogenic processes. Acquired disorders may also include dysfunction of the genitourinary organs. Examples include kidney failure; dysfunctional voiding, including urinary incontinence; impotency; and infertility.

Renal failure, the inability of the kidneys to function normally, may be acute or chronic. This condition has a variety of etiologies such as medical diseases (diabetes, hypertension), primary renal diseases, and urinary obstruction (prostate enlargement or cancer). These conditions may be reversible or irreversible. In the latter, also called end-stage renal disease, the kidneys do not function well enough to maintain life. In this situation, renal replacement treatment with dialysis or renal transplantation becomes necessary.

Acquired benign disorders, although not fatal in the majority of cases, may have a significant impact on the quality of life. Antibiotic and anti-inflammatory agents, along with early treatment, have improved outcome in infectious and inflammatory diseases. Resistant bacteria have emerged, however, and are an ongoing problem, especially in immune-compromised patients.

Stone disease, wherein bodies form in the urinary system (bladder, kidney, and ureter), is a

common problem with an increasing incidence in industrialized countries. Stones are caused by genetic abnormalities, metabolic abnormalities, dehydration, dieting factors, and urinary tract infections. Simple dietary and behavioral modifications, along with new medications, can decrease the chance of recurrent stones. Therefore, metabolic evaluation may help to prevent stone formation and decrease morbidity. Minimal invasive approaches now allow most urinary stones to be treated without open surgery.

Obstruction of the urinary tract due to an enlarged prostate is a common health problem in older men. Management of this condition has moved from a primarily surgical approach to effective medical management. Early recognition of symptoms of urinary obstruction can avoid serious complications such as kidney failure.

Malignant disorders may involve any organ. The distribution of most malignancies, however, is age dependent. The most common example of a childhood malignant tumor of the kidney is the Wilm's tumor, which typically occurs between ages 2 and 5. Testicular cancer is most common in young men between 20 and 35 years of age. In contrast, the highest incidence of kidney cancer and bladder cancer is in adults between 60 and 70 years of age. Prostate cancer is the most common genitourinary malignancy in men and is the second leading cause of death due to cancer in men. The incidence of prostate cancer increases with age. Elevated levels of prostate-specific antigen (PSA) in the blood has been found to be a marker for prostate cancer, as cancer cells leak more PSA into the blood than do normal cells. Current data suggest that annual prostate cancer screening for PSA and digital rectal examination may translate into a decreased mortality rate from prostate cancer in the future.

There are many genetic, racial, environmental, and behavioral risk factors for genitourinary malignancies. Race and family history are strong risk factors for prostate cancer, with black men having the highest incidence and Asian men the lowest incidence in the United States. Early screening of black men and those with a family history of prostate cancer may improve outcome. Dietary fat has been implicated as an important risk factor for prostate cancer.

Kidney cancer is a relatively rare tumor and accounts for 3 percent of all adult malignancies. Certain types of kidney cancer are associated with inborn defects in specific genes, such as kidney cancers in patients with Von Hippel-Lindau syndrome. Epidemiological studies have incriminated tobacco as an etiologic agent. No other definite environmental or occupational factors have been identified.

Bladder cancer is three times more common among men than women, and it is the fourth most common cause of cancer in men. It is almost two times as common in white men as it is in black men. The incidence of bladder cancer increased approximately 50 percent in the second half of the twentieth century. The mortality rate has decreased, however, primarily in men. This suggests a difference in bladder cancer diagnosis, treatment, or disease characteristics between the sexes.

Genetic and environmental factors play an important role in the development of bladder cancer. Cigarette smoking is the most significant risk factor, and smokers have a fourfold higher risk. This risk correlates with the duration and quantity of smoking. Occupational exposure accounts for 20 percent of bladder cancer cases in the United States. Aniline dyes and other chemicals, especially aromatic amines, have been associated with bladder cancer. Occupations that involve working with these chemicals, such as automobile manufacturing and painting, have an increased risk of bladder cancer. Other etiologic factors for bladder cancer include chronic bladder infections, analgesic abuse, pelvic irradiation, and chemotherapy. Knowledge of these risk factors may aid in the prevention and detection of bladder cancer.

The incidence of testicular cancer has strong geographical and ethnic distribution. For example, African Americans have one-third the incidence of American whites and ten times that of African blacks. A history of undescended testis in childhood presents the highest risk. Regular self-examinations in high-risk population may result in early detection and improved outcome.

Urology also includes penile pathology, including erectile dysfunction (i.e., an inability to achieve or maintain an adequate erection for sexual intercourse). Male-factor infertility and urinary

incontinence are other areas of genitourinary disease. Urologists are the physicians trained to diagnose and treat these and all other disorders of the organs related to reproduction and urination.

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(SEE ALSO: *Colorectal Cancer*; *Ovarian Cancer*; *Prostate Cancer*; *Prostate-Specific Antigen [PSA]*; *Sexually Transmitted Diseases*; *Testicular Self-Examination*; *Urinalysis*; *Urine Cytology*; *Uterine Cancer*)

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GENOCIDE

Genocide is the deliberate and systematic destruction of a group of people defined by their nationality, or by their ethnic, cultural, or religious background. While public health has long been

concerned with the promotion, provision, and protection of a population's health during war and conflict, genocide became of interest to the field of public health only in the late twentieth century. The public health impact of genocide is enormous; in the last half of the twentieth century alone, dozens of genocides—accounting for over 23 million deaths—occurred, including in Bosnia-Herzegovina, Rwanda, Burundi, Cambodia, and Bangladesh. Recognizing the relationship between public health and genocide is important because of the contributions public health professionals can make to preventing and mitigating genocide and its impact.

Genocide may include a direct assault on public health as it did in Bosnia-Herzegovina. There, public health came face to face with genocide when acts were committed to destroy the public health of the population, thereby threatening to destroy people through inflicting serious harm to their health. Food, fuel, electricity, running water, and medical supplies were cut off from Sarajevo and its environs during the siege of that city. Since many things are essential to public health, including housing, nutrition, sanitation, and access to public health, any acts committed to destroy or seriously undermine the conditions needed for health are potentially acts of genocide if they are committed against a specific population. For instance, during the siege of Sarajevo, waterborne diseases such as hepatitis A increased because the sanitation systems no longer worked properly, 10 percent of the city's population was moderately malnourished, and the combined effects of malnutrition, cold, and lack of adequate medical care led to increased illness and deaths. In the case of Bosnia-Herzegovina, genocide disproportionately affected the most vulnerable Bosnians—the very young, the elderly, women, the chronically ill, and the disabled.

Genocide may also include indirect assaults on public health, as it did in Rwanda in 1994. There, massive displacement of persons from their homes created large-scale health risks to the internally displaced and refugees. While the high morbidity and mortality in the Rwandan refugee population was recognized as a public health crisis, it was also the product of genocide. Refugees from the genocide who were living in camps did not contract cholera solely because of the infectious

agent, but also because they were forced to flee their homes and encounter grossly unsanitary conditions due to their status as members of an ethnic group (the Tutsi) and resultant attacks by the Hutu government.

GENOCIDE AND OTHER FORMS OF MASS VIOLENCE

Genocide is a particular type of mass violence perpetrated against a large population. Other threats to the survival of a population, such as arbitrary imprisonment, discrimination, mass and systematic rape, torture, cutting off essential civilian supplies, and forced migration, can perpetrate large-scale harm against that population and have many of the same implications for public health as overt genocide. However, since 1946, when the United Nations General Assembly declared that genocide is “a crime under international law,” genocide is recognized as distinct from other forms of mass violence. The Convention on the Prevention and Punishment of the Crime of Genocide, enacted in 1951, defines genocide as:

Any of the following acts committed with intent to destroy, in whole or in part, a national, ethnical, racial or religious group as such: (a) killing members of the group; (b) causing serious bodily harm to members of the group; (c) deliberately inflicting on the group conditions of life calculated to bring about its physical destruction in whole or in part; (d) imposing measures intended to prevent births within their group; or (e) forcibly transferring children of the group to another group.

This distinction between genocide and other forms of mass violence is as significant to public health as it is to international law. First, when public health professionals name mass violence “genocide,” they can invoke the Genocide Convention in their calls for action of intervention from the international community. Second, genocide is a punishable crime under the Genocide Convention. Since many health professionals believe that justice and legal accountability facilitate both the healing of victims and primary prevention of future genocides, determining that mass violence constitutes genocide invokes legal mechanisms for punishing the perpetrators under the Genocide Convention.

THE ROLE OF PUBLIC HEALTH

The precursors, processes, and consequences of genocide are increasingly being understood, and public health contributes to this understanding in a distinct manner from other disciplines, such as the law profession and the human rights field. Specifically, public health brings to the study of genocide the unique tools of epidemiology, which is the study of the distribution of disease and the factors associated with a disease within a population. Since public health views a specific population or group of human beings in an ecological model that includes the institutions (e.g., paramilitary organizations) and the objects (e.g., weapons of genocide) they have created, it is only natural that public health views genocide in this manner, too. Thus, public health professionals can examine genocide as a disease, along with social and behavioral factors that correlate with the disease, and may even cause it.

The work that public health professionals do to examine, prevent, and mitigate genocide can be understood in terms of the three traditional core functions of public health: assessment, policy development, and assurance of services. Assessments can be performed through data collection and analysis intended to identify, document, and notify the public about potential or ongoing genocide. Here the public health principles of disease and injury surveillance can be applied to violence against a population, and the traditional tools of public health—such as case reports and surveillance studies—are well suited to this function. A genocide may have early warning signs that public health professionals can detect, such as escalating violence, increased refugee flows out of a country, and increasing systematic discrimination. In those cases where a war strategy targets the health of an entire group of people, public health professionals are best able to recognize the nature of the genocide.

Assessment is equally important after a genocide occurs. The methods, effects, and outcomes of all public health interventions must be assessed objectively. Epidemiologic studies to determine and quantify the public health impact of genocide can be performed, as has been done in numerous studies of international and civil wars. The public health impact of genocide goes beyond the number of people killed. It must also be understood for its long-term effect on public health, including the

destruction of medical facilities; the killing and flight of physicians, nurses and other health care professionals; the psychological impact on the survivors; and the interruption of programs for immunizations, infectious disease prevention, and prenatal care. Public health can also inform other types of assessments, such as retrospective studies to determine and identify the conditions, risk factors, and precursors that led to genocide.

Policy development may include recommending courses of action to prevent or mitigate a genocide. Again, policy development is an established function of public health in response to situations that threaten the health and safety of an exposed population. For instance, public health programs such as vaccination campaigns are proposed when large numbers of people living in a defined geographic area are at risk for illness or death from a contagious disease that vaccination would protect against. Similarly, public health policy proposals can advocate to protect groups at risk of genocide. Whenever there is a threat or occurrence of genocide, public health officials can advocate strongly for immediate international action. The principles of public health, coupled with the protests of public health professionals, can influence governments regarding the need, timing, and level of intervention required to protect a group from genocide.

Assurance of services may include designing and implementing programs that address the efforts at genocide. In the event of genocide, health care professionals can provide emergency services and physical and psychological treatment and rehabilitation of survivors. Interventions for complex humanitarian emergencies must be implemented as quickly as possible and made available to refugees and internally displaced persons.

Public health can play an important role in determining the truth about events of mass violence. Much of the work regarding genocide in the fields of human rights, law, and history revolves around determining the truth of claims for and against an occurrence of genocide. Public health contributes to these efforts through the powerful tool of epidemiology. With its methods for systematic compilation, consolidation, and assessment of data, epidemiology can be used by war crime tribunals to argue that specific war violations occurred on a scale consistent with crimes against

humanity and possibly even genocide. For instance, epidemiologic investigations are useful in determining whether the cluster of methods that make up a policy of “ethnic cleansing” are consistent either with a series of unorganized and isolated acts or with a systematic policy of genocide—which would be a punishable act under the Genocide Convention.

S. Swiss and J. Giller have demonstrated how public health methods are critical to defining the nature of a particular mass violence, such as the systematic use of rape in Bosnia-Herzegovina. They estimated that “based on the assumption that 1 percent of acts of unprotected intercourse result in pregnancy, the identification of 119 pregnancies, therefore, represents some 11,900 rapes.” They stress that the goal is not to arrive at a final number of events but rather to determine its magnitude and extent, since evidence of a systematic pattern is critical to determining whether rape constituted part of a policy of genocide. This is because the Genocide Convention prohibits even intent or attempts to commit genocide. Though proof of thousands of rapes is useful evidence when prosecuting a case under the Genocide Convention, the Genocide Convention focuses on the perpetrator’s intent to destroy a social group in whole or in part. The degree to which a genocidal plan is successfully carried out is not part of the law of the Genocide Convention. Thus, behind the inevitable complexities that surround questions of the responsibility of the different nationality or ethnic group involved in the violence, public health can analyze a genocide from a public health perspective and can contribute to the prevention of genocide and the healing of its survivors.

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(SEE ALSO: *Famine; International Health; Politics of Public Health; Refugee Communities; Violence; War*)

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GEOGRAPHY OF DISEASE

The descriptive study of disease distribution, or the geography of disease, was formerly popular among pathologists and is often called geographic pathology. This type of study has often revealed real differences in disease distribution among nations and in regions within nations. It is a simple way to draw attention to the disease risks associated with particular environments, but is seriously flawed if it fails to take into account the other factors (social, genetic) that can influence disease distribution. The geographic study of disease, patterns of mortality, health care, and other health-related issues is useful when it reveals unusual distributions that can be further investigated and confirmed or refuted by appropriate epidemiologic and other studies.

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(SEE ALSO: *Descriptive Study; Environmental Determinants of Health; Epidemiology*)

GERIATRICS

Geriatrics literally means the care of old persons. Practically, geriatrics combines two elements: gerontology and chronic disease. Gerontology refers to the study of aging. It addresses all aspects of how aging affects individuals—physically, socially, psychologically, and economically. Geriatrics adapts this knowledge to improve the provision of care to older persons. Geriatricians must know how diseases present in older persons and how to manage

them. Because one of the hallmarks of aging seems to be a loss of reserve capacity, and hence a loss of ability to respond to stress, many older persons may fail to exhibit the characteristic symptoms associated with a given disease. Most symptoms represent the body's response to the external stress of a disease, which may be dampened with age. Moreover, most older persons suffer from several chronic conditions, making it often difficult to distinguish clearly a new symptom in the context of many existing problems. Geriatric diagnosis thus requires a substantial degree of insight and subtlety.

Geriatric management is likewise complicated by the presence of multiple, simultaneously interactive problems, which often reach across several domains of life. One must treat not only the immediate illness in the context of several others, but also address their financial and social consequences. Inadequate income may make it difficult to buy needed medications. Housing may need to be altered to accommodate physical limitations. Social support may be needed to provide both direct assistance and social stimulation.

Geriatrics overlaps substantially with chronic-disease care. Most of the illnesses older people suffer are chronic. According to C. Hoffman, D. Rice, and H.-Y. Sung (1996), approximately 95 cents of every health care dollar spent on older persons goes toward a chronic illness. However, the same study notes that chronic disease is, in fact, predominant in virtually all ages—over two-thirds of the money spent on health care in this country goes toward chronic illness. Yet, somehow, the medical care system has failed to adapt to this epidemiological reality. Health care continues to be organized as it was during the era of acute disease. A substantial contribution to public health would be to translate this fundamental epidemiological observation into a more appropriate system of health care—one that changed the focus of care to extend over longer periods, that shifted attention from single clinical interactions to episodes of care, and that created a more meaningful participatory role for consumers of care.

Perhaps the most dreaded manifestation of aging is dementia. Much has been learned about dementia. It is no longer viewed as an inevitable consequence of aging, although its incidence is

likely in very old age. While new drugs are constantly being developed, no effective treatments are yet available. Some currently available agents appear to be able to slow the progression somewhat, but their overall contribution is still uncertain.

Much of geriatrics involves the intersection of medicine and long-term care. For some time, these have been viewed as separate areas of endeavor, responsible to medical and social models, respectively. Here too, epidemiology has a valuable insight to contribute. Most older persons needing long-term care suffer from serious problems that have led to the loss of physical and/or cognitive abilities. The underlying conditions often require close medical attention. Thus, those in long-term care usually need more, not less, medical attention.

The goal of geriatric care is to maximize the functioning of patients. Function can be viewed as the end result of several factors. The first of these is the appropriate treatment of medical conditions. The first maxim of geriatrics is to treat the treatable. This step is not always easy. One of the most difficult differential diagnoses in medicine may be distinguishing pathological change from that simply associated with aging. Good treatment is necessary but not sufficient. The next step is to recognize the potential effects of environment, both physical and social. Much of the modern health care institution (hospital and nursing home) actually serves to debilitate patients, especially those who are most vulnerable. The environment is alien, the timetable suits the schedules of the providers of care, and individual patient identity is easily lost. Something as simple as a hospital bed with bedrails may create a new series of barriers for a frail older person. It is hardly surprising that delirium is common among older persons in hospitals. Perhaps most pernicious of all, the pressures for efficient care prompt staff to do many tasks for older patients, thereby creating an atmosphere of learned dependence. At the very time when they should be fostering self-reliance, institutions encourage dependency. As the advocate for vulnerable populations, public health has a duty to alter this inappropriate and dangerous system.

One of the most successful accomplishments of geriatrics has been the demonstration of the value of comprehensive geriatric assessment, or, more specifically, geriatric evaluation and management. The latter term is used to emphasize the

importance of adequate ongoing involvement until the problems uncovered are sufficiently managed. A long series of studies is now available to demonstrate the benefits of such interventions. This approach has been applied in various settings, from inpatient situations to home assessments. The results have been generally positive, including improvements in function and reduction in subsequent medical costs. In public health terms, this assessment represents a variation on secondary prevention.

Geriatrics offers other opportunities for prevention. Primary prevention usually focuses on such elements as immunizations, especially for influenza and pneumococcal disease; but other risk factors can be addressed. The role of estrogens is still being explored. They seem to have a positive effect on delaying osteoporosis and heart disease, although they do carry an added risk for gynecological cancers. Exercise is widely touted as beneficial for both physical and social well-being. Smoking cessation is beneficial well into old age. Efforts have been made to prevent falls with only modest success. The most preventable problem among older persons is iatrogenic disease. Multiple medications, which transform older patients into living chemistry sets, are probably the most ubiquitous threats. Mention has already been made of the dangers of institutionalization. Misdiagnosis, including both overtreatment and undertreatment, is a recurrent problem.

Public health has an obvious stake in the health of older persons. They are the ones who are most likely to be ill. They are the most rapidly growing segment of the population and represent some of the most difficult elements of care. Approaches that are successful with older persons should be readily adaptable to serving other subgroups. Because chronic disease is endemic among older persons, they provide the impetus to develop a more effective and appropriate approach to health care, an approach that has broad applications in the face of changing demographics and a new epidemiological reality.

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(SEE ALSO: *Aging of Population; Alzheimer's Disease; Chronic Illness; Dementia; Gerontology; Hip Fractures; Life Expectancy and Life Tables; Medicare; National Institute on Aging; Osteoarthritis*)

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GERM THEORY OF DISEASE

See Theories of Health and Illness

GERMAN MEASLES

See Rubella

GERONTOLOGY

Gerontology, the study of aging, has become a major focus of attention in science and the professions. With increasing life expectancy and falling birth rates, populations are getting older. Increases in life expectancy in both developed and developing countries and increased needs for services for older persons have contributed to a growing volume of research and education on both basic and applied aspects of aging. Geriatrics, the branch of medicine that treats the clinical problems of late life, is also an area of expanding professional activity. Both gerontology and geriatrics emerged as disciplines immediately after World War II with the establishment of professional societies and specialized journals. Why it took so long, compared with other fields, for academic and professional interests in aging to emerge is an interesting question to pursue.

There have always been speculation and cultural myths about aging and the association of death with advanced chronological age. Gerald Gruman has described many myths about death and aging from ancient times to about 1800. The common interpretation in the Middle Ages was that death was either the outcome of humankind's fate as punishment for sin or an outcome of cosmic forces that were insurmountable. The growth of science in the nineteenth century was accompanied by the conviction that all phenomena of nature were governed by natural laws, and that these laws can be discovered through scientific investigation. The point of view that aging was not a supernatural phenomenon, knowable and explainable by study, was fully expressed by the Belgian mathematician, statistician, and astronomer Lambert Quetelet (1796–1874). In 1835, Quetelet wrote: "Man is born, grows up, and dies, according to certain laws which have never been

properly investigated, either as a whole or in the mode of the mutual reactions" (Quetelet, 1968). Quetelet reviewed data on mortality in relation to age, sex, urban, rural, and national differences and found that the duration of human life varied according to the environments in which people lived.

An international exhibition on health in London in 1884 extended further interest in how differences in age affect human functions. The exhibition was sponsored by Francis Galton (1822–1911), a cousin of Charles Darwin. Galton had a broad background in mathematics, medicine, psychology, and anthropology. At the exhibition, he took measurements of seventeen different bodily functions, including hand strength, hearing, vision, speed of movement, and vital lung capacity. Over 9,337 males and females were measured. Since Galton was exposed to a large mass of data, and given his background in mathematics, he was able to develop the first quantitative measure of the degree of association between two variables, such as age and strength.

Gerontology requires the support of mathematics and statistics to identify and compare the complex sources of variance that influence human aging. Quetelet and Galton were pioneers in creating a quantitative basis for gerontology and replacing older myths. Another contributor to the quantitative approach to aging was Benjamin Gompertz, a British actuary, who, in 1825, described the relationship of mortality to age as an accelerating curve described by exponential equation. The fact that mortality data could be described as an exponential equation did not itself explain why mortality is related to age. It was, however, an early step toward bringing science into discussions about aging.

Similarly, relating health, disease, and changes in function to chronological age does not reveal the causal variables. Modern gerontology recognizes that organizing data by age is but a first step toward explanation. To understand the process of aging and the changes that occur as people age, the causal variables must be understood.

The term "gerontology" was introduced in 1903 by Elie Metchnikoff, a Nobel laureate and professor at the Pasteur Institute of Paris. In America, the emergence of gerontology as a scientific movement can be traced to a small group of

leaders who, in the mid-1930s, recognized that the health of the American population was undergoing a change from domination by infectious diseases to chronic diseases. The Gerontological Society of America was founded in 1945, and the International Association of Gerontology about five years later.

THE BEGINNING OF MODERN GERONTOLOGY

The concerns of public health and medicine in the early years of the twentieth century were focused on the major causes of death at that time, the infectious diseases. Disease was generally regarded as a result of an invasion of the human body by a foreign organism whose influence had to be destroyed. As chronic diseases—heart disease, stroke, cancer, diabetes, and others—began to replace the infectious diseases as the major causes of death, a revision of basic explanatory paradigms had to occur, since the human host was beginning to be regarded as a major element in the cause of the chronic diseases. In the mid-1930s, the Josiah Macy, Jr. Foundation, based in New York, began a series of conferences on aging. The foundation's director was Dr. Ludwig Kast, who believed that degenerative diseases were a manifestation of the process of aging. The foundation had supported studies of degenerative diseases, but Kast encouraged research on aging itself. Thus, work on heart disease was examined in relation to the physiology of aging.

The foundation encouraged E. E. Cowdry, a professor of cytology at Washington University, to organize a book that would embrace not only the biomedical aspects of aging, but include social, psychological, and environmental influences as well. Cowdry's book, *Problems of Ageing*, was published in 1939. The foundation continued to sponsor conferences on aging, which led to the establishment of The Club for Research on Aging, in New York. By 1940, thinking about aging was becoming more sophisticated. Reflecting the thinking of the times, the U.S. Public Health Service organized a multidisciplinary conference in 1941 on mental health aspects of aging. At the same time, the Surgeon General of the U.S. Public Health Service established the Section on Aging within the National Institutes of Health. Thus, leadership

in public health helped to establish aging as an important research topic.

AGING AND EVOLUTION

The nineteenth-century interest in the biological evolution of species, expressed by Charles Darwin (1809–1882), and Alfred Russel Wallace (1823–1913), was also accompanied by an interest of a small number of biologists in fitting aging into an evolutionary paradigm. It is not a simple step to account for the natural selection of late-life features, since they appear past the age of reproduction, and therefore out of direct reach of the pressures of natural selection. In 1957, Peter Medawar (1915–1987) reasoned that selective pressures for survival features were maximum at the time of reproduction and then declined. He described this as a result of selective pressures to create a “precession” of positively selected characteristics toward the age of maximum reproduction and a “recession” after the age of reproduction. Natural selection is therefore presumed not to affect late-life characteristics, and a series of unrelated characteristics may appear (e.g., Alzheimer's disease, Parkinson's disease, and other life-limiting conditions). Such diseases are presumably out of reach of selective pressures. This point of view is associated with the idea that life after reproduction is subject to random degradation of the well-functioning organism.

However, this reasoning need not exclude the possibility of indirect selection in which a late-life trait like intact memory and reasoning could operate to meet threats to tribal survival in preliterate societies. That is, tribes that had long-lived elders with intact memories of meeting the problems of families, floods, and warfare could have greater chances of survival. This has been described as a “counterpart theory,” in which late-life characteristics of older persons influence the selective survival of the young and those of reproductive age who are dependent upon them for survival (Birren, 1964).

An impressive amount of data has been gathered on the life spans of a wide variety of different species. The comparative biology of aging suggests that most have relatively fixed upper limits of the lengths of life. Particularly, the lengths of life of

vertebrates are relatively fixed in relation to each other (e.g., mice, rats, cats, dogs, horses, and primates). Evidence on the comparative longevity of primates suggests that if the environments are controlled to minimize the influence of predators and other influences, the average length of life, and the maximum length of life of members of a species, can be increased. Thus, while many primates may have life-limiting genetic traits, the expression of inherited traits is modulated by the environments in which they are expressed.

An issue facing the translation of the comparative biology of aging into principles about human mortality and morbidity is why different species have characteristic lengths of life. The quest is to identify common or shared interspecies genetic determinants that may have evolved. In contrast, examining individual differences in longevity within a species (intraspecies variability) can involve different traits, or the interaction of traits with the characteristics of a particular environment. Within a species there appear to be simultaneous positive and negative factors contributing to length of life.

ADVANCES IN LIFE EXPECTANCY

Dramatic advances in life expectancy took place in the twentieth century. Life expectancy at birth for the U.S. population rose from 47 years in 1900 to 77 years in 2000. Clearly, genetic selection could not have operated so quickly, and nongenetic factors had to be the cause of this startling increase in life expectancy. A different pattern of the major causes of death emerged during the century. In 1900 the five major causes of death were: (1) pneumonia and flu, (2) tuberculosis, (3) diarrhea and intestinal disease, (4) heart disease, and (5) stroke and brain lesions. By 2000, the five major causes were: (1) heart disease, (2) cancer, (3) stroke and brain lesions, (4) lung disease, and (5) accidents. Presumably, a cleaner environment, in terms of improved water supplies and improved sewage disposal, together with the discovery and use of vaccines and antibiotics, contributed to the spectacular fall of infectious diseases as causes of death. Also, improvements in the transport of fruits, vegetables, and other foods led to the elimination of seasonal dietary deficiencies. General improvements in diets also contributed to the improvement in life expectancy. But the rise in lung disease and cancer as causes of death suggests there

may have been simultaneous environmental deficits occurring parallel to these improvements. At any particular time in history there may be simultaneous positive and negative influences on aging, life expectancy, the incidence of particular diseases, and the quality of life.

One of the largest correlates of life expectancy is food intake. In 1935, MacCay, Crowell, and Maynard reported that dietary restriction promotes longer life in mice. Since that time, the effects of restricted dietary intake have been reported in many studies. Little early attention was given to the fact that in addition to the life extension effects of dietary restriction in small animals, many diseases to which the animals are disposed were delayed in their onset. There being no available explanation or mechanism to explain this delay of appearance of diseases, it received little attention. However, in 1954, Denham Harman proposed that free radicals can contribute to the aging of organisms. Free radicals refer to molecules that have one or more electrons in their outer orbits that can interact with DNA, proteins, and unsaturated lipids in cell membranes. They appear to be very reactive at all levels in an organism. In recent years, the identification of oxidant damage from free radicals has led to acceptance of the view that oxidant damage can modulate the expression of the genetic traits of animals, including humans.

CONTEMPORARY GERONTOLOGY

Undoubtedly there have been many contributing factors to the relatively slow emergence of gerontology as a subject of study. The implications of aging as a natural phenomenon were to some extent threatening to some religious or philosophical convictions. The large number of children born early in the twentieth century gave rise to the professional specialties of pediatrics, child psychology, and child psychiatry. K. F. Riegel (1977) did a quantitative study of publications in the psychology of aging and found that such publications increased exponentially after 1950, fifty years after child psychology became an established academic field of study.

Children's susceptibility to infectious diseases contributed to a health focus on early life, and little attention was given to phenomena of aging and later-life morbidity. Also, the dominant views

of medicine in the early twentieth century were focused on single variable explanations of disease and on external causes. When the focus shifted, in the late 1930s, to include the chronic diseases typical of late life, aging tended to be attributed to single causes (e.g., "you are as old as your arteries"). Specific organ failures were examined in detail, and interactive physiological influences were overlooked. In particular, the nervous system was largely neglected in thinking about aging, although it is a basic regulator of bodily functions.

Economic factors undoubtedly played a role in the slow emergence of gerontology as an area of study. In the early twentieth century, few institutions, private or nonprofit, were devoted to the care and treatment of the aged. Pensions, social security, disability insurance, retirement communities, assisted living facilities, adult education programs, and many other programs emerged later, increasing the need for knowledge about the characteristics of the older population. As the institutional lag in serving older persons began to ebb, research on aging began to grow.

The elevation of the Section on Aging to the National Institute on Aging in 1975 by the U.S. Public Health Service within the National Institutes of Health was a landmark in the growing support of research on aging. Gerontology was coming of age. Handbooks on the biological, psychological, and social science aspects of aging made their appearance in 1977, providing further evidence of the significant growth of the study of aging after 1950.

The complexity of aging as a set of interacting phenomena presented early life scientists with questions that could not easily be answered with the methodology of the time. In the past it was much easier to study single organs and their functions in isolation than to study them in an aging human organism. Important shifts in the major causes of death over the last hundred years indicate that aging is a highly dynamic phenomenon. Early studies of heart disease, however, did not recognize the contribution of the social environment and the behavioral dispositions of individuals as contributing factors to disease. For example, bereavement was found to have an effect on the mortality of the surviving spouse, increasing the awareness of the complex interactions in aging.

AGING AS AN ECOLOGICAL PHENOMENON

In the early twentieth century, the realization began to grow that aging is also an ecological phenomenon. Longitudinal studies of human populations in the latter part of the twentieth century have provided considerable evidence of the range and plasticity of human variability in the way aging is manifest. Since experimental studies of human longevity and aging are not morally possible, longitudinal studies have been important in providing evidence of the relative effects of environment and heredity on mortality, morbidity, and functional characteristics. Further advances in our understanding of human aging have been provided by longitudinal studies of identical twins reared together or apart over their life spans. No longer are simple assumptions acceptable about the contributions of "nature" and "nurture" to human aging. Contemporary questions focus on the relative magnitudes of different influences. The life-span identical twin studies of the Karolinska Institute in Stockholm, Sweden, have provided evidence that both genetic and environmental factors influence individual variability in the expression of late-life characteristics. Such findings make it impossible to explain human aging solely in terms of genetic inheritance or environmental influences.

A strong force in attributing human aging to genetic inheritance is the fact that the various species have characteristic lengths of life relative to one another. Even if one increases the length of life of rats by 100 percent, they still do not live as long as cats or dogs. Thus there is a hierarchy of life spans, which presumably has evolved by natural selection of animals exposed to different environmental pressures such as availability of food, extreme temperatures, and predation.

To answer questions raised by gerontology about how long people live—and how well they live—it is clear that some answers will come from the bottom up; from the study of elemental sub-cellular and cellular biological processes. Other answers will come from the top down; from the organization of our behavior through experience and the interaction of "software and hardware" in the nervous system. For example, smoking and high alcohol consumption have been found to shorten life and predispose people to diseases of the heart, lungs, and liver. Behavior and lifestyle

also have an effect on health. The concept of “self-regulation” has been introduced to express the higher level of control exercised by the nervous system as a result of learning.

People with higher levels of education appear to have a greater capacity for self-regulation, and they live longer, on average. Being aware of different sources of information, they tend to seek medical assistance sooner and have more medical diagnoses than the less educated, and they spend fewer days in hospitals. Those with less education tend to initiate interventions only when there are health crises accompanied by a higher risk to survival. In contrast, the highly educated seek early interventions, when desired outcomes are more likely.

The “software” of the nervous system can also acquire different tendencies to self-destruction through suicide in different societies. Suicide is about the ninth leading cause of death in America, but is more common in Hungary and Finland. In the history of Japan, ritual suicide (*hara kiri*) was a justified accompaniment of loss of face or disgrace. The tendency to violence and homicides also varies among different cultures, which again illustrates the interaction of the environment and length of life. While the major causes of death are chronic diseases, culture modulates our disposition to such illnesses, as well as to suicide and homicide.

In the past, religions have placed a high emphasis on individual fates being determined by a higher power. Prayer has therefore been assumed to have great intervention potential. In recent years there has been more exchange between the cultures of religion and of science. The result has been research showing that participation in religious activities does indeed have beneficial effect on aging. Some of the benefits may result from selection of the subjects studied—better adjusted and more socialized adults may be more likely to belong to a religious community. Also, a belief in a higher power by itself may reduce stress and promote health. Regardless of the preferred interpretations of causality in the relationships of longevity, health, lifestyle, culture, spirituality, and religion, the fact that information is being gathered and exchanged is likely to be of use in improving human well-being in later life.

This complex picture defines the subject of gerontology. The study of the biology of aging exists at many levels, from cell parts to whole organisms. In the case of humans, the various critical organs, such as the heart, liver, kidneys, immune system, and the nervous system, have often been studied in isolation. There are both interactions and factors, however, that effect all organs. One of the general factors coming into prominence is the energy-producing component of cells, the mitochondria. Energy is needed by the whole organism for the development, maintenance, and repair of organs, tissues, and cells. Aging of the mitochondria can have widespread consequences throughout an organism. Clearly, new knowledge about aging must be sought at all levels—biological, psychological, social, and cultural. Risk factors are being identified that provide insights into the causes of late-life disabilities and provide clues about ways to ameliorate or control their consequences.

New theories of aging are being advanced as our data and our understanding of the human organism improves. One of the earliest theories was that of Raymond Pearl (1879–1940), who, in 1928, held that the metabolic rate of different species underlay the difference in their length of life. Longevity, he proposed, is inversely proportional to the metabolic rate per unit of body mass. Presumably animals are born with a capacity for a fixed amount of irreplaceable energy. Pearl viewed rate of energy expenditure as predictive of the length of life of a species.

Energy is needed at all levels of an organism, and it ultimately depends upon the functioning of the mitochondria. Thus, aging of the mitochondria can have widespread consequences throughout an organism. The fact that the mitochondria has its own DNA that lies outside of the DNA on the chromosomes, is important. The mitochondrial DNA is transmitted to the fertilized ovum solely from the mother. It has a structure different from the chromosomal DNA, but it too is susceptible to the effects of damage from oxidants. One general consequence of the metabolism of large amounts of food is the production of oxidants that can interfere with the process of energy release in the cells of the body’s critical organs and reduce their level of functioning. In a sense, this is a general environmental interference with genetic expression in the cells of vital organs of the body.

The oxidative damage done by free radicals may also interfere with the signaling or communication between biological systems, which may include immune system in older persons, and its failure to recognize the necessary proteins of a body and attack them. Recent work suggests that the body's inappropriate production of oxidants and the capacity of the body to control oxidative stress is a key feature of aging and the length of life (Finkel and Holbrook, 2000). Also, there is the question of the extent to which the life-limiting effect of oxidant damage results from the oxidant level itself, or from a change in the capacity of the organism to manage it. In either case the result may be individual organ failure or a life-limiting disease.

TRENDS

Gerontology continues to be an expanding field of study and a rising area of public interest. Academic positions are increasing, and even more increases are seen in private-sector employment in service areas such as retirement housing, assisted living, exercise programs, health care, adult education, travel, and entertainment. Also expanding are training activities related to aging in the professions; and new academic and professional journals are appearing. One consequence of this rapid growth is a rise in research on specialized aspects of aging. The rapid growth in published literature has been accompanied by a lag in integrating data from different disciplines. There is a need for integration of information within and across academic disciplines. One might expect to see more emphasis on meta-analysis of many studies, not only on narrow topics, but on broader issues related to genetic, environmental, and behavioral factors.

Many of the factors influencing aging have lower and upper limits that have yet to be defined and measured. The benefits of exercise, for example, conceivably have a ceiling beyond which further activity can have negative outcomes. Such a ceiling is in contrast to the "floor" of low physical activity, which leads to disuse atrophies in the organism and can contribute to episodic risk factors such as falling. In a similar manner, cognitive activity and the use of memory have both optimum

upper limits of use for maintenance of function and floor effects leading to regression of function.

As a species, humans have undoubtedly been selected for rapid and sustained physical activity to avoid predators and seek food sources. The capacity of the human nervous system for strategic control of the environment has led to a drop in the need for physical activity and for high food availability. Individuals tend to lower their physical activity when it is not needed, and to overconsume food in relation to metabolic needs. Cultural controls have to be cultivated in these areas to maximize potentials for long and useful lives, along with better health promotion and disease prevention efforts.

With the rising interest in promoting the well-being of aging populations, new metaphors are being introduced to motivate people to undertake lifestyle changes. Such metaphors appear to be designed to cast a motivating optimistic aura about aging. Terms like "successful aging," "productive aging," and "vital aging" do not in themselves identify the important variables in human aging. Rather, they reflect a rising interest on the part of the research community to attract public interest to areas of research thought to be useful in an aging population. The proliferation of terms used in gerontology and in reference to aging led to the development of a *Thesaurus of Aging Terminology* by AARP.

The understanding of aging and the analysis of its complexity requires the consideration of many contributing variables and their interactions. It is inherently a multidisciplinary and interdisciplinary field of research. There appears to be little doubt that the twentieth century will introduce new concepts and theories about aging, and that the sciences concerned with gerontology will advance our understanding of aging and lead to further increases in life expectancy and improved quality of life.

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(SEE ALSO: *AARP; Aging of Population; Cohort Life Tables; Cohort Study; Dementia; Epidemiologic Transition; Geriatrics; Life Expectancy and Life Tables; National Institute on Aging; Physical Activity; Rates: Age-Adjusted; Rates: Age-Specific; Widowhood*)

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GINGIVITIS

Gingivitis is a form of periodontal disease. Periodontal disease involves an inflammation and/or infection that results in the destruction of the supporting tissues of the teeth, including the gingiva (gums), the periodontal ligaments, and the tooth sockets (alveolar bone). Gingivitis is the inflammation of the gums, and often includes redness, swelling, bleeding, exudation, and sometimes pain. Gingivitis can be chronic or acute, but is usually a chronic condition.

Factors that can cause gingivitis can be either extrinsic (localized) or systemic. The most common extrinsic factor is the long-term effect of plaque deposits. "Plaque" is the sticky material that accumulates on the exposed portions of the teeth, and is composed of mucous, food debris, and bacteria. The bacteria release destructive by-products, and unremoved plaque may mineralize into a hard deposit called "calculus" or "tartar."

Plaque, the bacterial toxins, and calculus cause irritation and inflammation of the gingiva.

Injury or any irritation to the gingiva from vigorous toothbrushing, hard food, rough fillings, and mouth appliances such as dentures, can also cause gingivitis. Breathing through the mouth can also be a contributing factor.

Systemic factors, such as diseases that affect the body's immune response, hormonal changes in puberty and pregnancy, nutritional deficiencies, and diabetes mellitus, may increase the gingiva's sensitivity to irritation. Medications such as birth control pills and antiepileptic drugs, and ingestion of heavy metals such as lead and bismuth (found in some pharmaceuticals), may also exaggerate the inflammatory response.

Because gingivitis is primarily plaque-induced, good oral hygiene, including regular brushing and flossing, is the best prevention method. Calculus deposits cannot be removed by brushing alone, however, but must be removed by a dentist or dental hygienist using proper dental instruments. Gingivitis, left uncontrolled, may lead to severe periodontal disease, resulting in the loss of gingival attachments, bone, and, subsequently, teeth.

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(SEE ALSO: *Oral Health; Plaque*)

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GLOBAL BURDEN OF DISEASE

The term "global burden of disease" was coined by epidemiologists and economists who were studying international variations in the patterns of disability-adjusted life expectancy for the World Bank in 1993. They used the term as a numerical indicator of the impact of all forms of illness and disability on the expectancy of remaining years of healthy life in the population of a country, or in age- or sex-specific or other segments of the population. The

global burden of disease is calculated by using nationally available data on life expectancy and on major varieties of disability. It is therefore a rather insensitive indicator, albeit a very useful one. Details on the method of calculation appear in the World Bank's *World Development Report* for 1993.

JOHN M. LAST

(SEE ALSO: *Descriptive Study; Epidemiology; Life Expectancy and Life Tables; Years of Potential Life Lost [YPLL]*)

GLOBAL WARMING

See Climate Change and Human Health

GLYCOSYLATED HEMOGLOBIN

The red blood cells of all individuals contain hemoglobin, which is responsible for carrying oxygen through the bloodstream. When hemoglobin combines with glucose (sugar), a molecule called glycosylated hemoglobin, or Hemoglobin A1c (HgbA1c), is formed. Since everyone has glucose in their blood, all individuals also have glycosylated hemoglobin in their blood (usually between 3 and 5 percent of blood).

The amount of A1c in red blood cells is proportional to the amount or concentration of glucose in the blood, and to the age of the red blood cells. (The average red blood cell lives approximately 120 days, with new ones replacing dying red blood cells continuously. Accordingly, healthy individuals have a mixture of "young" and "old" red blood cells at all times.)

If an individual has high blood-sugar levels, such as exists in poorly controlled or untreated diabetes mellitus, the glycosylated hemoglobin percentage will be elevated. Since it is also related to the "age" of the red blood cells, the glycosylated hemoglobin percentage will correspond to the average glucose level over the previous two to three months. This average level is in contrast to a routine measurement of the blood-sugar level,

which reflects any food intake over the previous twelve hours.

CLINICAL USEFULNESS

In diabetes mellitus, the blood sugar is elevated in the fasting state, with levels exceeding 126 milligrams per deciliter (mg/dL). Persistently elevated blood-glucose levels result in many chronic complications, such as kidney failure, blindness, and poor circulation in the legs, which can result in amputation. Accordingly, it is recommended that diabetics keep their blood-sugar level in the normal range whenever possible. This can be achieved through diet, exercise, and medications. The American Diabetes Association (ADA), recommends that all health care clinicians routinely obtain glycosylated hemoglobin levels in all diabetics. In 2001, the ADA recommended that this testing be performed at least twice annually for those diabetics whose blood sugar is well-controlled, and more frequently in those with persistently elevated blood sugars. Just as cholesterol levels are used to predict the risk of developing heart disease, the glycosylated hemoglobin value can predict the risk of developing many of the chronic complications associated with diabetes.

OTHER USES

Researchers collecting information on large numbers of individuals can assist scientists in determining whether relationships exist between glycosylated hemoglobin levels and age, gender, ethnicity, or socioeconomic status.

Research directed at the relationship between high glycosylated hemoglobin levels and various disease states could assist health care providers to predict the presence or absence of disease. For public health officials, the determination of glucosylated hemoglobin levels for community areas could provide them with information to develop community-based interventions to improve the control of blood-sugar levels in communities and neighborhoods with elevated average glycosylated levels.

PATRICK DOWLING
MICHELLE ANNE BHOLAT

(SEE ALSO: *Diabetes Mellitus*; *Screening*)

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GOITER

Goiter is an enlargement of the thyroid gland. It may be diffuse, involving all thyroid tissue, or it may be caused by one or more lumps (nodules)—called nodular goiter. Diffuse goiter reflects an underlying thyroid problem, most commonly iodine deficiency in iodine-deficient areas of the world, where nearly 1 billion people may be subject to the disorder. In the United States, iodine deficiency is rare (because of widespread use of iodized salt) and goiter is most commonly caused by Graves' disease or Hashimoto's disease. Nodular goiter affects 3 to 5 percent of adults, mainly women. Nodules may reflect thyroid cancer (in 5% of cases), but the remainder are benign processes due to multiple causes. Cancers can be distinguished from benign disease by microscopic evaluation of thyroid tissue obtained by fine-needle aspiration biopsy.

MARTIN I. SURKS

(SEE ALSO: *Hyperthyroidism*; *Hypothyroidism*; *Iodine*; *Thyroid Disorders*; *Thyroid Function Tests*)

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GOLDBERGER, JOSEPH

In the pantheon of epidemiologists, Joseph Goldberger (1874-1927) ranks high. An Austrian immigrant, he grew up in New York, attended Bellevue Hospital Medical College, and began working with the U.S. Public Health Service in 1899. He had a distinguished career, investigating yellow fever with Milton Rosenau, typhoid in the Potomac River basin, dengue in Texas, louse-borne typhus, and other infectious diseases of public health importance.

In 1914, Goldberger turned his attention to pellagra, which was then prevalent in the southern United States. As Milton Terris has pointed out, Goldberger's achievement in unraveling the true nature of this previously mysterious disease equals John Snow's groundbreaking work on cholera. Pellagra causes a characteristic symptom cluster of skin eruptions, loose bowel movements, wasting of body mass, and in severe cases, mental and intellectual damage. When Goldberger began his investigation, a government commission had recently concluded that pellagra was an infectious disease of unknown nature, perhaps aggravated by a protein-deficient diet. Based on logical conclusions from three basic facts, Goldberger showed the infection hypothesis to be wrong. Goldberger knew that staff in institutions where pellagra was common among inmates did not get the disease; that it was much commoner in isolated rural regions than in cities, where people were in closer contact; and that it was associated with poverty. Goldberger concluded that pellagra must be due to a dietary deficiency.

His subsequent investigations, often in collaboration with Edgar Sydenstricker and others, included experiments with rhesus monkeys; a dietary survey of affected and unaffected families; and experiments using himself, his colleagues, and his own wife, in which they subjected themselves to ingestion and inhalation of bodily secretions. None of his investigations revealed evidence of a transmissible agent. The final stage of the investigation was another human experiment done on the residents of orphanages (without the ethical approval such studies would require now). This identified the pellagra-preventing factor, which was found to be associated with foods containing high concentrations of vitamin B. Unfortunately, Goldberger died before this factor, nicotinic acid, or niacin, was isolated and chemically identified.

JOHN M. LAST

(SEE ALSO: *Nutrition; Snow, John; Sydenstricker, Edgar*)

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GONORRHEA

Gonorrhea is a sexually transmitted disease (STD) caused by *Neisseria gonorrhoeae*, a bacterium. Gonorrhea is spread through sexual contact (vaginal, oral, or anal). The organism can grow easily in mucous membranes of the body, including the cervix, uterus, and fallopian tubes in women, and the urethra, mouth, throat, and rectum in women and men. It can also invade the conjunctiva (e.g., during childbirth). Each year approximately 650,000 persons in the United States get gonorrhea. Approximately 75 percent of gonorrhea cases are found in persons age fifteen to twenty-nine years. About 50 percent of men have some initial symptoms, typically a burning sensation when urinating and a discharge from the penis. Many infected women are asymptomatic or have only mild symptoms. Initial symptoms include a painful or burning sensation when urinating and a vaginal discharge that is yellow or bloody. Untreated gonorrhea in women can develop into pelvic inflammatory disease (PID), which can cause infertility or increase the future risk of ectopic pregnancy. An infected pregnant woman can transmit the infection to her newborn during vaginal delivery.

N. gonorrhoeae in the male or female genital tract can be diagnosed in a laboratory using a urine specimen. Many of the currently used antibiotics can successfully cure gonorrhea. Persons who engage in sexual behaviors that place them at risk of STDs should use latex or polyurethane condoms every time they have sex, limit the number of sex partners, and not go back and forth between partners. All young, sexually active, nonmonogamous persons who do not use condoms every time they have sex should consider being screened for gonorrhea yearly. Infected persons should notify all sex partners so they can receive treatment.

ALLISON L. GREENSPAN
JOEL R. GREENSPAN

(SEE ALSO: *Sexually Transmitted Diseases*)

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GOVERNMENTAL HEALTH AGENCIES

See Official U.S. Health Agencies

GRAUNT, JOHN

Like many of his literate and well-educated contemporaries, John Graunt (1620–1674), a London merchant and haberdasher, was an amateur scientist. He was a member of the small community of scholars who were early Fellows of the Royal Society, which was founded by King Charles II just as Graunt reached his years of greatest creativity. Graunt was interested in the fluctuations in epidemics, especially the plague, and how these caused the numbers of deaths, and the age at death, to vary from one year to another. For over one hundred years English parishes had kept records of baptisms and deaths, and what was then understood about causes of death was derived from these "bills of mortality," which Graunt collected and analyzed. He found differences in death rates between the sexes, between the city and the outlying rural and more remote regions, and he analyzed the ebb and flow of the epidemics of plague. He published his work in *Natural and Political Observations . . . Made upon the Bills of Mortality* (1662), now regarded as a seminal work in vital statistics.

Graunt influenced, and was influenced by, Sir William Petty (1623–1687), author of *Political Arithmetic* and other works that analyzed available facts in a number of areas, including life expectancy and earning capacity, emphasizing their economic and fiscal implications. There has long been debate about which of these two men should be credited with founding the statistical study of births and deaths. Both deserve to be remembered, but of the two, John Graunt, though he had less formal education, was probably the more creative and innovative. His writings were clear and concise, a model of what the analysis of vital statistics should be.

Graunt therefore can justly be described as the founder of vital statistics.

JOHN M. LAST

(SEE ALSO: *Bills of Mortality*; *Mortality Rates*; *Vital Statistics*)

GROUNDWATER

An estimated 100 million Americans rely on groundwater for their source of drinking water. Approximately one-third of all public supplies and 95 percent of all rural domestic supplies use groundwater sources. In Asia, groundwater provides half of the drinking water, and in Europe the percentage is even much higher, as much as 98 percent in Denmark and 96 percent in Austria.

An aquifer is an underground formation of permeable rock or loose material that can produce useful quantities of water when tapped by a well. Groundwater is held within the tiny pores of the surrounding aquifer material. Aquifers vary in size from a few hectares to thousands of square kilometers of the earth's surface. The rate of groundwater flow is very slow compared to the flow of water on the surface—usually in the range of several inches per year to several feet per year. More than 96 percent of all available fresh water supplies occur in the form of groundwater, which is usually cleaner and more pure than most surface water sources.

Groundwater only partially fills unconfined aquifers. The upper surface of the groundwater, known as the water table, is thus free to rise and fall. The height of the water table will be the same as the water level in a well drilled in an unconfined aquifer. Unconfined aquifers can be vulnerable to contamination, especially if they are close to the surface. In these unconfined aquifers, gravity drives the movement of groundwater. Groundwater can leave the aquifer through the process of discharge, either when it reaches the land surface at a spring or other surface water body, or through the pumping of a well. Discharge can lead to contaminants in groundwater flowing into surface water bodies.

A confined aquifer (also known as an artesian aquifer) occurs between confining beds, which are layers of impermeable materials, such as clay, that impede the movement of water in and out of the

aquifer. The groundwater in these artesian aquifers is under high pressure due to the confining beds. A recharge zone occurs where the confined aquifer is exposed to the surface. The confined aquifer is actually unconfined at the recharge zone. Confining beds serve two purposes. The first is to obstruct the movement of water into and out of the aquifer. The second is to bar the entry of contaminants from the overlying unconfined aquifers.

Aquifers are replenished with water from the surface through a process called “recharge.” This occurs as a part of the hydrologic cycle when water from rainfall percolates into underlying aquifers. The rate of recharge can be influenced by different factors, such as soil, plant cover, water content of surface materials, and rainfall intensity. Groundwater recharge may also occur from surface water bodies in arid areas. Overwithdrawal of groundwater occurs when the discharge of groundwater in an aquifer exceeds the recharge rate over a period of time.

Groundwater can be polluted by landfills, septic tanks, leaky underground gas tanks, and from overuse of fertilizers and pesticides. This pollution poses a great risk to public health since the majority of the fresh water supply occurs as groundwater. Many of the groundwater pollutants are colorless, odorless, and tasteless. Degradation of groundwater supplies also occurs as a result of poor waste-disposal practices or poor land management.

MARK G. ROBSON

(SEE ALSO: *Ambient Water Quality; Drinking Water; Groundwater Contamination; Water Quality*)

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GROUNDWATER CONTAMINATION

Groundwater can be defined as any body of water that is contained in underground waterways known as aquifers. Because groundwater flows through compressed gravel and soil deposits, it flows very slowly. John Cary Stewart, in *Drinking Water Hazards*, estimates that groundwater typically flows from a few inches per year to a few feet per day.

There are two ways in which groundwater is replenished. The first is from water percolating through the soil from rain or snowmelt, and the second is through recharge zones where the aquifer contacts the surface. During its replenishment groundwater is vulnerable to contaminants that may be in the surface water or the soil. The aquifer may be protected from surface contamination by the presence of underground deposits of impervious materials such as clay or bedrock. For example, a sanitary landfill constructed in sand and gravel deposits is more likely to lead to groundwater contamination than a landfill constructed in clay deposits.

Microorganisms, inorganic chemicals, and organic chemicals from many sources may contaminate groundwater. Joseph Salvato, in *Environmental Sanitation and Engineering*, lists sources of groundwater contaminants that fall into the following four categories:

- *Waste Category I.* These are systems designed to discharge wastewater onto the surface of the land or to the groundwater. This category includes land application of wastewater, septic systems, waste disposal wells, and brine injection wells.
- *Waste Category II.* These are systems that may discharge wastewater to the land or groundwater but are not designed to do so. This category includes surface impoundments such as lagoons, landfills, and other excavations; animal feedlots; leaky sanitary sewer lines; and acid mine drainage.
- *Nonwaste Category III.* These are nonwaste systems that may discharge contamination to the land or the groundwater. This category includes buried storage tanks or

pipelines, stockpiles of such things as highway de-icing materials, agricultural activities, and accidental spills.

- *Nonwaste Category IV.* These are nonwaste and nondischarge sources of contamination. This category includes saltwater intrusion, river infiltration, improperly constructed or abandoned wells, and farming practices.

Groundwater contamination presents very complex issues. Because groundwater moves so slowly it may take many years for contaminants to travel to the drinking water of a community from their original source. Once an aquifer is contaminated, merely removing the source of contamination will not clean it up. Control of groundwater contamination is dependent on four interrelated systems: regulation, design, monitoring, and remediation.

Regulations intended to control groundwater contamination are very difficult to enforce. Numerous federal acts such as the Resource Conservation and Recovery Act, the Superfund Act, and the Safe Drinking Water Act are all designed to protect groundwater. Building control and monitoring measures into new facilities is the most promising method for long-term regulation of groundwater contamination. The use of liners, leachate collection systems, monitoring wells, and the impervious strata of natural geology must be incorporated into new facilities that may pose a future threat of contamination to groundwater. Finally, remediation or cleanup of a contaminated aquifer through air stripping, a process by which water is removed from an aquifer, treated to remove contaminants, then returned to the aquifer, may be performed in limited situations.

WILLIAM J. FRANKS

(SEE ALSO: *Environmental Determinants of Health; Groundwater; Land Use; Waterborne Diseases*)

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GULF WAR SYNDROME

Gulf War syndrome, or Gulf War illness, refers to a group of poorly understood symptomatic illnesses afflicting veterans of the 1990–1991 Persian Gulf War. The most characteristic symptoms are fatigue, musculoskeletal complaints, and psychiatric complaints of emotional distress, anxiety, and cognitive problems. To date, no specific underlying physical abnormalities have been identified, which links Gulf War illness to other medically unexplained syndromes such as chronic fatigue syndrome and multiple chemical sensitivity. In fact, substantial proportions of ill Gulf War veterans have complaints consistent with these other conditions.

Medically unexplained symptoms have been common in soldiers who have returned from previous deployments. The symptoms among Gulf War veterans are somewhat different from those noted after previous conflicts, however. Further, complaints of contemporary soldiers who were not deployed to the Persian Gulf are similar in character, though the symptoms occur at substantially greater rates, and with greater severity, among those deployed to the Gulf.

Specific causes for Gulf War illness are unknown. The presence of similar complaints in those not deployed to the Gulf suggests that a unique Gulf War exposure is not the sole cause. While individuals with complaints report higher rates of exposure to various toxins in the Gulf, including pesticides, anti-nerve gas pills, immunizations, and exploding missiles, these associations are not regarded as definitive at this time, with recall and information bias being very problematic. Because of this uncertainty, prevention efforts have been nonspecific and aimed at a reduction of various stressors and an improvement in risk communication with at-risk soldiers. Further research is ongoing.

HOWARD M. KIPEN

(SEE ALSO: *Multiple Chemical Sensitivities; War*)

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GUN CONTROL

Every year, more than two thousand people die in the United States from gun-related injuries. The population groups most affected by these avoidable deaths are children and young adolescents. The misuse of firearms is a problem worldwide, of course. However, the incidence of firearm use does vary from country to country. According to the *United Nations Report on Firearm Regulation, Crime Prevention, and Criminal Justice* (1997), the United States has "weaker firearm regulations and higher numbers of deaths involving firearms than all other industrialized—and even most developing—nations." The study also noted that the total firearm death rate in the United States in 1995 was 13.7 per 100,000 people, "three times the average rate among other responding countries and the third highest, after Brazil and Jamaica."

More than half the homes in the United States possess firearms, so it is hardly surprising that they rank among the "ten leading causes of death . . . accounting for more than 30,000 deaths annually" (Wintermute 1987, p. 3107). While most people have guns primarily for sporting activities, many owners also have them for personal protection and security purposes.

The public health approach to violence prevention attempts not only to reduce the occurrence of violence, but also to limit the numbers of fatal and nonfatal injuries when such events occur. To prevent gun-related violence, indeed any type of violence, it is important to understand the dynamics of violence as well as the role of different

kinds of weapons in both fatal and nonfatal injuries. Research from around the world indicates that sociostructural factors such as high unemployment rates, ethnic and religious hostilities, political instability, financial inequalities, lack of resources, and economic deprivation increase the likelihood of violence. When guns are readily available in such settings, or where legislation to curb their illegitimate use is lax or inappropriate, injuries are more likely to occur, intentional or otherwise. Individual factors can also precipitate violence, including the use of firearms. Substance and alcohol abuse, mental disorders, feelings of personal inadequacy and social isolation, and an individual's experience with violence in the home are among some of the factors that have been associated with violence. One thing is certain: The more guns there are in circulation, the greater the likelihood that they will be misused. Hence, from a public health perspective, it is important to devise strategies which aim to ensure that those in possession of arms use them for legitimate purposes and not for violent or criminal acts.

There are a variety of ways of dealing with the problems caused by guns in society, and legislation is one of the methods most commonly used. Franklin Zimring has noted that laws that regulate gun use fall into three categories: those that limit the place and the manner of firearm use, those that keep guns out of the hands of high-risk users, and those that ban high risk firearms. Place and manner legislation sets out to do as it suggests, to limit certain uses of firearms in certain locations. Examples include banning the use of firearms in public places and prohibiting the carrying of a firearm (except for those carried by security personnel and police). This legislation is difficult to implement, however, without the active support of the police force, and that support requires additional funding to make sure that police monitor potentially violent events.

Successful place and manner legislation has been implemented in the country of Columbia, where firearms are involved in 80 percent of homicides. Here, an innovative gun control intervention was implemented by the Program for Development, Security, and Peace (DESEPAZ), in collaboration with the Mayor of Cali, Colombia's third largest city. A police-enforced ban was introduced in Cali that prohibited carrying firearms on weekends, public paydays, public holidays, and

election days because “such periods were historically associated with higher rates of homicide” (Villaveces 2000, p. 1206). Media-led information campaigns informed the public of the new gun control measure. On the days when the ban was in operation, police set up strategically located checkpoints in areas of the city where criminal activities were commonplace, and they conducted random searches of individuals. “During the ban, police policy directed that if a legally acquired firearm was found on an individual, the weapon was to be temporarily taken from the individual and the individual fined. Individuals without proof of legally acquiring the firearm were to be arrested and the firearm permanently confiscated” (Villaveces, p. 1206). The aggressive intervention program operated in Cali during 1993 and 1994. A similar intervention was applied in Bogota from 1995 to 1997. The researchers studying the preventive effects of these measures reported that the “rate of homicide (in Cali) was 14 percent lower than expected during periods when the ban on carrying firearms was in effect” while it was “13 percent lower than expected (in Bogota) during intervention periods” (Villaveces, p. 1209). Whether such a program would work in areas where homicide rates are not as high is debatable. However, the researchers of this study suggest that this initiative could be replicated in places where similar conditions exist.

Denying high-risk users access to firearms is the second type of legislative tool to control gun misuse. In order for this approach to work, the law has to define clearly who falls into the category of “high-risk user.” The term is usually applied to convicted criminals, those deemed “mentally unfit,” and to drug addicts. It also applies to minors. Such legislation attempts to make it difficult for members of these groups to possess a firearm.

Every year, in developed and developing countries across the globe, thousands of children and young adolescents die while playing with loaded guns. Additionally, studies have shown that adolescents are vulnerable in terms of firearm misuse and successful suicide attempts. In the United States between 1965 and 1985 “the rate of suicide involving firearms increased 36 percent, whereas the rate of suicide involving other methods remained constant. Among adolescents and young adults, rates of suicide by firearms doubled during

the same period” (Kellermann 1992, p. 467). Restricting the access minors have to weapons can help to reduce these events. Many states now attempt to prevent high-risk groups from obtaining firearms by identifying “ineligible” individuals before they can acquire a gun. Minors would obviously fall into this category. “The screening system included in U.S. legislation known as the Brady Bill permits police to determine whether a prospective gun purchaser has a criminal record. If the check turns up nothing . . . the purchaser can obtain the gun” (Zimring 1991, p. 53).

There are limitations to legislation that denies high-risk users access to firearms. Again, this kind of a law is difficult to enforce because it needs continuous police surveillance and relies heavily on the “ineligible person” actually being caught in possession of a firearm. It assumes that the potential outcome of being caught and punished will dissuade such persons from obtaining firearms. Moreover, there will always be alternative ways of obtaining a weapon, whether it be through the black market, theft, or getting another person to purchase the weapon. Screening systems also carry a cost and imply delays. However, even with these limitations, such legislation is a step in the right direction, as it can help to ensure that firearms are not sold directly to convicted felons or to minors. To overcome some of these difficulties, many states now require gun owners to register their weapons. However, many crimes are committed with stolen weapons that are used by someone other than the registered legal owner.

The third legislative strategy used to combat the misuse of firearms is to introduce legislation regulating the use of very dangerous weapons. Such “laws . . . limit the supply of high risk weapons” and “can complement the strategy of decreasing high risk uses and users” (Zimring, p. 53). Such supply reduction laws “strive to make the most dangerous guns so scarce that potential criminals cannot obtain them easily” (Zimring, p. 52). They also set out rigid requirements that must be met to prove that possession of such a weapon is necessary. Sawed-off shotguns, machine guns, and certain military devices are the kinds of weapons covered by this type of legislation. Research into this area in the United States has shown that states in which such strict laws operate have lower levels of violent crime than states that do not.

Another means of legislating for firearm misuse is to introduce stiff penalties for criminals caught using firearms. "More than half of the states in the USA have passed such laws. This approach is popular with gun owners because the penalties concern only gun related crime and place no restrictions on firearm ownership" (Zimring, p. 52).

Attempting to legislate for the complex realities of gun-related violence is a daunting task. The ideal gun control measure would be one that would "prevent all crime and violence involving guns without interfering with their legitimate use in contemporary life." In reality, the best we are likely to achieve is to reduce the problems caused by the illegitimate use of firearms while "minimizing the restraints on the legitimate uses of guns" (Zimring, p. 52). The strategy, or combination of strategies, employed in any given context will depend on the nature and severity of the problem.

PAMELA HARTIGAN
ELAINE LAMMAS

(SEE ALSO: *Adolescent Violence; Community Health; Legislation and Regulation; Suicide; Terrorism; Violence*)

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H

HABITUATION

See Addiction and Habituation

HAEMOPHILUS INFLUENZAE TYPE B VACCINE

This vaccine is prepared from polysaccharides (sugars) contained in the capsule of *Haemophilus influenzae* type b (Hib). Hib can cause otitis media, pneumonia, septic arthritis, meningitis, and other severe systemic infections. The earliest Hib vaccines contained only the polysaccharides. They did not reliably induce immunity in infants, who are at highest risk for Hib disease, and did not induce immunologic memory. Current Hib vaccines are prepared by conjugating the polysaccharide with some protein (such as tetanus toxoid), which enhances its ability to protect infants and induces immunologic memory. The vaccine is typically administered in a series of two or three doses separated by two months with subsequent doses administered approximately one year and four years later. Ninety percent or more of infants immunized are protected. Vaccine-induced immunity lasts at least through age six, by which time the risk of Hib disease is quite low. There are no known serious adverse events attributable to Hib vaccine.

ALAN R. HINMAN

(SEE ALSO: *Child Health Services; Communicable Disease Control; Immunizations*)

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HALO EFFECT

The term "halo effect" describes what happens when a scientific observation is influenced by the observer's perceptions of the individual, procedure, or service that is under observation. The observer's prejudices, recollections of previous observations, and knowledge about prior observations or findings can all affect objectivity and must be guarded against. The term also describes the effect, usually beneficial, that a health care provider's manner, attention, and care have on a sick person, regardless of the nature of the service or the procedure involved. This is a variation of the placebo effect, though it differs from the placebo effect in being associated with the personality of the service provider rather than with the service or regimen as such.

JOHN M. LAST

(SEE ALSO: *Hawthorne Effect; Observational Studies*)

HAMILTON, ALICE

Alice Hamilton was born in New York City in 1869, and died in Hadlyme, Connecticut, in 1970.

She graduated from the University of Michigan's medical school in 1893 and pursued postgraduate study in pathology and bacteriology in Germany as well as Johns Hopkins University. In 1897, a position as professor of pathology at the Women's Medical School of Northwestern University brought her to Hull House, located in Chicago, where she remained for the next twenty-two years. Hull House was a hotbed for social reform during the turn of the twentieth century, and Hamilton participated in activities designed to ameliorate urban poverty—from teaching basket weaving to starting an infant health clinic.

In 1908, Hamilton's work at Hull House led to an appointment on the Illinois Commission on Occupational Diseases. The commission lacked any in-depth study on which to recommend legislation and Hamilton was asked to conduct a nine-month survey on the prevalence of industrial diseases in the state. Her survey combined laboratory findings with an extensive investigation of hospital records, inspections of industrial plants, and the testimonials from workers and their families. While she studied a number of dangers, she focused on lead poisoning and was able to connect the disease with specific occupations. Her seminal study, the [Illinois] *Report of Commission on Occupational Diseases; To His Excellency Governor Charles S. Deneen* (1911), demonstrated that the majority of Illinois' industrial workers faced life-threatening hazards at their jobs. The state responded by immediately passing a law that established occupational safety standards.

Considered the leading authority on industrial toxicology, Hamilton worked as a special investigation for the U.S. Bureau of Labor from 1911 to 1920. She also became an assistant professor of industrial medicine at Harvard from 1919 to 1935, and wrote the first American textbook on the subject, *Industrial Poisons in the United States* (1925).

JENNIFER KOSLOW

(SEE ALSO: *Lead; Occupational Disease*)

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HASHISH

See Marijuana

HAWTHORNE EFFECT

The effect on a person's or a group's behavior of knowingly being under observation is called the "hawthorne effect." It is commonly positive or beneficial, because knowing that they are being observed encourages people to behave or perform at a higher level of efficiency than they might otherwise. The name derives from a study on employee satisfaction at the General Electric manufacturing plant in Hawthorne, Illinois, where the effect was first observed.

JOHN M. LAST

(SEE ALSO: *Halo Effect; Observational Studies*)

HAZARD EVALUATION, RECOGNITION, CONTROL

See Risk Assessment, Risk Management

HAZARDOUS AIR POLLUTANTS

The U.S. Environmental Protection Agency (EPA) refers to air pollutants that can cause serious health and environmental hazards as "hazardous air pollutants" (HAPS) or "air toxics." The 1970 Clean Air Act authorized EPA to first list HAPs for regulation and then to regulate the chemicals. As of 1990, only seven chemicals (beryllium, arsenic, mercury, asbestos, benzene, vinyl chloride, and radionuclides) had been listed and regulated by the EPA. The 1990 Clean Air Act Amendment,

however, included a list of 189 HAPs selected by Congress on the basis of potential health and environmental hazards. (The HAP list can be found on the EPA web site: www.epa.gov/ttn/uatw/188polls.html.) The 1990 amendments also allows EPA to add new chemicals to the HAP list as necessary. One of the major breakthroughs in the amendments is a permit program for large sources that release pollutants into the air. The permit program requires the application of maximum achievable control technology (MACT) to a nonutility source that emits over 10 tons per year of any one HAP, or 25 tons per year of any combination of HAPs.

The sources of HAPs include large stationary sources such as chemical factories and incinerators; small stationary sources such as dry cleaners and auto paint shops; and other sources such as tobacco smoking, fuel combustion, certain cooking practices, gasoline vaporization, and motor vehicle exhaust. Household products such as paints, carpets, and detergents can also release certain HAPs, and chemical reactions occurring in both outdoor and indoor air can generate HAPs.

The EPA's regulatory approach with HAPs, unlike the ambient-air-oriented approach with criteria air pollutants that are regulated through the National Ambient Air Quality Standards (NAAQS), is source oriented. The approach starts with identification of categories of sources that release the 189 HAPs listed under the 1990 amendments. Categories could be gasoline service stations, electrical repair shops, coal-burning power plants, oil refining plants, or chemical plants, and many others. The HAP producers are generally identified as "large" or "small" sources. The 1990 amendments deal with more strictly with large sources than small ones.

Mobile sources release large amount of HAPs such as benzene, formaldehyde, and toluene. Technical and regulatory efforts have been made to reduce HAPs from motor vehicles. These efforts include the use of cleaner fuels and improved engines, and the periodical examination of vehicle exhaust. The 1990 Clean Air Act amendments also requires that factories and other businesses develop plans to prevent accidental release of highly toxic chemicals. (This was largely inspired by the 1984 tragedy involving methyl isocyanate release, which killed about 4,000 people and injured more

than 200,000 in Bhopal, India.) The amendments established the Chemical Safety Board to investigate and report on accidental releases of HAPs from industrial plants. However, small sources of HAPs will have to be directly or indirectly regulated as well in order to achieve effective reduction of exposure, because in many cases small sources contribute more to total human exposures than large sources. This is mainly due to the close proximity of people to small neighborhood polluters (e.g., auto shops and print shops) as well as household and personal sources (e.g., dry-cleaned clothes, deodorants).

JUNFENG (JIM) ZHANG

(SEE ALSO: *Airborne Particles; Ambient Air Quality [Air Pollution]; Automotive Emissions; Clean Air Act; Environmental Protection Agency; National Ambient Air Quality Standards; Pollution; Smog [Air Pollution]; Sulfur-Containing Air Pollutants [Particulates]*)

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HAZARDOUS WASTE

All human activities generate some form of waste. In its most general sense, the term "hazardous waste" comprises toxic chemicals, radioactive materials, and biologic or infectious waste. Hazardous waste poses a threat to workers through occupational exposure and to the public through exposure in homes, communities, and the general environment. Exposure may occur near the site of generation, along transportation corridors, and near the ultimate disposal sites. Most hazardous waste results from industrial processes that yield

unwanted intermediates, products that fail quality control, and spilled material.

Hazardous waste management is divided into two main areas: currently generated waste, which is regulated under the Resource Conservation and Recovery Act (RCRA) of 1976, and waste at abandoned sites, which is regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980. The Environmental Protection Agency (EPA) has jurisdiction and responsibility for managing the "cleanup" of hazardous waste sites. The Agency for Toxic Substances and Disease Registry (ATSDR), a branch of the Centers for Disease Control and Prevention (CDC), evaluates and assists communities that have been exposed to hazardous waste.

Under RCRA, industries assume responsibility for all of the waste they generate. They may manage it on-site or ship it off-site. In the latter case they retain responsibility, even when it has reached a legal disposal site. This is termed "cradle-to-grave" responsibility. Under CERCLA (also known as the Superfund Act), states may petition the EPA to have a hazardous waste site listed on the National Priorities List. This makes the site eligible for federal cleanup assistance in the event that a responsible party is not identified or does not accept responsibility.

Under RCRA, solid waste is defined as hazardous if its "quantity, concentration, or physical, chemical, or infectious characteristic" leads to death or serious illness or otherwise poses a "substantial present or potential hazard to human health or the environment, when improperly treated, stored, transported, or disposed of, or otherwise mismanaged." Under the Toxic Substances Control Act, more than 55,000 individual chemicals can fit the definition of a hazardous waste.

The main types of hazardous wastes are depleted raw materials, reaction products, tank residues, filter cake, precipitates, and spent solvents. They may be disposed of in liquid or solid form, either contained or uncontained. Wastes must be listed on a manifest, hauled by a licensed hauler, and disposed of at an approved hazardous waste site.

It is estimated that hazardous chemical wastes have been stored at more than 50,000 sites in the United States alone, although only 1,500 are listed on the National Priorities, or Superfund, List. To

be listed, a site must be assessed using the EPA Hazard Ranking System. Once the site is identified, a preliminary site assessment is performed to determine if there is a potential hazard. If a hazard exists, there may be emergency remediation, but typically the second phase is a remedial investigation/feasibility study that categorizes a site and identifies remediation options. Remediation may range from an enclosure and warning signs to complete removal of waste, capping, and treatment of groundwater.

The Hazard Ranking System yields three scores, involving: (1) the possibility of offsite migration; (2) the likelihood of human receptors coming in contact with contaminated air, water, soil, or organisms; and (3) the explosivity or fire hazard posed by the material.

The ten substances most often identified at Superfund sites are: trichloroethylene, toluene, benzene, lead, chloroform, polychlorinated biphenyls (PCBs), tetrachloroethylene, phenol, trichloroethane, and chromium. The receptor populations include not only neighbors living adjacent to industrial sources or waste sites, but emergency responders, public safety officials, regulatory agency personnel, and hazardous-waste remediation workers.

Pathways of exposure include: direct contact with contaminated soil from playing or working on or adjacent to a waste site, consumption of contaminated groundwater, inhalation of vapors or dust from a site, and consumption of contaminated food stuffs.

MICHAEL GOCHFELD

(SEE ALSO: *Agency for Toxic Substances and Disease Registry; Benzene; Environmental Determinants of Health; Environmental Protection Agency; Hazardous Waste; Landfills, Sanitary; Lead; Municipal Solid Waste; Nuclear Waste; Occupational Safety and Health; PCBs; Pollution; Toxic Substances Control Act; Toxicology*)

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HDL CHOLESTEROL

HDL cholesterol is the cholesterol found in high-density lipoproteins (HDL) in the bloodstream. HDL's major purpose is to carry cholesterol to the liver where it can be excreted in the bile, the only way the body can get rid of cholesterol. High levels of HDL cholesterol in the blood are protective against atherosclerosis, a condition that can cause heart attacks and strokes, while low levels increase the risk of such conditions. The level of HDL cholesterol is generally determined genetically; but smoking, obesity, and inactivity can lower it and the smoking cessation, increased physical activity, and modest alcohol intake can increase it.

DONALD A. SMITH

(SEE ALSO: *Atherosclerosis; Blood Lipids; Cholesterol Test; Fats; Genetics and Health; Hyperlipidemia; LDL Cholesterol; Lipoproteins; Triglycerides; VLDL Cholesterol*)

HEAD START PROGRAM

Head Start and Early Head Start are comprehensive U.S. child-development programs that serve economically disadvantaged children (from birth to age 5) and pregnant women and their families. In 2000, these programs provided services to approximately 855,000 children in over 47,000 classrooms throughout the United States. The 1999 federal budget for Head Start was about \$4.2 billion with an additional \$0.34 billion for Early Head Start. Evaluations of Head Start and Early Head Start suggests that these programs have modest positive effects on a range of child-development outcomes, and recent evaluations of Early Head Start also found benefits on some parenting outcomes, as well as reductions in parenting stress and family conflict.

JONATHAN E. FIELDING

(SEE ALSO: *Child Care, Daycare; Child Health Services; Child Welfare; Family Health; Health*)

Promotion and Education; Healthy Start; Maternal and Child Health; United States Department of Health and Human Services [USDHHS])

HEALTH

The word "health" derives from Middle English *helthe*, meaning hale, hearty, sound in wind and limb. Dictionary definitions allude to soundness and efficient functioning and give the same meaning to financial health as to bodily health. Modern medical practice and public health are concerned about the health of individuals and populations. However, for most individuals and for many cultures, health is a philosophical and subjective concept, associated with contentment and often taken for granted when all is going well. Health in this sense is difficult to describe or define, but its absence is readily recognizable, even when replaced by minor departures from an accustomed level of health.

DEFINITIONS AND CONCEPTS OF HEALTH

In the preamble to the constitution of the World Health Organization (WHO) health is described as "a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity." This description has often been criticized as being too vague. Further, it describes an ideal state rarely attained by most people, and it contains no ingredients that can be readily measured or counted, either at the individual or the population level.

Another definition, composed by specialists in preventive medicine, specifies some tangible components of health; calling it "a state characterized by anatomical, physiological, and psychological integrity; ability to perform personally valued family, work, and community roles; ability to deal with physical, biological, psychological, and social stress; a feeling of well-being; and freedom from the risk of disease and untimely death" (Stokes, Noren, and Shindell, 1982). Everything mentioned in this definition can be measured and counted at the individual and at the population level, although assessing "a feeling of well-being" may be a challenge, and "freedom from the risk of disease and untimely death" is not an achievable state.

An increasing level of interest in health promotion in the early 1980s inspired a WHO working group to compose a definition recognizing the role of individuals and communities in determining their own health status. They can be paraphrased to the extent to which an individual or a group is able to realize aspirations and satisfy needs and to change or cope with the environment. Health is a resource for everyday life, not the objective of living; it is a positive concept, emphasizing social and personal resources as well as physical capabilities (Last, ed., 2000). This definition draws attention to the need for partnerships among individuals and communities, and to the importance of protecting the integrity of the environment in the cause of promoting good health. Moreover, many aspects of this definition are measurable.

The health of humans cannot be dissociated from the health of the life-supporting ecosystems with which humans interact and are interdependent. Moreover, no matter how healthy the present generation may be, the health of future generations is dependent upon the integrity and sustainability of these ecosystems. A definition of “sustainable health” that recognizes this interconnectedness states that health is a sustainable state of equilibrium among humans and other living things that share the earth (Last, ed., 2000). The key word in this definition is “equilibrium” meaning harmony. Human beings cannot long remain healthy in an environment in which they are out of harmony with other living things, or if other living things are dead or dying as a consequence of people’s actions. This is true of all life forms, from the smallest microorganisms to the largest mammals. Since the mid-twentieth century, medical professionals have been trying to “conquer” pathogenic microorganisms with antibiotics. This is a war that ultimately cannot be won because microorganisms have very short generation times, measurable in minutes. Microorganisms can therefore adapt to the challenge of antibiotics by evolving and producing antibiotic-resistant strains much more rapidly than new antibiotics can be developed.

An alternative to antibiotics, which is perhaps insufficiently implemented, is based on the ecological concept that humans are an integral part of the global ecosystem. Immunization programs aimed at protecting people from diphtheria, tetanus, and other diseases have been very effective.

The microorganisms responsible for these diseases are still there, in people’s throats, in the soil, wherever is their usual habitat. But once protected by immunization, people can live in harmony with these otherwise dangerous microbes. The challenge is to develop methods that will enable humans to live in harmony with other dangerous microorganisms and insect vectors of disease. This is a more certain way to ensure long-term health for the population than the impossible goal of attempting to exterminate these other life forms. Pathogens that have no other host than humans can sometimes be eradicated, as the smallpox virus was, and as the polio virus could soon be, at least regionally if not globally; but eradication is not feasible with microorganisms that can survive outside human hosts.

HEALTH THEORIES AND THEIR PRACTICAL APPLICATION

Beliefs about the foundations of good health are inseparable from theories of disease. Primitive beliefs about good and evil spirits; the benevolent or malevolent intervention of fate, gods, or ancestors; disease as a punishment for sin (Murdock, 1980); theories such as those of Aristotle and Galen about the balance of bodily fluids (humors) and about the effects of miasmas or “bad air” survive in the names by which we know some common diseases, including influenza, malaria, cholera, and rheumatism. A preference for holiday resorts and convalescent hospitals at the seaside or in the mountains reflects a belief in the notion that some environments are inherently healthier than others—as, indeed, abundant evidence demonstrates.

Scientists can trace the evolution of medical science in the changing nomenclature of disease. Some modern diagnostic labels indicate a precise understanding of the causal mechanisms of disease—streptococcal septicemia is, literally, the poisoning of the blood by streptococcus bacteria. Some that sound impressive, such as thrombocytopenic purpura (bruising associated with a deficiency of thrombocytes, or blood platelets) reveal partial knowledge: scientists know what causes the bleeding but not what causes the deficiency of platelets. Other disease names are deservedly vague—essential hypertension confesses

out ignorance about what actually causes high blood pressure.

Modern medicine and public health embrace several theories that are confirmed by abundant empirical and experimental evidence, and medical professionals have an increasingly broad and deep understanding of the ways in which health of individuals and populations can be impaired, endangered, or permanently lost. Scientists know that many diseases are caused by invading pathogenic microorganisms, which are often communicable. Some diseases are due to a disruption or imbalance among endocrine glands that secrete hormones needed to ensure efficient bodily function, some are caused by dietary deficiency of essential vitamins or minerals, and others are caused by exposure to harmful chemicals or physical insults such as ionizing radiation or excessive noise. Some diseases are due to, or strongly associated with, emotional stress. There remains a residue of important, and sometimes common, diseases and causes of disability and premature death for which there is no known cause, although effective treatments have been developed for some of these, often through trial and error or guesswork. High blood pressure is one such disease.

The activities of public health services aim to minimize the risk of serious departures from good health. The scope and methods of medical and public health practice demonstrate the depth and breadth of current understanding of the causes of disease, disability, and premature death, and also of the causes of good health.

Many who remain fit throughout a long lifetime attribute their good health (often incorrectly) to their behavior; whether it be to an ascetic or hedonistic way of life, to abstaining from (or indulging in) alcohol or tobacco, to vigorous exercise, or to leading a quiet, sedentary life. Some credit their parents or genetic heritage—certainly an important determinant of longevity—along with many environmental and behavioral factors. In fact, the causes of good health are as diverse and complex as the causes of disease.

Even literate, well-educated people sometimes have misguided views about what makes or keeps them healthy, often believing that regular daily exercise, regular bowel movements, or a specific dietary regime will alone suffice to preserve their good health. The Nobel laureate Linus Pauling

believed that massive daily doses of Vitamin C preserved his health. Those who are less well educated and more gullible are easy prey to hucksters who purvey all manner of dubious nostrums to prolong life, enhance vitality or virility, promote fitness, and eliminate ailments ranging from halitosis and body odor to failing sexual potency and even cancer and heart disease.

Modern approaches to health education and health promotion make use of the Health Belief Model along with several other theoretical constructs to predict health-related behavior. These are based on assumptions derived from empirical studies of how people perceive their health and their understanding of what has to be done to preserve and protect their own health, or that of their children.

OBJECTIVE AND SUBJECTIVE PERCEPTIONS OF HEALTH

A well-trained physician, or an observant member of a family, can often tell at a glance that someone is unwell. There are obvious signs—pallor, sweating, unsteady gait, a bone-shaking cough. The converse is more challenging. Someone who appears to be outwardly perfectly fit—hale and hearty, sound in wind and limb—may harbor an early cancer that is eating away at a vital organ, or, when asked the right questions may reveal a potential mental health problem, though there is no physical evidence of a departure from excellent health. Health has many dimensions, and each must be assessed and measured on some sort of scale. This is what physicians do when conducting a routine medical history and physical examination, which includes various laboratory tests. The results of such an examination have a range of values that usually follow a normal distribution, and for many of these the decision that a particular value lies within or outside the range of normal is rather arbitrary, although it is based on empirical experience. For example, experience and follow-up of many sets of observations allow us to agree on what level of systolic and diastolic blood pressure give grounds for a confident recommendation that treatment is needed to reduce an excessively high pressure that could lead to a stroke or heart attack.

Conversely, many severely disabled people can function efficiently and cheerfully within their

limited capacity—paraplegics can perform with consummate speed and skill in road races in wheelchairs, and blind people can play chess and swim in competitive tournaments. The theoretical physicist Stephen Hawking, described in his book, *A Brief History of Time* (1988), the full and productive life he leads, though he is profoundly disabled physically by amyotrophic lateral sclerosis (Lou Gehrig's disease). Physical, mental, and emotional health are clearly three different dimensions of health.

Determinants of Health. Both individual and population health are determined by physical, biological, behavioral, social, and cultural factors. First among the physical factors is the radiant energy of the sun, which is ultimately essential for all life on earth. In *Airs, Waters, and Places*, Hippocrates identified climate, environmental topography, and aspects of behavior as determinants of health. Climate is assuming greater importance than hitherto due to the climate changes caused by increasing industrialization and energy consumption. Environmentally, the presence or absence of trace elements in the soil or water, such as fluorides to toughen dental enamel, iodine to stimulate the thyroid gland, and lead compounds that damage the developing brain, act to enhance or impair our health.

Biological determinants of health are inherent or acquired. Genetic heritage is a contributing factor to longevity, and to susceptibility or resistance to a wide range of diseases that include the pathogenic microorganisms responsible for some of the great plagues that have afflicted humans for millennia. Molecular geneticists have demonstrated that the interaction of human communities with the plague bacillus, the influenza and smallpox viruses, the malaria parasite, and with several other microorganisms, played a role in determining the differentiation and distribution of early races of humans in Africa and Asia. On a much shorter time scale, pathogenic microorganisms may be the most important biological determinants of health and disease. Immunity or resistance to pathogens is a very important determinant of good health. Immunity is enhanced by prior exposure, or by maternal exposure in the case of newborn infants, who acquire maternal (passive) immunity to some infections before they are born, and have it reinforced after birth by antibodies in breast milk.

Routine immunization of infants and small children protects them from harm by many common and formerly dangerous pathogens including those that cause diphtheria, tetanus, measles, poliomyelitis, and whooping cough. Nutritional status is another important influence on resistance to infection. Individuals and populations are most vulnerable when they are malnourished or starved, which is why plagues often accompany famines.

Behavioral determinants have been much studied. An association of certain diseases with particular personality types has been observed empirically for centuries. An irascible temperament, for example, has been linked to occurrence of strokes, and an association has been demonstrated between high risk of coronary heart disease and a type A personality, marked by forceful and aggressive behavior. Research on mind-body interactions, which unites the disciplines of psychology, neurology, and immunology, made great progress in the last quarter of the twentieth century and began to clarify and explain these relationships.

Social factors that influence or determine health are also complex. There is epidemiologic evidence that good health is determined at least in part by social connectedness. Persons who have many and frequent interactions with other family members and with a network of friends have a more favorable health experience in many ways than those who are socially isolated, live alone, are estranged from their family, and have little or no family and social support systems. It is difficult however, to unravel social connectedness and personality factors that may encourage gregariousness or a solitary way of life. Position in the social hierarchy plays a role. Michael Marmot, a professor at University College in London, and his colleagues studied British civil servants, showing that top managers lead healthier lives than middle managers, who in turn are healthier than semi-skilled and unskilled clerical workers. Social networks and support systems, and social positions, are in part determined by factors beyond the control of individuals. While they are interrelated with personality factors, they are very complex and not well understood.

Studies have shown that economic conditions dramatically effect health and longevity. A consistently strong relationship has been demonstrated

between income levels and health status in every country where the relationship has been examined. Many interactions between social, economic, and cultural factors also help to determine or influence community health.

Culture is defined as the set of customs, traditions, values, intellectual, and artistic qualities, and religious beliefs that distinguish one social group or nation from another. Culture influences behavior through customs such as use of or abstention from meat, alcohol, and tobacco; the practice of rituals such as circumcision; marital customs such as the prevailing age at which women marry; attitudes toward family size, childbearing, and child rearing; personal hygiene; disposal of the dead; and much else. People's values may be the most significant component of culture that affects behavior and through behavior, health. For example, since the late nineteenth century, an understanding of the importance of personal hygiene has become part of the value system of many cultures. In the late twentieth century, values in many nations shifted towards a rejection of tobacco smoking as a socially acceptable custom. In the 1960s, the oral contraceptive pill contributed to the sexually liberated values and behavior that encouraged casual promiscuity, and which was only partially overshadowed by the threat of infection with HIV/AIDS (human immunodeficiency virus/acquired immunodeficiency syndrome) in the 1980s and later.

PREREQUISITES FOR HEALTH

Another way to consider conditions required for people's health to flourish was outlined by working groups of the World Health Organization Regional Office for Europe in the 1980s, during the development of targets to be met in order to achieve Health for All, a program conceived with the goal of assuring that essential health care is accessible to everyone through organized programs of health promotion. The prerequisites for health were identified as: freedom from the fear of war, equal opportunity for all, satisfaction of basic needs (food, education, clean water and sanitation, decent housing), secure work, a useful social role, and political will and public support. All these are embodied in one way or another in the

determinants of health outlined above, but when expressed as they were by the WHO working groups, the relevance of human values to achievement of good health becomes more explicit. Ultimately, values may matter more than anything else in influencing health.

HEALTH PROMOTION AND HEALTH MAINTENANCE

The basic goals of health promotion and health maintenance are a safe environment, enhanced immunity, sensible behavior, good nutrition, well-born children, and prudent health care. Each of these merits a brief discussion.

Safe Environment. Among the fundamental requirements for good health are clean air, safe water, land free from toxic substances, and shelter that protects people against the elements. The term "filth diseases" coined in the mid-nineteenth century, summarizes many life-shortening environmental hazards that prevailed at that time. Unpolluted water, sanitary disposal of human wastes, and improved housing conditions transformed overall health by the end of the nineteenth century. Access to food and resources essential for survival, as well as freedom from threat of war, persecution, and discrimination, are included in the European Charter for Health Promotion. A high proportion of the world's people are in want of these essential requirements for good health.

Enhanced Immunity. Next in importance to the provision of pure water supplies and sanitary disposal of human waste is the protection of infants and children against lethal and crippling infectious diseases. By the middle of the twentieth century, immunization campaigns had virtually wiped out diphtheria, tetanus, and whooping cough. Smallpox was eradicated worldwide by 1980. Development in virus vaccines in the second half of the twentieth century added poliomyelitis, measles, rubella, and mumps, to the list of diseases preventable through vaccination. This list includes other dangerous diseases that are rare in Western industrial nations, including typhoid, typhus, and yellow fever.

Sensible Behavior. The way people behave influences their health in many ways, and behaving sensibly is an obvious requirement for good health.

Health-related behavior is influenced by our values, which are determined by upbringing, by example, by experience, by the company one keeps, by the persuasive power of advertising (often a force of behavior that can harm health), and by effective health education. These influences affect everyone—especially impressionable children—and lead to good or poor health, depending on the predominance of sensible or risk-taking behaviors that result.

Good Nutrition. A balanced diet comprises a mixture of the main varieties of nutriment (protein, carbohydrates, fats, minerals, and vitamins). For many reasons, not everyone has easy access to or incentives to eat a balanced diet. Some cannot afford it, others are ignorant of what kinds of food are good for them and what kinds are not; many are attracted by the advertising, convenience, and low cost of junk foods. Nevertheless, those who eat a well-balanced diet are healthier than those who do not.

Well-Born Children. By this term we mean children who are free from genetic defects, safely and easily born to healthy mothers after a pregnancy of normal duration, and nurtured securely to ensure that they pass developmental milestones in a timely manner so they grow up fit and strong. A great many characteristics are summarized in that statement, and are discussed elsewhere in this encyclopedia.

Prudent Health Care. It has been said that, until about 1930, the average patient with the average disease consulting the average physician had a less than 50 percent chance of benefiting from the encounter. In some respects the situation has greatly improved since then, but doctors even now inadvertently harm some whom they attempt to help, and hospitals remain dangerous places where patients are at risk of infection by other patients and contaminated instruments, invasive procedures can go wrong, and medications can be administered to the wrong patient or given in wrong dosages.

HEALTH INDICATORS

The health of potential military recruits and applicants for life insurance is assessed by their past

history of illness and harmful behavior (e.g., smoking), and by a physical examination that includes blood pressure, tests of exercise tolerance, and other measures. Similar methods can be used to assess the health of a nation. The physical examinations of military conscripts early in the twentieth century provided evidence of the poor health of the British working classes, and which in turn motivated the government to introduce the first tax-supported medical services. In the United States, the National Health Surveys provide information about the health status of Americans (such as the increasingly prevalent obesity among young people). But this is a costly way to assess a nation's health. Traditionally, health care professionals have relied on summary statistics, especially life expectancy, which is derived from the age distribution of the population as determined by a national census. Life expectancy at birth is particularly sensitive to infant mortality, which is another widely used indicator of a nation's level of health.

More sensitive indicators take into account the available evidence on commonly occurring disabling diseases to derive summary statistics such as disability-adjusted life years. Health measurement scales are more elaborate derivatives of disability-based health indicators. These require the use of questionnaires, interviews, and sometimes physical examination of individuals to derive a numerical score for particular aspects of health such as an ability to climb stairs, shop for food, prepare meals, get dressed unaided, or drive a car. Standardized interviews can also be used to derive a numerical score for aspects of mental health, social interaction with others, and employability. When all available health indicators are compiled, various conclusions can be drawn. They show, for example, that Japan, Australia, Sweden, the Netherlands, and Canada are among the world's healthiest nations; while Sierra Leone, Mozambique, and Malawi are in many respects the least healthy. The United States is among the top twenty nations according to some indicators, and among the top twenty-five according to others. But no nation has a monopoly on indicators of good health. If athletic prowess is an indicator, African Americans consistently outperform all others in sprints, while Africans from Kenya outperform all others in middle- and long-distance running. Some small nations in the mountainous Caucasus region between the Caspian Sea and the Black Sea, in the

Table 1

The top 25 and the bottom 25 nations ranked according to Disability-Adjusted Life Expectancy (DALE)

Rank	Nation	DALE	Rank	Nation	DALE
1	Japan	74.4	166	Djibouti	37.9
2	Australia	73.2	167	Guinea	37.8
3	France	73.1	168	Afghanistan	37.7
4	Sweden	73.0	169	Eritrea	37.7
5	Spain	72.8	170	Guinea-Bissau	37.2
6	Italy	72.7	171	Lesotho	36.9
7	Greece	72.5	172	Madagascar	36.6
8	Switzerland	72.5	173	Somalia	36.4
9	Monaco	72.4	174	Congo	36.3
10	Andorra	72.3	175	Central African Republic	36.0
11	San Marino	72.3	176	Tanzania	36.0
12	Canada	72.0	177	Namibia	35.6
13	Netherlands	72.0	178	Burkina Fasso	35.5
14	Britain	71.7	179	Burundi	34.6
15	Norway	71.7	180	Mozambique	34.4
16	Belgium	71.6	181	Liberia	34.0
17	Austria	71.6	182	Ethiopia	33.5
18	Luxembourg	71.1	183	Mali	33.1
19	Iceland	70.8	184	Zimbabwe	32.9
20	Finland	70.5	185	Rwanda	32.8
21	Malta	70.5	186	Uganda	32.7
22	Germany	70.4	187	Botswana	32.3
23	Israel	70.4	188	Zambia	30.3
24	United States	70.0	189	Malawi	29.4
25	Cyprus	69.8	190	Niger	29.1
			191	Sierra Leone	25.9

SOURCE: World Health Organization, 2000.

foothills of Mount Ararat, are famous for many authenticated cases of extreme longevity, and they may have the world's highest proportion of persons surviving to ages over one hundred. Yet these same nations have relatively high infant and childhood mortality rates, as well as high death rates from causes associated with violence.

Determining which nations are healthy depends on which health indicators are looked at. The Netherlands, for example, ranks at the top using indicators of health quality—literacy levels, low incidence of abortion and unwanted pregnancy, low incidence rates of impairments, disabilities, and handicaps—though other countries may rank higher in terms of longevity and other indicators.

Table 1 shows the ranking of various nations based on years of healthy life expectancy or disability-adjusted life years, the age to which on average people are expected to live in good health.

This number is reached by subtracting the average years of ill health from the overall life expectancy. The top nations are Japan, Australia, and France; the bottom three are Malawi, Niger, and Sierra Leone. The United States is twenty-fourth on this list, though it is the richest nation on earth in terms of economic indicators. The poorest fifth of residents in the United States have a healthy life expectancy of just fifty-five years, compared to seventy years for the nation as a whole. Clearly there is room for considerable improvement.

CONCLUSION

Health is clearly a complex, multidimensional concept. Personal or individual health is largely subjective. It is possible to be physically robust, to be “the picture of good health,” and yet have serious mental or emotional impairment. Conversely, an individual can be profoundly disabled physically yet have an intact mind and be emotionally well-adjusted. So while many facets of health can be identified, the assessment or measurement of individual health must take them all into account. Economists can derive a single number—the net worth or gross domestic product—as a measure of the economic status of an individual or a nation. But there is no comparable one-dimensional measurement scale for the health of an individual, much less a nation. At best, public health professionals can create community or national profiles using crude health indicators like life expectancy; infant mortality rates; death or sickness rates from specific causes like cancer, heart disease, suicide, and homicide; or surrogate measurements such as use of drugs, (prescribed or over-the-counter) and spells of hospital care.

Health is, ultimately, poorly defined and difficult to measure, despite impressive efforts by epidemiologists, vital statisticians, social scientists, and political economists. The dramatic differences in levels of health among the nations of the world only challenge public health professionals to pursue global health standards.

At the beginning of the twenty-first century the principal causes of premature death and departures from good health were violence, including violent armed conflict; smoking-related disease; automobile accidents; and overindulgence in

high-calorie foods that are ill-suited to modern, sedentary lifestyles. All of these are ultimately associated with human behavior, which is greatly determined by values. Only by adopting values that support a healthy lifestyle can people improve their overall health.

JOHN M. LAST

(SEE ALSO: *Assessment of Health Status; Attitudes; Behavioral Determinants; Climate Change and Human Health; Community Health; Cultural Factors; Environmental Determinants of Health; Genetics and Health; Health Belief Model; Health Maintenance; Health Measurement Scales; Health Promotion and Education; Infant Mortality Rate; Lay Concepts of Health and Illness; Life Expectancy and Life Tables; Maternal and Child Health; Mental Health; Nutrition; Social Determinants; Sustainable Health; and articles on specified diseases mentioned herein*)

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HEALTH ADMINISTRATION, CAREER IN

Public health departments range in size from agencies with a few part-time employees to those with more than a thousand full-time employees. In every department, administrators carry responsibility for services related to personnel and program management. In most departments, full-time administrators have ultimate responsibility for payment of staff, tracking use of sick leave and vacation time, evaluating staff performance, enforcing personnel policies, preparing and managing budgets, developing contracts, ordering supplies and equipment, filing reports for funders and governing bodies, and so on. Some of these responsibilities may be shared with program managers and supervisors.

C. WILLIAM KECK

HEALTH BELIEF MODEL

The health belief model, developed by researchers at the U.S. Public Health Service in the 1950s, was inspired by a study of why people sought X-ray examinations for tuberculosis. It attempted to explain and predict a given health-related behavior from certain patterns of belief about the recommended health behavior and the health problems that the behavior was intended to prevent or control. The model postulates that the following four conditions both explain and predict a health-related behavior:

1. A person believes that his or her health is in jeopardy. For the behavior of seeking a screening test or examination for an asymptomatic disease such as tuberculosis, hypertension, or early cancer, the person must believe that he or she can have the disease yet not feel symptoms. This constellation of beliefs was later referred to generally as "belief in susceptibility."

2. The person perceives the “potential seriousness” of the condition in terms of pain or discomfort, time lost from work, economic difficulties, or other outcomes.
3. On assessing the circumstances, the person believes that benefits stemming from the recommended behavior outweigh the costs and inconvenience and that they are indeed possible and within his or her grasp. Note that this set of beliefs is not equivalent to actual rewards and barriers (reinforcing factors). In the health belief model, these are “perceived” or “anticipated” benefits and costs (predisposing factors).
4. The person receives a “cue to action” or a precipitating force that makes the person feel the need to take action.

The model soon changed shape when applied to another set of problems concerning immunization and more broadly to (the variety of) people’s different responses to public health measures and their uses of health services. In these wider applications, the model substituted a belief in susceptibility to a disease or health problem for the more specific belief that one could have a disease and not know it, which had been featured in Godfrey Hochbaum’s original study as the most important belief accounting for seeking screening examinations.

In the mid-1970s, a monograph devoted to the wide-ranging applications of the model described its history and experience (Becker, 1974). This was soon followed by a review of the standardized scales for measuring its several dimensions (Maiman et al., 1977). The model continued to evolve into the 1980s, largely at the hands of Marshall Becker at Johns Hopkins University and later at the University of Michigan School.

The Health Belief Model relates largely to the cognitive factors predisposing a person to a health behavior, concluding with a belief in one’s self-efficacy for the behavior. The model leaves much still to be explained by factors enabling and reinforcing one’s behavior, and these factors become increasingly important when the model is used to explain and predict more complex lifestyle behaviors that needs to be maintained over a lifetime.

A systematic, quantitative review of studies that had applied the Health Belief Model among adults into the late 1980s found it lacking in consistent predictive power for many behaviors, probably because its scope is limited to predisposing factors (Harrison, Mullen, and Green, 1992). One study that specifically compared its predictive power with other models found that it accounted for a smaller proportion of the variance in diet, exercise, and smoking behaviors than did the theory of reasoned action, theory of planned behavior, and the PRECEDE-PROCEED model (Mullen, Hersey, and Iverson, 1987).

Nevertheless, the health belief model continued to be the most frequently applied model in published descriptions of programs and studies in health education and health behavior in the early 1990s. It has since been displaced in frequency of application by the transtheoretical model of stages of change. It remains, however, a valuable guide to practitioners in planning the communication component of health education programs.

LAWRENCE W. GREEN

(SEE ALSO: *Behavioral Change; Behavioral Determinants; Health Goals; Health Outcomes; PRECEDE-PROCEED Model; Psychology, Health; Theory of Planned Behavior; Theory of Reasoned Action; Transtheoretical Model of Stages of Change*)

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HEALTH BOOKS

There is a vast range of books available to the public about health, including volumes focused on specific illnesses, therapies, and prevention strategies, along with various compendia—many of which are targeted to a specific audience (such as women, gays, or the elderly). Many books are written by physicians, but more and more nontraditional healers and laypeople are also authoring health-related books. Many of the lay authors write about a condition or illness they have personally experienced.

A heightened demand by the public for information about health is one reason for the flood of health books. The demand arises from other sources as well, including a growing interest in taking personal responsibility for one's health, self-care for chronic illness, complementary and an alternative therapies, and various dissatisfactions with the state of medical care. Another factor is the growing sophistication and marketing prowess of major media corporations. Health books are frequently profitable, and are increasingly part of a coordinated sales campaign that includes video tapes, audio tapes, magazine articles, and Internet publicity efforts.

The wide distribution of books on health, along with the broader marketing of information about health, has raised the level of public awareness about many health issues. Books are especially potent in their ability to provide information

beyond that offered by clinicians. However, as these books are purchased and read primarily by middle-class individuals with specific preexisting concerns, the impact of the books on the health of the overall public is less clear.

MICHAEL S. GOLDSTEIN

(SEE ALSO: *Communication for Health; Health Promotion and Education; Lay Concepts of Health and Illness; Mass Media; Self-Care Behavior*)

HEALTH CARE FINANCING

The methods used to finance personal health care service play a major role in shaping a country's health care system. Personal health care include services such as hospital care, physician care, dental services, and drugs that are provided directly to individuals. How this care is financed influences how people access health care, the types of health care provided, and the mechanisms used to allocate health care services. Financing methods also influence how the costs of health care are distributed among members of society by income and by health status. Two aspects of health care financing are the focus of this section: the sources of funds for health care services, and the mechanisms used to pay health care providers.

BROAD OVERVIEW OF THE HEALTH CARE FINANCING SYSTEM

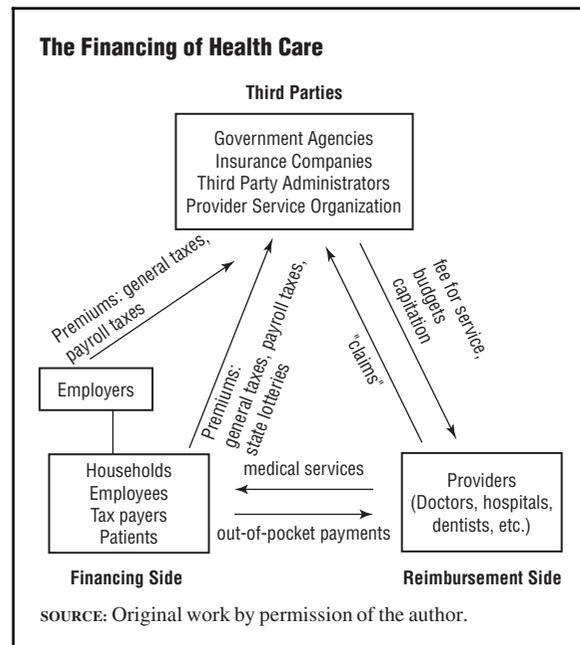
In most markets, buyers and sellers trade directly. A person who wants to buy a loaf of bread pays the merchant for that bread. A person who wants to buy an automobile pays the dealer for the car. This concept of direct exchange between the buyer and the seller is not repudiated by the existence of credit. The health care market, however, is quite different. A basic characteristic of health care systems in all developed countries is that the majority of payments for medical services flows through third parties. A third party is an entity, usually an insurance company or government agency, that pays for medical services but does not receive or provide health care services. In general, third-party financing arose for two different reasons: (1) people wanted to insure against the large and uncertain cost of illness, and (2) governments

wanted to assure access to health care for its citizens.

Figure 1 presents a diagrammatic representation of the various aspects of health care financing systems. If there were no third parties, then only the bottom part of the figure would apply. Individuals would pay providers directly for health services at prices set by those providers. With the presence of third parties, the situation becomes more complicated. Each third party (the insurance plan or government agency) has its own rules determining the source of funds, who is eligible to enroll, what medical services will be provided, and how medical providers will be paid. As a concrete example, consider a group of employees who are all covered by an insurance plan obtained through their employer with part of the cost of the insurance (the premium) paid by the employer and part by the employees. The insurance plan will indicate who (employee and/or their dependents) is covered by the plan; what services (such as hospital stays, physician visits, medical tests, drugs) are covered under the plan; what payment limits (such as a maximum number of hospital days per year) if any, are imposed; which medical providers (such as a roster of providers who participate in the insurance plan) will be paid under the plan, and how medical services are obtained (for example, whether a medical specialist can be consulted without authorization from the plan). An insurance plan also dictates the cost-sharing arrangements, that is, how much of the cost of care is to be paid directly by the patient and how much by the plan. Examples of common types of cost-sharing arrangements are deductibles (i.e., a specified amount for medical care before the plan makes any payments), co-payments (i.e., a fixed amount for each clinic visit or service), or coinsurance rates (i.e., a percentage at the total medical bill). Additionally, most insurance plans place limits on the maximum amount of direct health care costs patients will be responsible for paying in any given year. Finally, insurance plans set rules to govern how medical providers are paid for their services.

The nature of health care financing systems varies widely across developed countries. With the exception of the United States and South Africa, all of the developed countries have implemented some kind of national health insurance system; that is, they have established programs to ensure that the majority of their citizens have access to

Figure 1



health care services with minimal cost-sharing. Some countries (such as Germany and France) require employers to offer and employees to purchase a health insurance plan with payroll taxes as the major source of funding for this. In other countries, such as Canada, general tax revenues supply the major source of funding for their health insurance systems.

HEALTH INSURANCE COVERAGE IN THE UNITED STATES

Health care financing in the United States is fundamentally different from that in most other developed countries because there is no national health insurance plan. There are a variety of third-party payers such as government programs (Medicare and Medicaid), insurance companies (which can be either for-profit and not-for-profit), self-insured plans operated by employers and provider sponsor organizations (providers that contract directly to provide health care services). Each of these types of third-party payers offer different health plans that have different financing "rules."

In the United States the majority of employed people and their dependents obtain health insurance through their employment. However, the

provision of health insurance by employers is strictly voluntary (other than the state of Hawaii) with few regulations governing how insurance is provided. Some employers do not offer insurance at all, while others pay anywhere from all to none of the insurance premium. Employers may offer only one insurance plan or a multitude of plans for employees to choose from. Insurance plans are not standardized and can vary widely with respect to covered services, cost-sharing arrangements, and procedures for accessing medical services.

Active competition exists among insurance companies in the employment-offered health insurance market. Employer-offered plans are often experience rated, that is, the premium (or price of the plan) for employees of a particular employer are determined primarily by the past cost of medical care used by employees of that employer. When premiums are experience rated, they are lower for employers with healthier employees. However, premiums for some plans are community rated; that is, they are determined by the past cost of medical care for all people covered under a plan regardless of their employer.

Individuals may also purchase health insurance in either the individual insurance market or through groups that were formed independent of employment, such as professional associations. In this case, the premiums are generally experience rated and reflect the average, expected cost of illness for individuals within the defined group covered by a particular plan. The sicker the group of individuals covered by an insurance plan, the higher the premiums. There is tremendous variation in the types of insurance plans sold with respect to the characteristics such as cost-sharing, and access to services.

Although the United States does not have national health insurance for all its citizens, it does have a number of public programs that provide health insurance or other types of health programs for the poor, the disabled, and the elderly. The three most important public programs are the Medicare program, the Medicaid program, and the State Child's Health Insurance Programs (SCHIP).

The Medicare program is a federal program that was enacted in 1965. Medicare covers almost everyone who is sixty-five years of age and older, as well as a small subset of the general population

who have been receiving Social Security Disability payments for two years and almost everybody who has end-stage renal disease (kidney failure). The Medicare program covers a wide range of services, although it does not cover most outpatient drugs and its coverage of long-term care services is limited. There is also cost-sharing on covered services. The Medicare program is funded through a combination of payroll taxes, general tax revenues, beneficiary premiums, and direct beneficiary payments. Medicare beneficiaries can privately purchase additional insurance (Medigap) that covers some (or all) of the beneficiary cost sharing for covered services as well as some additional services.

Medicaid was also enacted in 1965 to provide medical care for certain vulnerable and needy individuals with low incomes and assets. Jointly funded by the federal and state governments, it is subject to broad national guidelines and state-specific rules, which can vary by eligibility criteria as well as the type and intensity of services. Payment methods also may vary by state. In general, the Medicaid program covers a wide range of services with very little cost-sharing imposed on the patients. The federal share of the Medicaid program is funded through general tax revenues, the states fund their programs in a variety of ways (such as general taxes, provider specific taxes, and tobacco taxes).

The SCHIP program, first established in 1996, provides health insurance for children in families with low incomes but not low enough to qualify for family coverage under Medicaid. In essence, it increases the number of low-income children eligible for public insurance. It covers a broad range of services and requires some limited cost-sharing. It is funded by federal and state taxes. The federal share of these taxes is provided through general taxes, while states use a variety of methods to fund the program.

In addition to these programs, a number of smaller programs finance medical services for targeted populations. For instance, some states, such as Pennsylvania, provide funding for drug coverage for low-income senior citizens who do not qualify for Medicaid. In Pennsylvania, this program is funded by state lottery sales.

In 1998, some 44 million people in the United States under the age of sixty-five (18.4% of the population) did not have a health insurance plan,

although some of them may have been eligible for medical services through specially targeted public and private programs (Fronstein, 2000).

FUNDING SOURCES IN THE UNITED STATES

In 1998, expenditures on personal health care services totaled \$1 trillion with 19.6 percent paid directly by patients (out-of-pocket payments) and 80 percent paid by third parties (Health Care Financing Administration, <http://www.hcfa.gov/stats/nheoact/tables>). Third parties paid for 97 percent of hospital care but only 55 percent for drugs and other services. This discrepancy reflects the nature of insurance coverage. While almost all insurance plans provide some level of payment for hospital services, payments for drugs is less universal. The amount of cost-sharing varies by type of covered services, but patients typically pay a larger share of outpatient clinic costs and inpatient hospital costs.

FINANCIAL BURDEN OF ILLNESS

The total payments made for health care are sometimes referred to as the “cost” of personal health care. Two aspects of the distribution of the cost of care are frequently examined: the distribution among individuals with respect to their income and among individuals with respect to their health.

Analysts classify funding sources with respect to income as progressive, regressive, or proportional. A funding system is considered progressive if the fraction of a person’s income paid to the system (for example, in taxes or premiums) rises as income rises; a funding system is considered regressive if the fraction of a person’s income paid to the funding system declines as income rises; and a funding system is proportional if this fraction of income paid to the funding system remains constant regardless of income—every person pays the same proportion of his or her income.

As indicated by Figure 1, all health care is funded either directly or indirectly by individuals. Individuals ultimately pay for the premiums to insurance companies and the taxes to governments that in turn pay for health care services. Aid in the employers often pay for a large share of insurance premiums and/or taxes, the amounts

paid by employers are passed on to individuals and households through lower wages for the employees, higher prices to consumers for the employers’ goods or services, or lower returns to investors on capital.

In general, health insurance programs funded predominantly through income taxes are the most progressive with respect to income. People with the highest incomes pay proportionately more than people with the lowest incomes, regardless of their use of medical services. On the other hand, insurance funded mainly by premiums is the most regressive because people with lowest incomes pay a higher proportion of their total income than people with high incomes. In general, payroll taxes are moderately regressive because the percentage of an individual’s income that comes from wages (as opposed to personal investments or other sources of income) tends to decline as total income rises. Insurance programs funded by lotteries are also considered regressive because most lottery tickets are purchased by those with low incomes.

The broader the segment of society that forms the funding base for health insurance programs, the more the financial cost of illness is shifted from the sick to the healthy. If all health care is paid for only by patients, then the financial cost of illness is born exclusively by the sick (or users of health care). On the other hand, if a broad segment of society (healthy and sick) is supplying funds for health insurance programs, then the financial cost of illness is shared among those individuals and less financial burden is borne by the sick. Likewise, the more out-of-pocket payments (direct patient payments) that serve as the source of funds for health care, the more the financial burden of illness is borne by the sick. When experience rating is used to set premiums, the sick bear a higher financial burden of illness than when community rating is used. Thus financing methods greatly influence the financial burden of illness in a society. For example, under national health insurance systems such as those of Great Britain, Germany, and Canada, the financial burden of illness is broadly spread across society and the actual expenditures made by the sick (in the form of out-of-pocket payments and disproportionately high premiums) are much less than the actual cost of their medical care. By contrast, in the United

States a higher proportion of medical expenditures is paid directly by the sick and many insurance plans are experience rated, thus the financial burden of illness is more concentrated on the sick.

PAYING HEALTH CARE PROVIDERS

A number of methods exist for paying health care providers (physicians, hospitals, clinics, labs, and other individuals and firms supplying health care services). This section presents an overview of the most important of these payment methods.

Paying for Care: Physicians and Other Health Care Professionals. Physicians and other health care professionals are generally paid using one of three payment methods: fee-for-service, capitation, and salary. In many cases, professionals are paid by more than one method. For example, a third-party payer may use a combination of payment methods or a professional might be paid by several different third parties, each using a different payment method.

Fee-for-service. Under the fee-for-service method of payment, professionals receive a fee (or payment) for each service they provide. The actual medical service is the unit of payment and there is some discretion regarding what constitutes a medical service. A service unit can be very distinct (i.e., urinalysis test) or relatively comprehensive (i.e., an appendectomy where the physician payment covers all care associated with the procedure including the preoperative visit, the surgical procedure itself, and some follow-up care). Thus, the service for which payment is made can actually be several separate, discrete services.

Fee-for-service payments to professionals are based on charges that are either set by professionals or by third-party fee schedules. A fee schedule defines the maximum acceptable charge for medical services. One of the most widely used schedules in the United States is the *Medicare Fee Schedule*, which was developed by the Medicare program to pay professionals for care used by Medicare beneficiaries.

Capitation. The capitation method of payment provides professionals with a defined, periodic, per-patient payment (usually monthly) for every individual enrolled in insurance plan, regardless of how many individuals seek care or how much

care is provided. Capitation agreements with providers specify what services are covered and those can vary considerably among agreements. The capitation payment may be based on the characteristics of individuals (such as age) enrolled in the plan. This helps compensate providers for differences in the expected use of medical care by groups of patients with similar characteristics.

Salary. The salary method of payment provides professionals with a fixed payment or salary (usually monthly or yearly) that does not vary with the number of people in the plan or the number of patients treated or the number of services provided. In the United States, this method is frequently used for nonphysician professionals in a variety of the employment settings. Physicians working for government agencies, some HMOs, or large group practices may also receive payment by the salary method.

A professional can receive payment under a single payment method while third-party payers make payments for that professional's services using several different payment methods. For example, a physician belonging to a large group practice may receive a salary from the group practice while the group practice receives payments for the physician's services from third-party payers using a capitation method.

Paying for Care: Hospitals and Other Institutional Providers. Numerous methods are used to pay for hospital services, such as payment based on established charges, retrospective costs, per-diem rates, per-case rates, capitated payments, or budgets. Countries, such as the United States, with many different third-party payers use a broader mix of these methods.

Charge-based payments. Prevalent only in the United States, the charge-based method requires hospitals to define a price or "charge" for each hospital service. This hospital-established charge is then paid either directly by the patient or the patient's health insurance company. Under this method of payment, hospitals determine the charge. This method is not used by government payers.

Cost-based payments. The retrospective cost-based method is designed to pay the actual costs of hospital services as opposed to whatever charge hospitals may request. Under this method, a set of accounting rules defines what the hospital costs

are for a defined group of patients. Although relatively common in the United States from 1966 to 1983 because it was used by the Medicare program, most state Medicare programs, and some large insurers, this method has lost importance since the mid-1980s.

Per-diem payments. Hospitals paid by the per-diem method receive payments based on the number of days a patient spends in the hospital. This payment is usually not adjusted to allow for differences in patient characteristics (i.e., the same payment is paid for patients undergoing heart surgery as for maternity cases). However, per-diem payments may vary by hospital. The payment is agreed upon through negotiations between a third-party payer and a hospital. The per-diem method is relatively common in Europe.

Per-case payments. The per-case method pays hospitals a fixed payment for each patient the hospital discharges. In the most extreme form of the per-case method, the payment is the same for all patients regardless of a patient's medical condition. More commonly, patients are classified into groups based on expected costs for necessary care (known as case-mix formulations) and payment varies according to a patient's group classification. The payment may also differ for different types of hospitals (teaching hospitals, community hospitals). Per-case payment methods may contain provisions for additional payments for patients whose treatment costs are exceptionally high (called outlier payments). The Medicare program uses the per-case payment method and payment is based on a patient classification system called DRGs (diagnosis-related groups).

Capitation payments. Under the capitation method, the hospital receives a fixed monthly payment for person enrolled in a health plan. This payment method shifts financial risk from the third-party payer to the hospital itself and the use of this method for hospitals is relatively rare.

Budget payments. The budget method provides hospitals with a global budget or payment designed to cover all services provided by the hospital over the course of the year. The global budget may be unilaterally set by government agencies or established by formulas that account for inflation and expected changes in the size of the inpatient population or negotiated between a payer and a

hospital. In some countries, global budgets account for expected differences in patient illnesses. This method is used in United States primarily for hospitals owned by the federal government.

THE IMPACTS OF FINANCING

Financing methods can influence consumers' decisions to seek medical care and how much and what type of medical care they seek. Consumers with no cost-sharing requirements are more likely to seek and use care because they don't have to make direct payments for their care. Likewise, consumers with high cost-sharing requirements are somewhat less likely to seek and use care. Financing methods may influence medical providers' decisions as to what treatments to offer and how frequently to interact with patients. Providers paid under capitation get the same payment to the regardless of whether or not they see a patient. This payment system discourages providers from requiring unnecessary visits. In these ways, financing methods influence the delivery of medical care to individuals.

OTHER CONSIDERATIONS

In addition to the financing methods discussed above, the health care system in all countries is shaped by the general regulatory environment within which consumers make decisions about accessing the health care system and providers make decisions about the types of treatments to provide or recommend. There are significant differences across countries regarding the extent of centralized regulation over the number and location of hospital beds, the number and specialties of physicians in training, physician licensing, practice location and mobility, and the ability of hospitals or providers to establish clinics or purchase advanced technology. Additionally, the level of control government authorities have over aggregate health care budgets varies across countries. In general, the more a health care system is directly funded by the government, the more governmental control there is over the size of the health care system (subject of course to the give and play of the political environment). In cases where governments regulate the price of care (per service, per day, or per case), providers can still influence the flow of payments by altering the types or intensity of medical care. However, it is possible to impose

budgetary control in a system where prices are directly controlled. For example, in the United States the Medicare program imposes physician expenditure targets called volume performance standards and bases the Medicare fee schedule in part on how well physicians (in the aggregate) meet the volume performance standard. Likewise, in the Canadian province of Ontario, the government imposes income limits for physicians and as payments to a physician approach the income limit, the proportion of the fee paid decreases. In general, there is much less aggregate control over the health care delivery system in the United States and there is in other countries.

NATIONAL HEALTH EXPENDITURES

National health expenditures are defined to include health care services and supplies, research, and construction supplies related to health care. Health care services and supplies include personal health care services, the cost of administering private and public health insurance programs, and government public health expenditures. Personal health services are by far the largest component of national health expenditures. Data on the national health expenditures for 1998 are presented at <http://www.hcfa.gov/stats/nheoact/tables/t11.htm>.

The Health Care Financing Administration's web site, <http://www.hcfa.gov>, presents detailed statistics on health care expenditures in the United States and the source of funds.

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(SEE ALSO: *Access to Health Services*; *Health Care Financing Administration*; *Health Maintenance Organization [HMO]*; *Managed Care*; *Personal Health Services*)

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Health Care Financing Administration, <http://www.hcfa.gov>

HEALTH CARE FINANCING ADMINISTRATION

The Health Care Financing Administration (HCFA) manages the federal government's largest health care financing programs and exercises regulatory and evaluative authority designed to assure the quality of health care services delivered to broad populations within the United States. Created in 1977, HCFA administers the federal Medicare program that purchases medical care for 39 million elderly and disabled individuals, as well as the Medicaid program that operates jointly under federal and state authority to provide care for 33 million low-income persons. Both of these entitlement programs were created in 1965 through amendments to the federal Social Security Act, and operated under separate federal agencies until HCFA was created in 1977 to manage them jointly. More recently, HCFA was given responsibility for administering a new federal health care financing program, the State Children's Health Insurance Program (SCHIP), created in 1997 to provide health insurance coverage for many of the nation's 11 million uninsured children. In managing these three programs, HCFA is the largest

single purchaser of health care services in the United States. This substantial purchasing power allows the agency to influence the quality and efficiency of care delivered not just to individuals eligible for Medicare and Medicaid, but also to the U.S. population at large. In addition to its financing responsibilities, HCFA carries out an array of activities designed to encourage improvements in quality and efficiency among health care providers that participate in public programs.

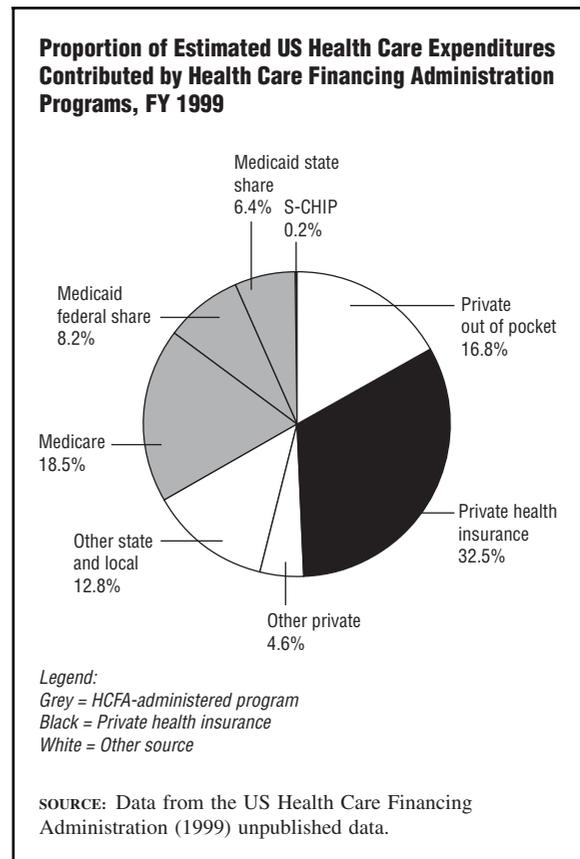
HCFA is one of the eleven federal agencies that comprise the U.S. Department of Health and Human Services. HCFA's programs are carried out through a central office in Baltimore, Maryland, and a network of ten regional offices across the country (see Figure 1).

HCFA's budget was an estimated \$342 billion in fiscal year 2000. Most of these resources were dedicated to the agency's three health care financing programs—Medicare, Medicaid, and SCHIP. Federal expenditures for Medicare and Medicaid benefits grew from \$41 billion in 1977 to an estimated \$311 billion in 1999. HCFA's human resources remained relatively constant at approximately four thousand full-time equivalent personnel over the same years.

Medicare is the nation's largest health care financing program covering individuals at least sixty-five years old or who have permanent disabilities or kidney failure. Operating under explicit congressional authority, HCFA establishes the coverage policies, payment mechanisms and rates for services provided by hospitals, physicians, and other providers authorized to serve Medicare beneficiaries. HCFA relies on a network of private contractors for processing claims for payment. HCFA also contracts with managed care plans to serve beneficiaries who choose to receive health care through these plans.

Unlike the Medicare program, HCFA operates both the Medicaid program and the SCHIP program in partnership with state governments. Individual states hold the authority to establish program eligibility criteria and program benefit levels that are consistent with broad federal requirements. States also participate in the financing of these programs, with the federal government covering a proportion of Medicaid program expenditures that varies between a minimum of 50 percent and a maximum of 83 percent depending

Figure 1



on a state's per capita income level. Similar federal matching rates are used for the SCHIP program, although these rates are tied to estimates of low-income uninsured children in each state. Many states now contract with managed care plans to serve Medicaid and SCHIP recipients.

In addition to administrating health care financing programs, HCFA works to improve the quality and efficiency of health care delivery.

The health care programs and services administered by HCFA expand access to medical care for millions of Americans who would otherwise face barriers to care because of age, income, health status, or disability. These programs also provide important support for the nation's health-profession training facilities, through payments made to teaching hospitals for training physicians and nurses. HCFA faces myriad challenges in protecting the integrity and effectiveness of these vital public health insurance programs, including those

posed by demographic changes, shifts in income and employment, rising health care costs, diversifying health care technologies, and changing political priorities and social values. But the agency also has opportunities to use its administrative authority over public programs in order to encourage improvements in the quality and efficiency of care provided throughout the U.S. health care system. In these ways, HCFA helps to shape the American public health system through its purchasing power, its regulatory authority, and its policy leadership.

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(SEE ALSO: *Economics of Health; Personal Health Services*)

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HEALTH CARE PERSONNEL

See Careers in Public Health

HEALTH EDUCATOR

A health educator informs people about the causes and prevention of health problems, especially those that relate to lifestyle, work, and cultural factors. Health educators help people to improve their health through consulting, education, and community-planning strategies. They may conduct a "community diagnosis" to assess health issues in an entire community, and then plan a way to improve problem areas. Health educators are employed in various public settings, including public health departments, worksites, community organizations, and government settings. Credentialing

information and an outline of the roles and responsibilities for health educators are available through the National Commission for Health Education Credentialing, Inc.

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(SEE ALSO: *Association of Schools of Public Health; Careers in Public Health; Community Health; Health Promotion and Education*)

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HEALTH GOALS

Health goals can provide direction to health policy, guide efforts to improve health, and help to evaluate progress. A goals process almost always leads to greater emphasis on health promotion and disease prevention. The idea of specifying health goals grew out of the management-by-objectives movement that developed after World War II and became part of the strategic planning movement in the 1960s and 1970s. Several related concepts are involved, although terminology varies from one setting to another. A "goal" is a statement of a desirable state of affairs, generally stated in fairly broad terms. An "objective" is a narrower, quantitative statement that sets out a target population, the intervention to be used, and the indicator to be measured. A "target" is a specific statement of the amount of improvement to be achieved and the date by which it is to be achieved.

THE UNITED STATES EXPERIENCE

In the United States, the initiative for setting goals has been led by the Office of Disease Prevention and Health Promotion. It grew directly out of the management-by-objectives movement, and has, accordingly, emphasized measurement. In 1979,

Healthy People: The Surgeon-General's Report on Health Promotion and Disease Prevention set out five goals for the nation, organized by life stage. One goal, for example, was "to improve the health of adults, and, by 1990, to reduce deaths among people between the ages of twenty-five and sixty-four by at least 25 percent." Ten subgoals and fifteen priority areas were also specified. This was followed in 1980 by *Promoting Health, Preventing Disease: Objectives for the Nation*, which elaborated these goals into 226 objectives, including that "by 1990, the proportion of adults who smoke should be reduced to below 25 percent." (In 1979, the proportion was 33%.) A public health service agency was designated to lead the efforts to achieve each objective, and *Model Standards for Public Health Agencies* was published to guide public health practice.

The 1990 Health Objectives for the Nation: A Midcourse Review presented progress to that date and predicted whether the objectives would be achieved. Progress for each measurable objective was presented graphically. At the end of the cycle, the results were summarized in *Prevention Profile Health, United States, 1991* (the prevalence of smoking in 1990 was reported to be 25.5%). Overall, the goals for mortality reduction had been achieved for infants, children, and adults, but not for young people; 32 percent of the objectives had been attained, 34 percent showed progress, 11 percent were moving in the opposite direction, and 23 percent could not be evaluated because of lack of data.

A new cycle began in 1991 with *Healthy People 2000: National Health Promotion and Disease Prevention Objectives*. While the first cycle emphasized mortality (except for elders) and was rather disease oriented, with little or no mention of inequalities in health, the goals in this cycle were broadened to include morbidity and quality of life, and a concern for reducing inequalities. The objectives for 2010 were released in January 2000.

Throughout, the objectives have not been intended solely for use by government agencies, but throughout the U.S. health care system, and there has been considerable consultation with health care organizations. Government activities have been strongly influenced in terms of programming, methodological work, and publication of newsletters.

THE EUROPEAN EXPERIENCE

The European initiative grew out of the Health for All initiative of the World Health Organization (WHO). The European Office of WHO decided that health promotion was the approach most likely to achieve the goal of health for all people, and an Office of Health Promotion was established. In addition to stimulating a worldwide health-promotion movement, the office coordinated the 1985 publication of *Targets for Health for All*, which listed thirty-eight targets for the European region. From the beginning the movement was much influenced by social scientists, and emphasized social development. (The first target stated, "By the year 2000, the actual differences in health status between countries and between groups within countries should be reduced by at least 25 percent, by improving the health of disadvantaged nations and groups.") Countries were encouraged to develop their own strategic plans and goals, and most countries in the region have done so. The targets were revised in 1991, and a new set of twenty-one targets, *Health21—Health for All in the 21st Century*, was released in 1998. There has been less emphasis on measurement and evaluation than in the United States, and more emphasis on motivation and leadership in health policy.

LESSONS LEARNED

It is difficult to evaluate whether improvements in health in many countries are related to the health goals process, especially since those jurisdictions with a major commitment to health improvement are also those most likely to specify health goals. There has been little formal evaluation of the health goals movement.

In setting these goals, quantitative objects and targets are very desirable, but there is a risk that topics that are more difficult to quantify (e.g., the social environment) may receive less attention than they deserve. While it is reasonable to specify objectives and targets at all levels of health causation, it is important to ensure that the targets set at the various levels are compatible. Computerized disease models, like those used for the U.S. cancer objectives, can help to ensure this consistency. A life stage approach, in which goals are set separately for each age group, has been useful in both the United States and Europe. Different age groupings, however, may be appropriate for different

goals. A more qualitative alternative to strategic planning is a scenario process (used in the Netherlands), in which hypothetical scenarios are developed for several plausible health changes, and policies developed that can deal with any of them.

Governments may be reluctant to commit themselves to health goals, especially to quantifiable targets, lest they be held to these commitments. But the U.S. experience suggests that the process can work. It is important for governments to involve the political opposition. Otherwise, when that faction comes to power it may regard the goals as “their” goals, and reject or ignore them. Although responsibility for the process is usually assigned to some government agency, consultation with nongovernmental organizations is essential. Marketing and communication are also extremely important. Development of the goals presents an opportunity to involve the entire nation or community in talking about health, and to assure cooperation. Implementation is particularly difficult, however, and may require special intersectoral structures like interdepartmental committees.

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(SEE ALSO: *Disease Prevention; Economics of Health; Essential Public Health Services; Evaluation of Public Health Programs; Health Goals; Health Promotion and Education; Healthy Communities; Healthy People 2010; Planning for Public Health; Policy for Public Health; Politics of Public Health*)

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HEALTH MAINTENANCE

Health maintenance is a guiding principle in health care that emphasizes health promotion and disease prevention rather than the management of symptoms and illness. It includes the full array of counseling, screening, and other preventive services designed to minimize the risk of premature sickness and death and to assure optimal physical, mental, and emotional health throughout the natural life cycle. The organization of medical care to encourage health maintenance includes removing financial, physical, and psychological barriers to obtaining health promotion and disease prevention services in clinical settings; the use of media to deliver health education messages; and advocacy of health policies that reduce the risk of injury; that reduce exposure to toxins in the water, air, and workplace; and that ensure the availability of recreational facilities.

ROBERT S. LAWRENCE

(SEE ALSO: *Health Maintenance Organization [HMO]*)

HEALTH MAINTENANCE ORGANIZATION (HMO)

The term “health maintenance organization” (HMO) was coined in the early 1970s to encompass various payment and organizational arrangements for health care. In an HMO, the organization is responsible for assuring that needed medical care is delivered to an enrolled population. This is unlike the typical insurer’s responsibility to just

pay for care. HMOs typically do not rely extensively on financial disincentives to patients (deductibles or co-payments) to control demand; and they often have providers such as physicians and hospitals share in their financial risk. Some HMOs, especially those using a group-practice model, are developing extensive information systems to monitor and improve on clinical practice patterns.

HAROLD LUFT

(SEE ALSO: *Health Maintenance; Managed Care*)

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HEALTH MEASUREMENT SCALES

Because health is an abstract concept it cannot be measured directly using a mechanical scale as weight or length are measured. Instead, indicators of health have to be selected, and some form of numerical judgement applied to quantify or "scale" these. For example, if health is defined in terms of physical, mental, and social well-being, several indicators of each of these themes will typically be selected and a scoring system for rating a person on each indicator will be devised. Finally, a second scoring system is developed to represent the relative importance of the physical, mental, and social areas in the final rating, or health measurement scale.

The indicators included in such a scale may be recorded mechanically as in a treadmill test, or they may derive from expert judgment as in a physician's assessment of a symptom. Alternatively, they may be recorded via self-ratings, as in a patient's replies to a disability questionnaire. Most indicators of physical or mental health assess the intensity, duration, or frequency of symptoms. The application of a numerical rating scale is often quite simple (as in counting a patient's arthritic joints). Alternatively, scores may be derived from sophisticated experimental scaling protocols, such

as the Time Trade-off or the Standard Gamble, which represent the severity of a disabling condition by showing how many years of life a person with that condition would be willing to lose in order to return to full health for his or her remaining years.

Because of the complexity of developing a reliable and valid health measurement, there has been a steady growth over the past half century in the range of standardized health measurement scales that are available for general use. Using the same instrument in separate studies enables direct comparisons to be drawn among them. The current repertoire of health measurements numbers in the hundreds, and these have been described in several books. These ready-made health measurement scales may be classified by (1) their topic, (2) their scope, (3) their purpose, or (4) their design.

1. Measurement scales exist for the majority of common diagnoses, as well as for broader-ranging themes such as disability or health-related quality of life. Measures range from those that focus on a particular organ system (vision, hearing), to methods concerned with a diagnosis (anxiety or depression scales), then to scales that measure broader syndromes (emotional well-being), to measurements of overall health and, broadest of all, to measures of quality of life.
2. Scales may be generic or specific. The latter may be designed for a particular disease (such as a quality-of-life scale for cancer), but can also be specific to a particular type of person (women's health measures, patient satisfaction scales) or to an age group (child health indicators). Specific instruments are generally intended for clinical application and are designed to be sensitive to change following treatment. Generic instruments, such as the Sickness Impact Profile or the European Quality of Life Scale, permit comparisons across disease categories and are used in evaluating systems of care.
3. The purposes of measurement scales include diagnosis, prediction, and evaluation. Diagnostic scales (such as the Cambridge Mental Disorders of the Elderly Examination or CAMDEX) collect a wide

variety of information from self-report and clinical ratings, and process these using algorithms that suggest differential diagnoses. Prognostic measures include Health Risk Appraisal measures (which estimate the odds that a person with certain characteristics will die from specified causes within a given time frame), or methods such as the Functional Assessment Inventory, which estimate whether a patient will be able to live independently in the community following rehabilitation. Finally, evaluative indices measure change over time and are used to indicate the impact or outcomes of care. This category forms by far the largest group of instruments, and includes both generic and disease-specific outcome measures.

4. Measurement scales may be grouped into rating scales and questionnaires; there is also the distinction between health indexes and health profiles. Cutting across these categories, there is the distinction between subjective and objective measures. Rating scales refer to methods in which an expert, typically a clinician, assesses defined aspects of health; an example is the Hamilton Rating Scale for Depression. In self-assessed measurement scales, set questions are answered by the person being rated. Both are examples of subjective measures, in which human judgment (by clinician or patient) is involved in the assessment. Objective measures involve no judgment in the collection of information (although judgment may be required in its interpretation). Subjective health measurements hold several advantages. They extend the information obtainable from morbidity statistics or physical measures by describing the quality rather than merely the quantity of function. They give insights into matters of human concern such as pain, suffering, or depression that cannot be inferred solely from physical measurements or laboratory tests, and they do not require invasive procedures or expensive laboratory analyses. Measures of either type can be summarized as a single index score, or as a profile of scores. Supporters of the profile approach argue

that health or quality of life is inherently multidimensional and scores on different dimensions should be presented separately. Conversely, index scores allow ready comparisons of the impact of different medical conditions, useful, for example, in economic evaluations of health care.

Health measurement scales have become firmly established as a routine part of evaluating new therapies and in planning care. Newer and more sophisticated techniques for scale development are being applied to health measurement scales, and a discipline of health measurement equivalent to econometrics or psychometrics is beginning to appear. Future advances will include further consolidation of the repertoire of health measurement scales, including the replacement of some outdated methods with newer instruments. Population norms are gradually being developed that will permit fuller interpretation of scores against reference standards.

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(SEE ALSO: *Assessment of Health Status; Health Risk Appraisal; Life Expectancy and Life Tables*)

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HEALTH OUTCOMES

The term "health outcomes" describes the consequences of an encounter between a patient and the health care system, and is generally accepted to mean the end result of an episode of illness or injury that has been treated. The potential range of unsatisfactory outcomes have been alliteratively identified as "death, disease, disability, disruption,

discomfort, and dissatisfaction.” Of course, another possible outcome is complete and full recovery with joy and happiness all around. Both positive and negative outcomes can be identified (most of them easily and objectively), counted, and classified, thereby facilitating the evaluation of health care systems and services.

It is important for health care providers and facilities to take action to address unsatisfactory health outcomes. Death, when it is untimely or untoward, especially if it is attributable to a medical misadventure or mistake, is an unmistakable indicator of shortcomings in the health care system. Disease, in this context, signifies complications or adverse effects of diagnostic and therapeutic interventions, such as hospital-acquired infections, blood clots associated with immobilization in bed, and innumerable other mishaps great and small. Disability refers to permanent or long-term consequences of the encounter between a patient and the health care system, again a very diverse range of possibilities. Disruption means incapacity to resume previously customary activities at work or home. Discomfort can be assessed through patient reports of symptoms such as pain and sleeplessness, and it can be measured by the need for analgesics, sleeping pills, and other medications. Dissatisfaction is revealed by responses to direct questions, and can be unobtrusively assessed by such means as failure to return for scheduled appointments and aftercare. In a well-run health care system all these outcome indicators are assessed and recorded, and action is taken to remedy shortcomings as they are detected.

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(SEE ALSO: *Administration of Public Health Services; Hospital Administration*)

HEALTH PROMOTION AND EDUCATION

The scope of health promotion is determined as much by expected health outcomes as by methods and forms. From its purpose to enable people to gain greater control over the determinants of their health, “health promotion” can be defined as “any combination of educational and environmental

supports for actions and conditions of living conducive to health” (Green and Kreuter, 1999). The actions or behaviors in question may be those of individuals, groups, or communities; or of policymakers, employers, teachers, or others in organizations whose actions or practices control or influence the determinants of health. When the determinants are ones over which individuals can exert personal control, this control ideally resides with the individual. But with some aspects of complex lifestyle issues, especially those that affect the health of others (e.g., drunk driving, public smoking), the control that people exercise must be through collective decisions and actions. Such strategies are reflected in the social policy targets of health promotion, which may call for aggressive and even coercive measures to regulate the behavior of those individuals, corporations, and government officials whose actions influence the health of others.

Health education aims primarily at learning experiences and the voluntary actions people can take, individually or collectively, for their own health, the health of others, or the common good of the community. Defining health education as “any combination of learning experiences designed to facilitate voluntary actions conducive to health” (Green and Kreuter, 1999) emphasizes the importance of multiple determinants of behavior. It also suggests an appropriate matching of determinants with multiple learning experiences or educational interventions. Health education is a systematically planned activity, and can thus be distinguished from incidental learning experiences. Further, this construction of health education draws attention to voluntary behavioral actions taken by an individual, group, or community with the full understanding and acceptance of the purposes of the action—either to achieve an intended health effect or to build capacity for health.

Health education can be seen as enveloped by health promotion, with its aim of complementary social and political actions that can achieve the necessary organizational, economic, and other supports that enable the conversion of individual actions into health enhancements and quality-of-life gains. In essence, the task for health promotion, beyond health education, is how to make more healthful choices easier choices. The commitment to an educational approach to health

promotion is part practical necessity, part political expediency, and part philosophical commitment to provide for informed consent and voluntary change before attempting to change social structures and ecologies.

That policy, organizational, economic, regulatory, and environmental interventions are necessary to accomplish the original intent of health education is not to disaffirm health education as the primary means for democratic social and behavioral change. Health education provides the consciousness-raising, concern-arousing, and action-stimulating impetus for the public involvement and commitment to social reform essential to its success in a democracy. Without health education, health promotion would be a manipulative social-engineering enterprise. Health education of the public keeps the social change component of health promotion accountable to the public it serves. Without the policy supports for social change, on the other hand, health education is often powerless to help people reach their health goals, even with effective individual efforts.

The evolution of health policy and programs for health promotion and education has reflected a shared responsibility among institutions, groups, and individuals that have an influence on health. From era to era, the balance of responsibility has swung like a pendulum between a heavy reliance on government and its institutions for environmental and policy change and a heavy reliance on individuals and families to change behaviors. Ideological attempts to shift the responsibility more exclusively from one side to the other have met with a seemingly inexorable cycle of political swings. The reality of program planning and execution is that both sides must be engaged.

Health promotion, encompassing health education, has achieved a shift in the locus of initiatives for health (and control over its determinants) from medical institutions and health professionals to individuals, families, schools, and worksites. This has occurred in a context of growing community, social, and technological support for shared responsibility for health. Worksites health promotion has expanded rapidly, with notable provisions for institutional supports for employee participation. Schools increasingly emphasize organizational and social factors in programs for the modification or development of diet and the prevention of

substance abuse. In many communities, an emphasis is given to concerns about the environment and about housing and other conditions of living that shape lifestyles, health, and quality of life. All of this calls for greater collaboration among sectors, organizations, and individuals.

Achieving an optimum blend of responsibility appropriate to the local context and the health issue of concern requires more participatory and socially responsive strategies than have prevailed in past eras. Responsive strategies call for individuals, families, professionals, private organizations, governments, and local and national agencies to decide case by case how to divide and share responsibility for each health issue. Whatever the need or objective, participants must assess its urgency, causes, variability, distribution, and the extent to which people want and are able to influence its determinants. Those directly affected should have a voice in negotiating this division of responsibility. Providing opportunities for all voices to be heard derives from the principle of participation central to learning theory and effective community organization. It also affirms a linkage to the philosophical and ethical basis of the professional commitment to supporting voluntary rather than coercive change where possible.

THE COMMUNITY AND HEALTH PROMOTION

The most appropriate “center of gravity” for health promotion is the community. Community health promotion requires the participation of local leadership and social networks to facilitate the transmission and uptake of interventions for the overall population, as well as environmental changes (e.g., legislating or enforcing policies) to support individual and organizational interventions to achieve social change. State and national governments can formulate policies, provide guidance, allocate funding, and generate data for health promotion purposes; and individuals can govern their behavior and control the determinants of their own health—up to a point—and they should be allowed to do so. Decisions on priorities and strategies for social change affecting the more complicated lifestyle issues are best made collectively, however, close to the homes and workplaces of those affected. This principle assures the relevance and appropriateness of the programs to the people affected, and it

offers the best opportunity for people to be actively engaged in the planning process. It also reflects the evidence that has accumulated on the value of participation in learning and behavior—that people are more committed to initiating and upholding changes they helped to design or adapt to their own purposes and circumstances.

A “community” may be a town or county in sparsely populated areas; or it may be a neighborhood, worksite, or school in more populous metropolitan areas. It can also apply to groups of people not sharing a specific geographic association, but sharing social, cultural, political, or economic interests that link them together. Community represents, ideally, a level of collective decision making appropriate to the urgency and magnitude of a health-related issue, the cost and complexity of the solutions implied, the local culture and traditions of shared decision making, and the sensitivity and consequences of the actions required of people after the decision is made.

Ensuring the active participation of the people intended to benefit from a proposed program is an essential principle of health promotion. Community or citizen participation is a social process by which members of particular groups with shared needs in a community setting actively pursue identification of those needs and make decisions and establish mechanisms to meet the needs identified. Small group processes such as meetings, coalitions, and committee structures offer avenues for participation, set into motion by effective community organization or organizational development. An example is the Healthy Cities movement, where participation in small group processes was a powerful locus of change for individuals, organizations, and communities.

The principle of participation, critical at the local level, is of no less importance at the national and state levels. When policies and priorities set at one level depend on individuals or institutions at another, those responsible for planning health interventions need to make every effort to solicit active participation, input, and endorsement from that second level. Without such collaboration, the cooperation and support needed from the second level may not appear. Participation in this form requires acts of courtesy and respect, the time needed to foster dialogue, and, ultimately, trust.

Failure to engender cooperation is a major oversight, as it can yield a threat to any proposed program. In contrast, consulting and reconciling differences through consensus decision making fosters trust and enables collaboration.

THE ECOLOGICAL APPROACH

Ecological approaches in health promotion view health as a product of the interdependence between the individual and subsystems of the ecosystem (e.g., family, community, culture, and the physical and social environment). To promote health, an ecosystem must offer economic and social conditions conducive to health and healthful lifestyles. These environments must also provide information and life skills that enable individuals to engage in healthful behaviors. Finally, healthful options among goods and services must be available. In an ecological context, all such elements are viewed as determinants of health. They also provide support in helping individuals modify their behaviors and reduce their exposure to risk factors.

The ecological view of behavior holds that the functioning of an organism is mediated by behavior-environment interactions. This concept of reciprocal determinism suggests that the environment controls or sets limits on behaviors that occur in it, and that changing environmental variables result in the modification of behaviors. The inference is that health promotion can achieve its best results by way of individuals, groups, and organizations exercising control over their environment. The reciprocal side of this equation, however, holds that the behavior of individuals, groups, and organizations also influences their environments. This leads to the credo that health promotion seeks to enable the empowerment of people by allowing them greater control over the determinants of their health, whether these are behavioral or environmental. In taking greater control themselves, rather than depending on health professionals to exercise the control for them, people should be better able to adjust their behavior to changing environmental conditions, or to adjust their environments to changing behaviors.

Reflecting its accent on the multiple interdependencies of the elements making up a social

web, an ecological approach suggests the need for interventions directed at several levels within a community and at multiple sectors of a social system (e.g., health, education, welfare, commerce, and transportation). The specification and application of such a sweeping, holistic conceptual framework challenges the capabilities and time of practitioners. The specificity with which ecological guidelines can identify the particular levels and sectors in need of attention is inherently constrained by the infinite variety of interactions that can apply in each idiosyncratic organization, community, or other social system. As the effectiveness of any health promotion strategy depends on its appropriate fit with the people involved, the health issue of concern, and the environment in which it is to be applied, any practical application of the ecological approach must target specific levels and sectors of a complex system. A realistic strategy, therefore, is to intervene where one can, with reasonable certainty, match actions with needs and where one can be accountable for unexpected side effects. Careful, systematic planning and practice are essential.

EMPOWERMENT

Empowerment can exist at four levels: (1) the personal level, by gaining control and influence in daily life and in community participation; (2) the small-group level, through the shared experience, analysis, and influence of small groups on their own efforts; (3) the organizational level, through capacity building by influencing decision-making processes; and (4) the community level, by gaining and utilizing resources and strategies to enhance community control. Empowerment has been defined as "a process by which individuals gain mastery over their own lives and democratic participation in the life of their community" (Zimmerman and Rappaport, 1988). A more detailed definition highlights empowerment as "a social-action process that promotes participation of people, organizations, and communities towards the goals of increased individual and community control, political efficacy, improved quality of community life, and social justice" (Wallerstein, 1992). Participation is central to these definitions, not only as an outcome of empowerment but also as a means by which individuals can organize, assess resources, and plan strategies to achieve collective goals.

Empowerment is a multidimensional construct, implying individual change and change in the social setting itself. True environmental change is distinct from environmental support for behavioral interventions, with structural modification of the environment necessary to support empowerment as an outcome for community interventions. While some individually aimed actions may be sufficiently empowering for some individuals to engage in healthful behavior, others will enter or remain in the "at risk" population because collective action has not been achieved in addressing the broader, social forces that created the problem initially.

Understanding empowerment requires clarifying the counterpoint from which it evolves, widely conceived as a sense of powerlessness. For either individuals or groups, powerlessness accompanies marginalization. Central to powerlessness and marginalization are societal arrangements of power and property, related patterns of production and consumption, and the impact of social experiences as reflected by population patterns of health, disease, and well-being. Powerlessness concerns the expectancy that people, individually or collectively, cannot determine the outcomes that they seek. Health promotion aims to facilitate empowerment by enabling people to take greater control over the behavioral or environmental determinants of health.

It is sometimes helpful to distinguish individual empowerment from community empowerment, but movement away from a position of powerlessness nearly always occurs in the context of community. This interdependence is consistent with conceptions of individual and collective efficacy, whereby increases in self-belief and self-esteem enable people, individually and collectively, to take control of their environment. Low sociopolitical control, even among those who have high levels of control in other dimensions, may limit the effectiveness of health interventions. Individualistic approaches that do not provide meaningful opportunities to support new habits will yield few changes. The status quo of public policy often implies, however, that responsibility for health resides not with government or social structures, but with those individuals or groups suffering particular problems. Thus, health issues can be seen as problems of certain groups, rather than of

the systemic determinants of conditions of living. The reality is that both individual and environmental factors must be addressed jointly to facilitate individual and community empowerment together with health and quality-of-life gains.

PUBLIC HEALTH STRATEGIES FOR HEALTH PROMOTION AND EDUCATION

Programs for health promotion and education apply integrated strategies appropriate to the local context. Most community programs to change health-related behavior are to some degree ecological, that is, they seek to influence the social norms, cultural values, and economic and environmental conditions that affect health behavior at the community level. Such programs usually focus on any combination of the following actions: (1) interventions to promote health and prevent the development of disease (primary prevention); (2) screening for early detection and treatment of previously unrecognized cases of disease (secondary prevention); and (3) activities to help persons with known or established disease to more successfully manage their disorder (tertiary prevention).

There are two alternative, but complementary, strategies by which actions directed at the social and behavioral determinants of health are undertaken in the local context. The “community intervention” approach seeks to effect change in the social determinants of health and disease in order to reduce the prevalence of unhealthful behaviors or increase the prevalence of positive health outcomes. The “high-risk,” or “intervention-in-a-community,” approach aims to identify people at greatest risk for disease, often in a specific community site, and to intervene selectively.

These two approaches compete for policy and fiscal support. They are sometimes combined, however, with the high-risk approach invoked in the service of a community intervention approach. A combination strategy might use interventions such as self-help materials, health education, workplace policy change, and health legislation. Settings for implementation could be practitioner-based as well as community-wide, extending further into the arena of state and national determinants of community health. Methods of intervention delivery could range from health professionals

interacting with individuals and groups to centralized planning and the actions of community agencies, consultants, and legislators, as well as mass media initiatives. The scope of programs would vary with the time accorded to achieving change, and with the strength of institutional and political commitment.

Community programs ideally target health-related behaviors not simply as isolated acts under the conscious control of the individual, but as socially conditioned, culturally embedded, and economically impelled forms of living that reflect unconscious behaviors that often have health consequences or risks. Such a complex of related practices and behavioral patterns in a person or group, maintained with a consistency over time, constitutes a “lifestyle.” Lifestyle is a composite expression of the social and cultural circumstances that condition and constrain behavior, as well as the consciously chosen personal behavior of individuals.

PROS AND CONS OF COMMUNITY INTERVENTIONS

Compelling reasons exist for undertaking community interventions for primary prevention. Only by changing risk factor distributions in the middle of the curve for an entire population—not by focusing on the upper reaches of the risk distribution—can communities expect to see their overall morbidity and mortality reduced significantly. Ecological actions for lifestyle change require the cooperation of various community sectors and people with sway over social policy and norms. Given such cooperation, a community intervention has an advantage over a high-risk intervention as it links education with structural modification of the environment. This increases the likelihood of successful behavioral change and reaches more people with a wider range of risk levels or propensities. As norms change and as supply industries (e.g., food stores and restaurants) adapt to a new pattern, the maintenance of changes no longer requires a high level of individual effort. A high-risk approach does not offer the potential for normative change, because it targets only a small percentage of the population at risk, and the causes of presenting cases (e.g., behavior) are not necessarily the causes

of incidence in populations (e.g., social, political, and economic factors).

There is also an economic and political case for community interventions. This perspective maintains that mass prevention is an “investment” that produces a dividend of reduced morbidity and mortality; produces an informed electorate and a consumer demand through education; and that yields a broader spin-off of secondary benefits for community stakeholders in terms of costs averted, quality of life, and productivity. An informed electorate spurs political change, and consumer demand achieves commercial advantages. A reduced burden on medical care systems, and a reduction of costs associated with absenteeism and reduced productivity and achievement, benefits a wider range of stakeholders. Community interventions have greater potential than high-risk approaches to achieve these political and economic benefits. The mainstreaming, rather than marginalization, of health problems (e.g., substance abuse) gives them greater political support and the programs greater momentum.

The drawbacks of community interventions in primary prevention are the greater complexity and duration of programs and policies addressing lifestyle and health-related behaviors and conditions of living. It can be difficult to activate a community sufficiently to enable individual and collective change through the development and implementation of broad and meaningful intervention strategies. Inadequate implementation and low levels of penetration explain the limited success of many community interventions. Underlying these explanations are specific causes, including: (1) the appropriateness of the theoretical foundation on which a program is based; (2) the level to which theory is integrated with local logic and cultural concepts of health and disease; (3) the extent to which a community is truly active in planning and implementing interventions; and (4) whether interventions vary across several different levels of implementation (e.g., individual, small group, organizational, and community). Also important is the continuation of a program: Too few programs allow for a sufficient duration of exposure to achieve sustainable changes and outcomes.

Allowing for diffusion and utilization of interventions to shift risk factor distributions for entire

communities requires more time than for projects targeting change only in high-risk groups. On the other hand, high-risk groups often require greater levels of exposure than the community in general, as more intensive and sustained outreach strategies are required to reach the last cohorts in the diffusion of knowledge and risk-reduction practices. In either case, the potential for realizing benefits depends on time for interventions to become established and achieve momentum, and program implementation should continue over the duration of a social intervention. Time is required to integrate program components, to achieve synergy among components, and to increase the potential for diffusion throughout the community. Time is also needed for feedback on the comprehensiveness of information diffusion channels in order to ensure that a knowledge-behavior gap is not created or exacerbated among subgroups in a community. This requires intensity of effort combined with appropriate adaptation at all phases of the program process—which, in turn, requires iterative appraisal of the processes of intervention delivery.

Given the cost and effort involved, community interventions have been criticized on the basis of perceived inefficiency or lesser effectiveness, relative to the high-risk approach and its greater efficacy by selective high-risk screening and intervention. Fueling this criticism is the reality that most communitywide efforts have yielded only modest gains attributable to the program, while the high-risk approach achieves more palpable benefits of prevention at the level of the individual. Weak motivation based on health rewards, however, is often replaced in community interventions with stronger motivators for individuals of the social rewards of enhanced self-esteem and social approval. Furthermore, for diseases with multiple determinants, the community intervention approach could be highly robust. If communities can realize a normative effect in reducing disease risk factors, the cost-effectiveness and efficiency (greater reach) of community interventions could surpass the greater efficacy of the high-risk approach for prevention. For instance, interventions targeting healthful behaviors and the reduction of environmental risks for chronic disease are likely to reduce morbidity and mortality from other diseases also influenced by the same lifestyle and environmental conditions.

In their capacity to shift norms, the evidence thus far suggests that some community interventions have, in their application, compromised what programs need in order to work in specific communities. A main pitfall of appropriate adaptation stems from the insistence of various advocates of community-based models that practitioners must distance themselves from anything that is not communitywide. Some of the theoretical and definitional literature on community strategies has implied or insisted that "community-based" must be synonymous with "communitywide." This leads to shunning the inclusion of prevention activities based in organizations or institutions. While it is expressed sometimes as a mere preference for mass media and centralized planning approaches to community programs, in its extreme forms it takes on an avoidance, if not hostility, to programs or activities that serve people at the one-to-one level, those that deal with high risk groups, and those that treat disease rather than restricting their focus to people who are well and who seek primary prevention measures.

Life is not so dichotomous for individuals who must anticipate a life course of progression in risk factors, in presymptomatic disease, and in diagnosed chronic disease. Nor are the individuals living at these various stages of progression living in isolation from each other. The organizations and institutions in which people at various stages on the spectrum of health and disease are living, working, and playing share mutual dependencies on each other. These considerations make a more comprehensive, spectrum-inclusive approach to health promotion and disease prevention, detection, control, and management more sensible and efficient.

The expectation that social norms will respond over the short term to intensive media and policy initiatives at the community level is overly ambitious. Most social norms are institution-bound as much as they are the product of broader mass media messages and images. Without the inward involvement of institutions and organizations in changing their own norms (rather than just outwardly cooperating in community-wide efforts), the occupants (employees, students, residents, customers) of those institutions will continue to follow norms dictated by their organizational surrounding.

In conclusion, health promotion and health education are complementary approaches to enable people to gain greater control over the determinants of their health. Whereas health education is concerned primarily with learning experiences and the voluntary actions people can take on their own, health promotion targets the social and environmental supports that can enable health education to meet its objectives. To assert that community is the most suitable locus for health promotion is not to overlook individual and societal factors as determinants of health, but that these should be appraised and targeted for change in terms of their meaning and importance in the community context. This will ensure the relevance and appropriateness of change strategies to the people affected. Further, it enables people to be engaged in the planning process themselves. Providing for participation at local and higher levels facilitates social, economic, and political change in the determinants of conditions in which individual and community health are nested, thus enabling individuals to modify their behaviors and reduce their exposure to risk factors. Identifying and targeting, where feasible and appropriate, those modifiable interdependencies between the individual and subsystems of the ecosystem that affect health is the essence of an ecological approach that enables individual and collective empowerment through greater control over the determinants of health.

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(SEE ALSO: *Behavior, Health-Related; Communication for Health; Community Health; Community Organization; Cultural Appropriateness; Mass Media; Planning for Public Health; Social Assessment in Health Promotion Planning; Social Determinants; Social Health*)

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HEALTH RESOURCES AND SERVICES ADMINISTRATION

The Health Resources and Services Administration (HRSA), one of twelve agencies in the U.S. Department of Health and Human Services (HHS), was created in 1982 by combining programs of the former Health Resources Administration and the Health Services Administration. Since its creation, HRSA has administered programs that improve

and support community-based primary health care for low-income people, the training of health professionals, and maternal and child health. Over the years, HHS has assigned important new responsibilities to HRSA, including Ryan White CARE Act programs to fight AIDS; rural health policy; and organ donation initiatives. HRSA's 2001 budget was \$6.23 billion, the highest in its history. The 2001 budgets for the agency's four main administrative units are: HIV/AIDS Bureau, \$1.81 billion; Bureau of Primary Health Care, \$1.33 billion; Maternal and Child Health Bureau, \$964 million; and Bureau of Health Professions, \$353 million.

The Challenge of the Uninsured. HRSA's stated mission is to guarantee all Americans access to health care and to eliminate health disparities among U.S. populations. At the end of 2000, almost 43 million Americans had no insurance to pay for health care. Many local providers of health care services to the poor and uninsured rely on a patchwork of uncertain and insufficient subsidies to keep their doors open. HRSA helps these providers remain viable by furnishing financial support, technical expertise and information on "best practices" in providing care to the uninsured.

In 2000, HRSA invested more than \$1 billion in health centers and clinics in more than 3,000 U.S. communities—facilities that annually provide primary health care services to more than 9 million people. Services are free for those who cannot afford them, while others pay on a sliding scale. About two-thirds of people served by HRSA programs have incomes below 200 percent of the federal poverty level; an equally high percentage are people of color. HRSA's National Health Service Corps places more than 2,500 primary-care clinicians in areas across the nation where medical care is scarce.

HRSA has increased access to health insurance for young people by working to implement the 1997 State Children's Health Insurance Program (SCHIP). Through the end of fiscal year 2000, more than 3.3 million children had gained health insurance coverage under this program.

Critical to access is the need for qualified, culturally competent health care professionals. Several HRSA programs promote a technically skilled medical workforce, support greater cultural diversity in health professions to meet the needs of an increasingly diverse nation, encourage medical

professionals to serve vulnerable populations, and seek to ensure that medical education responds to changing demands in the health care marketplace.

HIV/AIDS. After Medicaid, HRSA is the largest single source of federal funding for HIV/AIDS (human immunodeficiency virus/acquired immunodeficiency syndrome) health care. Since 1990, when Congress passed the Ryan White CARE Act, the agency has invested more than \$8 billion in essential primary care and support services and life-saving medications for low-income, underinsured, and uninsured people living with HIV/AIDS. CARE Act programs annually reach some 500,000 people—more than half of the U.S. residents estimated to be living with HIV.

Better Health for Mothers and Children. HRSA carries primary federal responsibility for improving the health of the nation's mothers and children. The agency's annual Maternal and Child Health Services block grants to states support efforts to develop and maintain service systems that assure access to comprehensive health care for women before, during, and after pregnancy and childbirth; reduce infant mortality; immunize children; limit adolescent pregnancies; and make preventive and primary care services available to children and adolescents. Other HRSA grant programs reduce infant mortality in targeted high-risk communities and fund state efforts to develop or improve emergency medical services for children.

Other HRSA Priorities. In FY 2001, HRSA will invest \$97 million to improve health care services for the 61 million people who live in rural America. To bridge health care gaps in rural and urban areas, the agency promotes telehealth—the use of electronic information and telecommunications technologies—to diagnose and treat patients. HRSA funds information and support networks on organ donations and transplantations and oversees an initiative to increase donations. As of early 2001, 76,000 people were on waiting lists for organ donations; about 22,000 organ transplantations occur each year.

The agency administers the Ricky Ray Hemophilia Relief Fund Act, which provides payments to individuals with blood-clotting disorders who contracted HIV through treatment with contaminated blood products between 1982 and 1987. Since 1996, HRSA has allocated \$200 million to improve the health of residents in the United

States-Mexico border region, a program in which more than 500,000 residents annually receive bilingual, culturally competent health care services at fifty HRSA-funded border health clinics.

HRSA publications may be obtained from the HRSA Information Center on-line at <http://www.ask.hrsa.gov> or by calling 1-888-Ask HRSA.

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(SEE ALSO: *HIV/AIDS; Maternal and Child Health; Maternal and Child Health Block Grant; Primary Care; Uninsurance; United States Department of Health and Human Services [USDHHS]*)

HEALTH RISK APPRAISAL

A health risk appraisal (HRA) is a computer-based health-promotion tool, consisting of a questionnaire, a formula for estimating health risks (e.g., premature death), an advice database, and a means to generate reports. Its roots lie in efforts to guide physicians in promoting health as well as treating illness. HRAs are widely used in worksite wellness programs and community-based health programs as well as health care settings.

Typical aims are to assess health risks and lifestyle choices; to motivate individuals to adopt or maintain beneficial lifestyle practices; to guide health-promotion activities of health plans, employers, and health agencies; and to create a database profile of the population appraised. A key element of any HRA is personalized feedback to identify areas of excess health risk and recommend actions. More information is available from the Society of Prospective Medicine at <http://www.spm.org>.

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(SEE ALSO: *Assessment of Health Status; Behavior, Health-Related; Behavioral Risk Factor Surveillance System; Health Promotion and Education; Risk Assessment, Risk Management*)

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HEALTHY COMMUNITIES

Ever since humans first started to live in urban settlements, people have tried to build healthier communities. Hippocrates, the Greek “father” of medicine, wrote about the location and planning of human settlements around 500 B.C.E., while the Romans undertook massive engineering and public works programs to provide clean water and sanitation. In Renaissance Italy in the fourteenth and fifteenth centuries, the Boards of Health established codes to regulate all manner of practices and behaviors in the interest of public health.

The roots of modern urban public health can be found in the Health in Towns Association established in Britain in the 1840s. Victorian pioneers, such as Sir Benjamin Ward Richardson, who wrote about “Hygeia, a City of Health” in 1875, and Ebenezer Howard, who pioneered “garden cities” in the 1890s, led the way in planning communities that were more environmentally and socially healthy. In North America, cities such as New York, Toronto, and Milwaukee were leading lights in the development of public health in the early twentieth century.

With the advent of modern medicine in the 1930s, however, this public health approach to creating healthier cities and communities became overshadowed by medical interventions focused on the individual. It was not until the mid-1980s that a new healthy cities and communities movement was brought into being by the European Region of the World Health Organization (WHO) and a wide variety of national and local organizations. The movement has grown since then to involve thousands of cities, towns, and villages around the world.

The concept of a healthy community is a simple one, rooted in the recognition that the major determinants of health have little to do with what is known as the health care system. Rather, health is determined by equitable access to such basic prerequisites for health as peace, food, shelter, clean air and water, adequate resources, education, income, a safe physical environment, social supports, and so on. While these assumptions form the basis for the approach, every community understands and applies the concept somewhat differently, asking itself two simple questions: What is a healthy community, and how do we get one?

WHAT IS A HEALTHY COMMUNITY?

WHO defines a healthy city as “. . . one that is continually creating and improving those physical and social environments and expanding those community resources that enable people to mutually support each other in performing all the functions of life and in developing to their maximum potential.”

Two key points in this definition are worthy of comment. The first is that it is a definition of a process, not of a status. A healthy city or community is not necessarily one that has a high health status but one that consciously seeks to improve the health of its citizens by putting health high on the social and political agenda. Second, the process is to enable people to increase control over and improve their health through applying the concepts and principles of health promotion at the local level.

WHO (Europe, 1986) also suggested a set of eleven key components that together make up a healthy city:

1. A clean, safe, high-quality physical environment (including housing quality)
2. An ecosystem that is currently stable and is sustainable in the long term
3. A strong, mutually supportive and nonexploitative community
4. A high degree of public participation in and control over the decisions affecting one's life, health, and well-being
5. The meeting of basic needs (food, water, shelter, income, safety, work) for all the city's people
6. Access to a wide variety of experiences and resources with the possibility of multiple contacts, interaction, and communication
7. A diverse, vital, and innovative city economy
8. Encouragement of connectedness with the past, with the cultural and biological heritage, and with other groups and individuals
9. A city form that is compatible with and enhances the above parameters and behaviors
10. An optimum level of appropriate public health and sick care services accessible to all
11. High health status (both high positive health status and low disease status)

HOW DO WE GET ONE?

What makes the healthy community approach unique when compared with other community-based health promotion programs is its focus upon the role of local government, for whom the health and well-being—the quality of life—of their citizens should be a key objective. Historically, local governments have played a significant role in creating physical and social environments supportive of health, and many of the policy decisions that shape our health are made by local governments.

Policies relating to urban planning, transportation, housing, community and social services, parks and recreation, education, policing, and public works, among others, can play a significant role in shaping the health and well-being of the residents of the community. Failure to engage local government in the process of creating a healthier community is thus to miss an important and powerful partner.

But local government alone cannot create healthier communities. What the healthy city process tries to do is to put health on the social and political agenda of a community, ensuring that the sectors whose actions affect the population's health and well-being accept their health role, adopt policies and develop programs that consciously seek to promote health while achieving their own objectives. It takes the combined effort of all sectors of the community, including local businesses, the voluntary sector, community organizations, schools, and health services. The creation of healthy community coalitions that bring together partners from many different sectors is thus a fundamental objective of the healthy city and community approach.

Health promotion requires the empowerment of individuals and communities, enabling them to exert more control over all of the factors that contribute to their health and well-being. This means that the community—both as individuals and as members of community and neighborhood organizations—has to be centrally involved in the process of creating a healthier environment. They

or their representatives need to be at the table as active participants in the citywide coalition as well as in neighborhood coalitions. Identifying and mobilizing the community's capacity and ability to take action in the interests of its health is another key aspect of a healthy city and community project.

The modern healthy cities and communities movement, because it is locally relevant and community-based, provides a powerful means of achieving better health for all.

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(SEE ALSO: *Built Environment; Ecological Footprint; Health Promotion and Education; Homelessness; Urban Transport*)

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HEALTHY PEOPLE 2010

The Healthy People initiative was started in 1979 in the United States Department of Health and Human Services (HHS) by Dr. Julius Richmond, who was the Surgeon General and Assistant Secretary for Health. He released a Surgeon General's Report called *Healthy People*, which laid the groundwork for *Healthy People 1990*. It was followed by the second decade-long Healthy People plan, *Healthy People 2000: National Health Promotion and Disease Prevention Objectives*. *Healthy People 2010* is the third set of national health objectives. It was released on January 25, 2000, under the leadership of HHS Secretary Donna Shalala and the Assistant Secretary for Health and Surgeon General, David Satcher.

Building on initiatives pursued over the past two decades, *Healthy People 2010* contains two major goals: 28 focus areas, or chapters; and 467 broad-reaching national health objectives for the first decade of the millennium. These objectives and goals will serve as the basis for the development of state and community plans.

The first major goal is to increase the years and quality of healthy life. This goal was developed in response to America's rapidly aging population—during the twentieth century, Americans gained thirty years of life expectancy. In 1900, life expectancy in the United States was about 47 years of age; in 2000, it was 77, and rising. As of 2000, there were 35 million Americans over 65 years of age; and those over 85 constituted the fastest growing age group in the nation. That's why this first goal focuses on increasing quality as well as years of life, paying careful attention to such areas as Alzheimer's disease, arthritis, osteoporosis, the management of chronic pain, and the aggressive diagnosis and treatment of depression of the elderly.

The second major goal is to eliminate disparities in health among different racial and ethnic groups. This goal was issued in response to the nation's rapidly increasing population diversity, with an eye toward imminent increasing demands on the health care system if the current disparities are not addressed. Eliminating disparities is not a zero-sum game; all groups benefit when the needs of the most vulnerable are met.

President Bill Clinton's Race Initiative, which he announced in June 1997, set the stage for this goal. Responding to the president's call that each Cabinet head support the Race Initiative, the Department of Health and Human Services developed the Race and Health Initiative, which was later incorporated into *Healthy People 2010*, becoming one of its two major goals.

In many ways, Americans of all ages and in every race and ethnic group have better health today than ever before—due to tremendous advances in medical research and technology, and in health care. But not all groups share these benefits equally, and considerable disparities remain. In many areas, minorities are lagging behind their white counterparts. For example, in the area of infant mortality, a baby born to an African-American mother has more than twice the risk of

dying during the first year of life than a white American baby. Vietnamese women living in this country experience cervical cancer at five times the rate of white women; Hispanic women over age sixty-five have twice the risk. Asian Americans are three to five times more likely to die from liver cancer. Heart disease strikes African-American men at a rate 25 percent higher than whites; and African-American women are 40 percent more likely to die from heart disease than white women. American Indians suffer from diabetes at nearly three times the average rate; for Hispanics, the rate is nearly double that of whites. African Americans have a rate of diabetes that is 70 percent higher than whites and the highest death rate of any group. When it was first identified in this country in 1981, HIV/AIDS (human immunodeficiency virus/acquired immunodeficiency syndrome) was predominantly a disease among white gay men. However, it has become increasingly a disease of people of color, of women, and of the young. No racial or ethnic group is doing well when it comes to immunizations for older people. Only 67 percent of older white persons, 58 percent of elderly Hispanics, and 50 percent of African-American senior citizens reported getting a vaccination against influenza, and the numbers are even more grim for the pneumococcal vaccine.

LEADING HEALTH INDICATORS

Healthy People 2010 is the first Healthy People plan to include ten Leading Health Indicators, which will be used in a manner similar to that of the leading economic indicators—they will serve as the mechanism for monitoring national progress to see how well the country is doing in meeting its goals and objectives.

Five of the ten indicators focus on lifestyle: tobacco use, overweight and obesity, physical activity, substance abuse (especially alcohol), and responsible sexual behavior. These are included in a specially developed *Surgeon General's Prescription for Healthy Living*, which was designed to help communicate important health messages.

Physical Activity. When coupled with dietary factors, physical inactivity is the second leading cause of preventable deaths in the United States, resulting in over 300,000 deaths each year. The

Surgeon General's Prescription recommends “moderate physical activity at least 5 days a week/30 minutes a day.”

Overweight and Obesity. This problem, which results mainly from physical inactivity and poor nutrition, has reached epidemic proportions in both children and adults, especially among African-American and Hispanic women. Even Type 2 diabetes (also called adult-onset diabetes) is showing up in children. The American diet is loaded with fats and sugars, and is deficient in fruit, vegetables, and grains. The *Surgeon General's Prescription* recommends “eating at least five servings of fruits and vegetables a day.”

Tobacco Use and Substance Abuse. Tobacco is the leading cause of preventable death in the United States. Three thousand young people become new smokers every day, and half of them will die prematurely from some tobacco-related illness. Substance abuse—involving illicit drugs and alcohol—is a major public health problem. The leading drug of choice among young people is alcohol. The *Surgeon General's Prescription* recommends “avoiding toxins—including tobacco, illicit drugs, and abuse of alcohol.”

Responsible Sexual Behavior. This means protecting oneself and others against sexually transmitted diseases (including HIV) and unwanted pregnancy when sexually active, and promoting abstinence, where appropriate. It also means understanding that relationships should not begin with sex, but with mutual respect, commitment, communication, and understanding.

The other five Leading Health Indicators are: mental health, injury and violence, environmental quality, immunization, and access to health care.

Mental Health. America's understanding of mental health has evolved significantly over the last twenty-five years, as reported in the landmark *Surgeon General's Report on Mental Health* (1999). One in five Americans suffers from some sort of mental disorder each year, but because of the stigma and shame, fewer than half seek care. Increased efforts are underway to gain parity of access to mental health services, to erase the stigma associated with mental illness, and to broaden awareness that many mental illnesses come from physical causes in that they result from changes in

chemical secretions in the brain, making them treatable by medication.

Immunizations. Children's immunizations have expanded markedly in recent years, but there is still work to be done. The nation has yet to achieve rates that are acceptable in adult immunizations, even among the majority population. For African Americans and Hispanics, the need is even greater.

Violence and Injury Prevention. Homicides, suicides, and vehicle crashes are serious public health challenges, and they are often associated with substance abuse. A *Surgeon General's Report on Youth Violence Prevention*, presented at the twenty-first annual Health Reporting Conference in San Diego, California, in April 2001, addressed the violence issue in this country.

Environmental Quality. An estimated 25 percent of preventable illnesses worldwide can be attributed to environmental factors, including air, water, soil, and exposure to toxins. While African Americans and Hispanics make up only 25 percent of the U.S. population, they comprise 40 percent of the people who live near hazardous waste sites. That puts children of color at an increased risk for asthma, lead poisoning, and other illnesses.

Access to Health Care. Almost 43 million Americans were uninsured in 2000. Minorities are more likely to be uninsured and underinsured, and therefore less likely to receive regular or quality health care (including oral health care) and less likely to receive screenings for early detection of disease. They are also less likely to receive quality care management. Health care services must ensure that cost, quality, and accessibility do not serve as barriers to care. Also critical are surrounding issues such as socioeconomic status, education, income, and housing. Since minorities are also more likely to be underrepresented in the health professions, the nation must ensure that a diverse pool of culturally competent physicians is available.

The answer to America's health problems lies in a balanced health system—a system that balances health promotion, disease prevention, early detection, and universal access to care. Well over 90 percent of America's health care budget is spent on treating diseases, many of them in their

late stages, because of the very small investment in primary prevention—less than 2 percent of America's \$1.3 trillion health budget is spent on population-based prevention.

The health of the nation has improved considerably since the first Healthy People initiative was launched in 1980. But many challenges remain, forming the foundation of *Healthy People 2010*. Improving the health of the nation is a long-term investment requiring participation from all sectors, including citizens, states and communities, leaders, professional organizations, and nonprofit, voluntary groups. Through partnerships, the first ten years of the new millennium can go down in history as the time when health disparities became a public health issue of the past and the quality of life for all Americans was significantly enhanced.

DAVID SATCHER

(SEE ALSO: *Ethnicity and Health; Health Goals; Healthy Communities; Inequalities in Health; Surgeon General; United States Department of Health and Human Services [USDHHS]*)

HEALTHY START

Healthy Start is a federally funded program designed to provide access to health services for the medically indigent; and to promote good health practices, health behaviors, and health attitudes among mothers and children. Healthy Start is part of Medicaid's Medical Assistance Program, and provides free or low-cost comprehensive medical coverage for children up to the age of nineteen, adults with minor children living in the home, and pregnant women. Coverage includes office visits, prescriptions, vision care, mental health care, alcohol and drug treatment, hospital care, and prenatal care.

DAISY L. ALFORD-SMITH

(SEE ALSO: *Child Health Services; Maternal and Child Health; Medicaid*)

HEARING DISORDERS

Hearing impairment occurs in all age groups. In children hearing loss can be genetic or acquired as

a result of infection either during fetal development or during childhood. It is estimated that up to 1 child in every 1,000 live births suffers from hearing loss. The prevalence of hearing loss in children grows to 1.5 to 2 cases per 1,000 children by the age of six. Overall, 50 percent of childhood hearing loss can be traced to genetic factors. This includes congenital conditions such as Down syndrome. Parents with familial deafness pass an increased risk of deafness to their children. Infections during pregnancy (e.g., German measles or cytomegalovirus) can cause congenital deafness. Only 6 percent of children with hearing impairment are profoundly impaired, while the majority retain some hearing ability. Children without a profound hearing loss still have difficulty with speech development and later learning.

In adults, the greatest hearing losses are due to presbycusis and noise-induced hearing loss. Presbycusis of “old hearing” affects men more than women and is estimated to affect up to 80 percent of persons over 65 years of age. Presbycusis may also be linked to noise exposure. Noise exposure is a preventable cause of hearing loss. It is also among the most commonly identified disabilities in industrialized nations. In 1996 the National Institute for Occupational Safety and Health estimated that 30 million people work with noise levels above the level of 85 decibels and 17 percent of production workers suffer some hearing loss. Hearing loss is also associated with a family history of hearing loss, a history of smoking, and presence of hypertension, diabetes, and elevated cholesterol.

The human hearing mechanism is complex. Sound waves enter the ear canal and set up movement of the eardrum, also called the tympanic membrane. The eardrum is connected to the hearing organ, or cochlea, by small bones called ossicles. The cochlea is filled with fluid and it rests in the fluid-filled inner ear. One of the ossicles is anchored to the eardrum; another to an opening in the cochlea called the oval window. The movement of the eardrum sets up movement in the bones, which in turn moves the oval window. This sets up waves in the fluid of the cochlea. Thousands of tiny hair cells that line part of the cochlea are stimulated by these waves, which are then translated to nerve impulses that travel to the brain where they are deciphered by the hearing center of the brain and perceived as sound.

Problems with hearing can be caused from problems all along the hearing pathway. Physicians generally divide hearing loss into two major types: “conductive” and “sensorineural” (sensory). Conductive losses are those involving the transmission of sound waves from the environment to the cochlea. Sensory losses involve the cochlea and its nerve cells, as well as the eighth cranial nerve, called the auditory nerve, which carries nerve impulses to the brain. Some physicians also include a third type of hearing impairment, called *central*, in which the brain is unable to decipher the information from the hearing complex because of stroke or brain damage.

CONDUCTIVE HEARING LOSS

The most common cause of conductive hearing loss is cerumen, or earwax, impaction. It is often caused by attempts at cleaning the ears with cotton swabs. Putting a swab in the ear usually pushes wax further back in the canal causing buildup over time and leading to impaction. Some patients genetically make more or harder earwax that predisposes them to impactions. Children are notorious for introducing foreign objects into their ears. These objects most often must be removed under controlled circumstances to avoid damage to the inner ear. Water can lodge behind wax buildups causing irritating noises and a sense of fullness in the ears. People who use hearing aids may also experience wax buildup, possibly because the introduction of the hearing aid affects the natural mechanism by which earwax flows from the inner ear. Irrigation and solutions are used to soften the wax so that it can be rinsed out. A physician may also use a removal scoop. Prevention includes avoidance of cotton tipped swabs and maintenance use of solutions to soften earwax.

Another cause of hearing loss is disruption or dislocation of the bones of the inner ear. This occurs when a foreign object, such as a cotton swab or pencil, is put in the ear. This can cause perforation of the eardrum and dislocation of the bones, requiring surgery. Conductive hearing loss is also caused by common cold and other upper respiratory infections, including infections of the fluid of the inner ear.

The eustachian tube drains the inner ear into the back of the throat, but when swollen because

of infection of the upper respiratory tract, the fluid builds up in the inner ear. This decreases the ability of the eardrum to move and decreases hearing. The effect is usually transient and hearing is restored when the infection resolves. In young children, however, repetitive ear infections can cause speech delay because children depend on acute hearing in order to mimic language sounds.

Cholesteatoma is a buildup of skin cells around the bones of the ear preventing their movement. It usually occurs as a complication of chronic middle-ear infections and is corrected by surgery, but it must be caught early in order to avoid destruction of the ossicles by the built up material. *Otosclerosis* is a slowly progressive hearing loss that is more common in women than in men. It is caused by a change in the bones of the ear and is treatable with surgery if recognized early. Other causes of conductive hearing loss are rigidity of the eardrum from scarring caused by old ear infections, eardrum perforations, and barotrauma (pressure trauma) in divers and air travelers.

SENSORY HEARING LOSS

Generally, sensory hearing loss is less amenable to surgery and treatment, and is better dealt with through prevention. The most common cause of sensory loss is presbycusis—hearing loss associated with aging. Treatment consists of hearing aids, or “amplification.”

Noise-associated hearing loss is usually preventable. Noise damage may be part of the hearing loss associated with aging. Earplugs and hearing protection in the workplace helps to prevent some hearing loss, but loud music, concerts, sporting events, and power tools and machinery used in the home also adds to the damage. Hearing protection should be used in all of these cases.

Other causes of sensory hearing loss include multiple sclerosis, tumors of the nerves, congenital deafness associated with infection, or genetic abnormalities and toxins. A tumor on the auditory nerve, known as acoustic neuroma, may be surgically removed, but depending on the position and size of the tumor, hearing may not improve. Toxic effects of drugs such as aspirin, certain antibiotics, and some cancer treatments can lead to hearing loss, and can be avoided by careful monitoring

of the dosage. Sudden sensory hearing loss has many causes including viral illness, diabetes, and Meniere’s syndrome.

KAREN L. HALL

(SEE ALSO: *Hearing Protection; Occupational Safety and Health*)

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HEARING PROTECTION

Life is made immeasurably richer by the sounds of the world around us, whether it be music, friendly conversation, or waves at the beach. These pleasures, however, may be denied to someone suffering from noise-induced hearing loss (NIHL). Thirty million U.S. workers are exposed to hazardous noise levels, and another 9 million are exposed to chemicals that may damage hearing. The most common occupational disease in the United States, NIHL is almost entirely preventable.

In 1969 the U.S. Department of Labor promulgated noise exposure regulations for companies with federal contracts. The maximum permissible exposure level allowed is an eight-hour time-weighted average (TWA) of 90 decibels, as measured on the A-scale (dBA), which approximates human hearing sensitivity. In 1970 the U.S. Congress created the Occupational Safety and Health Administration (OSHA) and the National Institute for Occupational Safety and Health (NIOSH). NIOSH conducts health-hazard research as a basis for advising OSHA in the drafting of regulatory standards. In 1971, OSHA expanded the applicability of the 90-dBA noise standard to the majority of the U.S. workforce, and it is currently enforced as amended in 1983.

Since 1972, NIOSH has recommended lowering the permissible exposure level (PEL), as research has determined that a TWA at or above 85 dBA poses excess risk of developing noise-induced hearing loss. OSHA has, to date, not lowered the PEL, due in part to economic considerations. OSHA also allows a 5-decibel increase in the TWA before reducing the permissible duration of exposure by half (the exchange rate). NIOSH recommends a 3-decibel exchange rate, which is more protective, supported by scientific evidence, and is already used by the U.S. Environmental Protection Agency, the Department of Defense, and many nations worldwide. Thus, simply meeting OSHA requirements may not preserve hearing.

Under current OSHA regulations, employees with a TWA of 85 dBA or above must be enrolled in a hearing conservation program (HCP), which includes a baseline hearing threshold exam (an audiogram) followed by annual reexaminations. In addition, employees with a TWA of 90 dBA or above are required to wear effective hearing protection to reduce their in-ear exposure to below the permissible level. If an annual audiogram reveals that the hearing threshold of an employee has worsened by an average of 10 decibels at 2,000, 3,000, and 4,000 Hz, then OSHA notification and specific corrective measures to prevent further deterioration are required. In most jurisdictions, workers suffering a permanent threshold shift to 25 decibels or worse may seek monetary compensation.

In order to prevent excessive in-ear noise exposures, it is best to reduce noise at the source through engineered solutions. A less preferred alternative is the use of personal hearing-protection devices (HPDs), such as ear plugs and muffs. Effective HPD use requires that employees are motivated, well trained, and issued the appropriate HPD. When choosing an HPD, comfort and convenience should be a concern, as an unworn HPD is obviously ineffective. Workplaces with effective hearing conservation programs enjoy less absenteeism and higher worker productivity than those without such programs. In addition, workplaces without hearing conservation programs risk significant potential liability.

Not all noise-induced hearing loss is occupational. Random audiometric screening of the population is showing worsening thresholds, which may

be the result of the use of power tools and personal and vehicular sound systems.

ERIC ZWERLING

(SEE ALSO: *Environmental Determinants of Health; Hearing Disorders; National Institute of Occupational Safety and Health; Occupational Disease; Occupational Safety and Health; Occupational Safety and Health Administration*)

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HEART DISEASE

See *Cardiovascular Diseases and Coronary Artery Disease*

HEAVY METALS

“Heavy metals” is an inexact term used to describe more than a dozen elements that are metals or metalloids (elements that have both metal and nonmetal characteristics). Examples of heavy metals include chromium, arsenic, cadmium, lead, mercury, and manganese. Generally, heavy metals have densities above 5 g/cm³. Because they cannot be degraded or destroyed, heavy metals are persistent in all parts of the environment. Human activity affects the natural geological and biological redistribution of heavy metals through pollution of the air, water, and soil. The primary

HEAVY METALS

Main-Group Elements		Transition Metals										Main-Group Elements								
		Atomic number Symbol Name Rn																		
		86 (222) Atomic weight radon																		
		Transition Metals																		
		Inner-Transition Metals																		
Period	1	1 1.00794 H hydrogen	2 9.012182 He helium											3 10.811 B boron	4 12.011 C carbon	5 14.00674 N nitrogen	6 15.9994 O oxygen	7 18.9984032 F fluorine	8 4.002602 Ne neon	
	2	3 6.941 Li lithium	4 9.012182 Be beryllium											13 26.981539 Al aluminum	14 28.0855 Si silicon	15 30.973762 P phosphorus	16 32.066 S sulfur	17 35.4527 Cl chlorine	18 39.948 Ar argon	
	3	11 22.989768 Na sodium	12 24.3050 Mg magnesium	21 44.955910 Sc scandium	22 47.88 Ti titanium	23 50.9415 V vanadium	24 51.9961 Cr chromium	25 54.9305 Mn manganese	26 55.847 Fe iron	27 58.93320 Co cobalt	28 58.69 Ni nickel	29 63.546 Cu copper	30 65.39 Zn zinc	31 69.723 Ga gallium	32 72.61 Ge germanium	33 74.92159 As arsenic	34 78.96 Se selenium	35 79.904 Br bromine	36 83.80 Kr krypton	
	4	19 39.0983 K potassium	20 40.078 Ca calcium	39 88.90585 Y yttrium	40 91.224 Zr zirconium	41 92.90638 Nb niobium	42 95.94 Mo molybdenum	43 98 Tc technetium	44 101.07 Ru ruthenium	45 102.90550 Rh rhodium	46 106.42 Pd palladium	47 107.8682 Ag silver	48 112.411 Cd cadmium	49 114.82 In indium	50 118.710 Sn tin	51 121.75 Sb antimony	52 127.60 Te tellurium	53 126.90447 I iodine	54 131.29 Xe xenon	
	5	37 85.4678 Rb rubidium	38 87.62 Sr strontium	*Lanthanides										81 204.3833 Tl thallium	82 207.2 Pb lead	83 208.98037 Bi bismuth	84 209 Po polonium	85 210 At astatine	86 222 Rn radon	
	6	55 132.90543 Cs cesium	56 137.327 Ba barium	71 174.967 Lu lutetium	72 178.49 Hf hafnium	73 180.9479 Ta tantalum	74 183.85 W tungsten	75 186.207 Re rhenium	76 190.2 Os osmium	77 192.22 Ir iridium	78 195.08 Pt platinum	79 196.96654 Au gold	80 200.59 Hg mercury	81 204.3833 Tl thallium	82 207.2 Pb lead	83 208.98037 Bi bismuth	84 209 Po polonium	85 210 At astatine	86 222 Rn radon	
	7	87 223 Fr francium	88 226 Ra radium	103 262 Lr lawrencium	104 261 Rf rutherfordium	105 262 Db dubnium	106 263 Sg seaborgium	107 264 Bh bohrium	108 265 Hs hassium	109 268 Mt meitnerium	110 269 Uun ununium	111 272 Uuu ununium	112 277 Uub ununbium	114 289 Uuq ununquadium	116 289 Uuh ununhexium	118 293 Uuo ununoctium				
		*Lanthanides																		
		† Actinides																		
		57 138.9055 La lanthanum	58 140.115 Ce cerium	59 140.90765 Pr praseodymium	60 144.24 Nd neodymium	61 (145) Pm promethium	62 150.36 Sm samarium	63 151.965 Eu europium	64 157.25 Gd gadolinium	65 158.92534 Tb terbium	66 162.50 Dy dysprosium	67 164.93032 Ho holmium	68 167.26 Er erbium	69 168.93421 Tm thulium	70 173.04 Yb ytterbium					
		89 (227) Ac actinium	90 232.0381 Th thorium	91 (231) Pa protactinium	92 238.02891 U uranium	93 (237) Np neptunium	94 (244) Pu plutonium	95 (243) Am americium	96 (247) Cm curium	97 (247) Bk berkelium	98 (251) Cf californium	99 (252) Es einsteinium	100 (257) Fm fermium	101 (258) Md mendelevium	102 (259) No nobelium					

The heavy metals cadmium (atomic number 48), mercury (80), and lead (82) pose the biggest threats to public health.

anthropogenic sources of heavy metals are point sources such as mines, foundries, smelters, and coal-burning power plants, as well as diffuse sources such as combustion by-products and vehicle emissions. Humans also affect the natural geological and biological redistribution of heavy metals by altering the chemical form of heavy metals released to the environment. Such alterations often affect a heavy metal's toxicity by allowing it to bioaccumulate in plants and animals, bioconcentrate in the food chain, or attack specific organs of the body.

Heavy metals are associated with myriad adverse health effects, including allergic reactions (e.g., beryllium, chromium), neurotoxicity (e.g., lead), nephrotoxicity (e.g., mercuric chloride, cadmium chloride), and cancer (e.g., arsenic, hexavalent chromium). Humans are often exposed to heavy metals in various ways—mainly through the inhalation of metals in the workplace or polluted neighborhoods, or through the ingestion of food (particularly seafood) that contains high levels of heavy metals or paint chips that contain lead.

The three heavy metals commonly cited as being of the greatest public health concern are cadmium, lead, and mercury. There is no biological need for any of these three heavy metals. Cadmium has many commercial applications, including electroplating and the manufacture of batteries. Exposure to cadmium can occur in the workplace or from contaminated foodstuffs and can result in emphysema, renal failure, cardiovascular disease, and perhaps cancer.

Humans discovered lead more than 8,500 years ago, and over time have used lead in artwork, plumbing, gasoline, batteries, and paint. Modern-day exposure to lead occurs in the workplace or through the ingestion of lead-contaminated items such as paint chips. The primary adverse health effect from exposure to lead is permanent neurological impairment (particularly in children). Other adverse health effects associated with lead include sterility in males and nephrotoxicity.

Mercury is equally toxic. Depending on its chemical form (elemental, inorganic, or organic) mercury is able to cause a myriad of adverse health

effects including neurotoxicity (elemental mercury, methylmercury), nephrotoxicity (elemental mercury, mercuric salts such as mercuric chloride), teratogenicity (methylmercury), and death (elemental mercury, methylmercury). The major source of human exposure to mercury compounds is through the consumption of seafood that contains high levels of organic mercury compounds.

The international community is beginning to recognize the adverse health effects of heavy metals. In 1998, the United Nations proposed the Protocol to the Convention on Long-range Transboundary Air Pollution on Heavy Metals. This protocol is designed to reduce worldwide air emissions of cadmium, lead, and mercury, but has yet to be officially adopted.

MARGARET H. WHITAKER
BRUCE A. FOWLER

(SEE ALSO: *Arsenic; Lead; Mercury*)

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HEMATOCRIT

Blood has a liquid component (plasma) and a particulate component (blood cells). The denser blood cells (most of which are red blood cells) will settle in a tube, particularly if the blood is spun in a device called a centrifuge. The fraction of the resultant column composed of red blood cells relative to the entire column is the hematocrit, which normally is in the range of 40 percent. The upper portion of the separated blood is yellowish plasma. Red blood cells carry oxygen, and blood with a low hematocrit (e.g., 20%) leaves the tissues relatively oxygen-starved and weak. A high

hematocrit (e.g., 70%) produces problems as well, but is uncommon.

KENNETH R. BRIDGES

(SEE ALSO: *Hemoglobin*)

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HEMOGLOBIN

Hemoglobin is contained within the red blood cells (erythrocytes), giving blood its characteristic color. It serves to transport oxygen from the lungs to the tissues. The concentration of hemoglobin is easily measured by diluting blood in an appropriate solution and measuring in an electronic instrument how much light is absorbed when it is passed through this solution. In the condition called anemia, the amount of hemoglobin in the blood is diminished; in polycythemia, it is increased.

ERNEST BEUTLER

(SEE ALSO: *Hemoglobinopathies; Iron*)

HEMOGLOBINOPATHIES

The term "hemoglobinopathy" has been used to describe abnormalities of hemoglobin, such as sickle-cell disease. Most common are those of hereditary origin in which there is a substitution of one or more of the amino acids in the amino acid chains that form either the α - or the β -globin (alpha- and beta-globin) chains. Some of these genetic changes, such as the substitution of valine for glutamic acid that causes sickle-cell hemoglobin, are common in certain ethnic groups. Others are quite rare. Some hemoglobinopathies, such as those that produce sickle-cell disease and those that produce unstable hemoglobin, cause anemia. Other hemoglobinopathies result in a hemoglobin that does not carry oxygen efficiently, giving a

brownish cast to the blood. Thalassemias such as “Mediterranean anemia” are sometimes classified as hemoglobinopathies, but differ in that they are characterized by quantitative deficiencies in hemoglobin chains, not abnormal chains.

ERNEST BEUTLER

(SEE ALSO: *Hemoglobin*)

HENLE, JACOB

A pioneer in the field of microscopic anatomy and pathology, Friedrich Gustav Jacob Henle (1809–1885) made signal contributions to elucidating the structure of both healthy and diseased tissues. His discovery of the ascending and descending loops of the uriniferous tubule is central to understanding renal function, but the “loop of Henle” is just one of many anatomical structures carrying his name. Henle’s recognition that all inner and outer surfaces of the body are lined with epithelial tissue has been called “one of the most momentous generalizations of the century” (Robinson, 1921), while his three-volume *Handbook of Human Anatomy* (1855–1871) is “considered by many authorities to be the greatest of the modern systems of anatomy” (Morton, 1965).

Epidemiologists celebrate Henle for his publication, in 1840, of *Von den Miasmen und Contagien* (On miasmata and contagia), which set out, more convincingly than previously, the concept that microscopic living organisms (Henle called them *contagia animata*) were the causative agents of many diseases, especially those that occurred in epidemic form. Henle argued that in communicable diseases morbid matter apparently increases in amount in the host, but only after a period of incubation, which must correspond to the period of reproduction of the agent. His work drew on the work of Agostino Bassi (1773–1856), who showed that the muscardine of silkworm was attributable to a specific fungus. He also drew on Schwann and Schleiden’s discovery that all life had a cellular structure; Schwann and Cagniard-Latour’s proof that fermentation by yeast was the work of a live organism; and the evident ability of certain morbid matters, such as vaccinia and variola lymph,

to experimentally produce systemic effects in animals even when greatly diluted.

Henle’s thinking, which provided a theoretical basis for germ theory, had affinities with earlier writings of Girolamo Fracastoro (1478–1553) and Athanasius Kircher (1601–1680), but was nevertheless resisted for decades. Yet he lived to see his student Robert Koch (1843–1910) demonstrate conclusively the role of specific bacteria in anthrax, tuberculosis, and cholera.

NIGEL PANETH

(SEE ALSO: *Epidemics; History of Public Health; Koch, Robert; Theories of Health and Illness*)

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HEPATITIS A VACCINE

Hepatitis A vaccine is prepared by inactivating hepatitis A viruses grown in cell culture. Two injections at intervals of approximately six months induce protection in 90 percent or more of recipients. Whether booster doses will be needed is not yet known. Soreness at the injection site is common and headaches are reported in up to 16 percent of recipients, but no significant adverse events are known to be caused by hepatitis A vaccine. The vaccine is recommended for persons at increased risk for hepatitis A, including children living in areas of the United States with high incidence of disease, persons of any age traveling to or working in countries with high levels of infection, and persons at increased risk due to occupation or behavior (e.g., injection drug use, men who have sex with other men).

ALAN R. HINMAN

(SEE ALSO: *Communicable Disease Control; Immunizations*)

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HEPATITIS B VACCINE

Hepatitis B vaccine is prepared in one of two ways: by concentrating and inactivating infectious particles in the circulating blood of persons who are hepatitis B carriers, or by using recombinant-DNA technology to artificially produce the antigen in yeast cells. In the United States, only the recombinant-DNA vaccine is currently available. In both processes, the result is a highly purified preparation that induces protection in 90 percent or more of persons who receive three injections, the second following the first by at least one month and the third at least two months after the second. Booster doses are not recommended. Since infection in the newborn period is associated with the highest risk of lifelong carriage of hepatitis B virus and death resulting from liver cirrhosis or cancer, the first dose is commonly given at birth. In the United States and most other countries, universal vaccination of infants with hepatitis B vaccine is recommended. Adolescents and adults who are at increased risk of hepatitis B infection as a result of lifestyle (e.g., injection drug use) or occupation (e.g., health care workers) should also receive the vaccine. No serious adverse effects have been shown to be caused by the vaccine, although the possibility has been raised of an association with Guillain-Barre syndrome (GBS) at a very low rate (approximately 1/200,000 vaccinees).

ALAN R. HINMAN

(SEE ALSO: *Communicable Disease Control; Immunizations*)

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HERBAL MEDICINE

See Chinese Traditional Medicine

HERBICIDES

Herbicides are a class of pesticides that are marketed specifically for the purpose of killing or inhibiting the growth of weeds. Under the Federal Insecticide, Fungicide, and Rodenticide Act, a weed is defined as "a plant that grows where it is not wanted." The benefits of herbicide use have been many. In agriculture, herbicides control weeds that may rob water and nutrients from crop plants. Compared to other methods, like tillage, herbicides have been promoted as methods of weed control that lessen the impact of soil erosion. They have also been used to control aquatic weeds that block water intakes or invade natural ecosystems, as well as in forestry, and even in swimming pools to inhibit growth of algae. These benefits have resulted in a steady demand for pesticides in the United States, where about 550 million to 600 million pounds per year were used between 1979 and 1997.

In the United States in 1997, there were an estimated \$6.8 billion in sales of herbicides and plant growth regulators. Herbicides constitute a large percentage of total pesticide use. Worldwide in 1997, there were 5.7 billion pounds of pesticides used, of which 2.2 billion were herbicides. Of the 1.2 billion pounds of conventional pesticides used in the United States in 1997, a total of 568 million pounds of herbicides were used—470 million pounds in agriculture, 48 million pounds in industry and government, and 49 million pounds in households. The largest quantities are associated with on crops planted to large acreages, such as soy, cotton, corn, and canola.

There are numerous classes of herbicides (see Table 1) with different modes of action for killing weeds, as well as different potentials to have an adverse effect on health and the environment. Herbicides from different classes also differ in their environmental persistence and fate.

Almost all herbicides can cause acute toxicity. Phenoxy herbicides are involved in acute symptomatic illnesses with relative frequency, accounting

Table 1

Class of Herbicide	Examples
Acetamides and analides	Alachlor, acetochlor, metolochlor, propachlor, propanil
Carbamates and thiocarbamates	Asulam, terbucarb, thiobencarb
Chlorphenoxy herbicides	2,4,-D, 2,4-DP, 2,4-DB, 2,4,5-T, MCPA, MCPB, MCPP, Dicamba
Dipyridyls	Paraquat, diquat
Heavy metals	Lead arsenate, arsenicals
Nitrophenolic and dinitrocresolic herbicides	Dinitrophenol, dinitrocresol, dinoseb, dinosulfon
Pentachlorophenol	Pentachlorophenol
Phosphonates	Glyphosate, glyfosinate, fosamine ammonium
Triazines	Atrazine, simazine, cyanazine, propazine
Urea derivatives	Diuron, flumeturon, linuron, rimsulfuron, tebuthiuron

SOURCE: Sine, C. ed. (1998). *Farm Chemicals Handbook*.

for a reported 453 illnesses in 1996. Glyphosate, a phosphonate herbicide, causes eye, skin, and upper respiratory effects in pesticide workers. Paraquat, a dipyridil pesticide, causes skin irritation and has been frequently associated with accidental death and suicide, especially in developing countries. Access to paraquat is restricted in the United States.

Herbicides are associated with a variety of chronic health risks. Most notable have been concerns about carcinogenicity. Both 2,4,5-T and pentachlorophenol are contaminated by carcinogenic dioxins and furans in manufacture. A number of the acetamide/analide and triazine pesticides are carcinogenic in animals. Studies of U.S. farmers have indicated that general exposure to herbicides is correlated with elevated rates of non-Hodgkin's lymphoma and certain other cancers; however, no specific chemicals have been pinpointed definitively. Many have been banned or severely restricted in the United States and elsewhere, including most of the chlorphenoxy herbicides, the dipyridyls, lead arsenate and arsenicals, and the nitrophenol/dinitrophenol herbicides.

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(SEE ALSO: *Farm Injuries; Pesticides; Toxic Substances Control Act; Toxicology*)

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HERPES ZOSTER

See Chicken Pox and Shingles

HIGH BLOOD PRESSURE

See Blood Pressure

HIP FRACTURES

Hip fractures are one of the most devastating and costly problems commonly faced by the older population. More than 300,000 people sixty-five years of age and older are hospitalized each year for hip fractures in the United States, and about one-quarter of these people will not survive more than a year because of the fracture or its complications. Of those who do survive, most experience major reductions in their levels of function and ability to walk, and a sizable minority (15 to 25%) will be living in long-term care institutions at the end of one year. Looked at longitudinally, by their ninth decade one of three women and one of six men will have suffered a hip fracture.

Hip fractures usually result from two interacting processes: a fall or other dramatic event resulting in direct impact to the greater trochanter (upper part) of the femur (thigh bone); and an underlying weakness in the bone—usually from osteoporosis. Each of these processes has underlying risk factors that had been reasonably well studied. For example, the leading risk factors for falls in older adults include muscle weakness, gait and balanced disorders, decreased overall functional status, vision impairment, cognitive impairment, and medication side effects. Also important are the presence of hazards in the environment,

such as icy pavements or objects on the floor. Risk factors for osteoporosis include having a first-degree relative with osteoporosis, smoking, physical inactivity, alcohol abuse, low level of calcium in the diet, low sunlight exposure, early menopause, certain drugs (e.g., hyperparathyroidism, thyrotoxicosis, myeloma, chronic liver disease, malabsorption syndrome).

Most attempts to prevent hip fractures have focused on reducing the two underlying causes and their risk factors. Controlled clinical trials of measures to reduce falls have shown promising effects from multifactorial risk assessments combined with targeted interventions such as exercise programs and environmental inspection and modification. Exercise programs have been particularly well studied, and the greatest fall-reducing benefits have come from programs that include programs that include strengthening exercise (e.g., progressive weight training) and balance training (e.g., Tai Chi exercises). Taken together, these interventions have been shown to reduce fall rates significantly, in the range of from 10 to 30 percent.

Controlled trials addressing the second major underlying process behind hip fractures, osteoporosis, have similarly shown positive results in strengthening bone and, in some studies, in reducing fracture rates through treatment with a variety of medications such as estrogen, calcium, vitamin D, and bisphosphonates. However, these interventions also provide only a partial protective effect in fracture reduction, again in the range of from 10 to 30 percent. Clearly, reducing the risk of falls and osteoporosis has only been part of the solution to preventing hip fractures, and new effective approaches are still needed.

One such promising approach is the use of special hip protectors made from cushioning material or high-impact plastic to dissipate the shock. Such protectors have been the subject of several studies. In 1993, J. B. Lauritzen found a 53 percent lower rate of hip fractures in nursing homes where hip protectors were used. Even more impressive was that none of the people who experienced a hip fracture had actually been wearing a hip protector at the time of fracture. In 2000, a major confirmatory controlled trial from Finland appeared that studied elderly subjects living both in nursing homes and in the community. In this study there was a 54 percent lower rate of hip

fracture in intervention group subjects as compared to the control group. The authors also compared fracture rates among fallers in the intervention group who were wearing and not wearing their hip protectors and found an 84 percent lower rate of hip fracture per fall among protector wearers. Another study of hip protectors showed that hip protectors improve self-confidence in frail individuals and may lead to improved mobility and function. Based on these studies, hip protectors should be strongly considered by individuals at increased risk for hip fracture (i.e., persons with osteoporosis and fall risk factors such as impaired gait or balance, weakness, and previous falls).

Treatment approaches for hip fractures usually involve surgery for internal fixation of the fracture or replacement of all or part of the hip joint. The choice of procedure depends on the type of fracture (e.g., sub-capital, femoral neck, intertrochanteric, subtrochanteric) and surgical risks of the patient. Early mobilization and active rehabilitation is crucial to minimize complications and maximize the chance of a good functional outcome. However, because many older individuals suffering hip fractures are frail to begin with, and have a relatively high surgical risk, there remains a high rate of surgical complications, lengthy and difficult rehabilitation periods, and long-term functional impairments. Prevention is clearly preferable to treatment, and as described above, many preventive avenues are available.

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(SEE ALSO: *Aging of Population; Geriatrics; Gerontology; Osteoporosis*)

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HIPPOCRATES OF COS

Celebrated as the Father of Medicine, Hippocrates (460–377 B.C.E.) was born on the Island of Cos, traveled widely throughout classical Greece in the period of its civilization’s greatest achievements, and died in Thessaly. He and his pupils made contributions to medical thinking that have endured for 2.5 millennia. His therapies, based on the humoral theory that imbalance among the four “humors” (phlegm, blood, black bile, and yellow bile) caused most diseases, were flawed, but this does not detract from the excellence of the meticulous descriptions of diseases and their accounts of their natural history that have come down to us in the Hippocratic aphorisms and other writings. Pupils in the Hippocratic medical school were apprentice priest-physicians—for medicine was then a priestly calling.

Hippocrates’ work *Epidemics* must have been based on prolonged and careful observation of the diseases described—all that is missing are numbers and statistical significance tests to make this work suitable for modern courses of epidemiology. *Airs, Waters, and Places* describes both healthy and

unhealthy environments and ways of living, offering timeless advice to physicians who seek to assess these determinants of health and disease:

Whoever would study medicine aright must learn of the following subjects. First he must consider the effects of each of the seasons of the year and the differences between them. Secondly he must study the warm and the cold winds, both those which are common to every country and those peculiar to a particular locality. Lastly the effect of water on the health must not be forgotten. Just as it varies in taste and when weighed, so does its effect on the body vary as well. When, therefore, a physician comes to a district previously unknown to him, he should consider both its situation and its aspect to the winds. The effect of any town upon the health of its population varies according as it faces north or south, east or west. . . . Similarly, the nature of the water supply must be considered; is it marshy and soft, hard as it is when it flows from high and rocky ground, or salty with a hardness that is permanent? Then think of the soil, whether it be bare and waterless or thickly covered with vegetation and well-watered; whether it is in a hollow and stifling, or exposed and cold. Lastly, consider the life of the inhabitants themselves; are they heavy drinkers and eaters and consequently unable to stand fatigue, or being fond of work and exercise, eat wisely but drink sparingly? (Lloyd 1978, p. 148)

The aspects of Hippocrates’ teaching that relate most closely to public health are contained in *Airs, Waters, and Places*, but much of the wisdom that permeates the rest of the Hippocratic corpus is as applicable to public health as it is to the practice of clinical medicine, and is as true today as when it was recorded twenty-five centuries ago. However, the Hippocratic oath, which is one of the basic texts of medical ethics and is still taken by medical school graduates, is no longer believed to have been written by Hippocrates, and it is unknown exactly how many of the seventy-odd Hippocratic treatises he did write.

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(SEE ALSO: *Ethics of Public Health; History of Public Health*)

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HISPANIC CULTURES

In popular usage, terms such as Hispanic and Latino are often a descriptive umbrella to refer to any American whose ancestry includes people of Spanish, Mexican, or Central or South American origin. Although, the "Hispanic" label can be found in the literature going back at least twenty centuries, its official introduction to the modern lexicon has come in recent decades. According to the U.S. Department of Health and Human Services, the term refers to anyone with linguistic or cultural antecedents in Latin America or Spain.

Hispanics are commonly considered a monolithic group of Americans, but this notion could not be further from the truth. This population is more accurately referred to as a mosaic of cultures. In reality, the various Hispanic subgroups reflect profound differences in ethnicity, culture, and origin, and they have remarkably few characteristics in common. For example, this population covers the racial spectrum. Hispanics can be white, African American, Asian or Pacific Islander, or Native American. Moreover, the diversity extends to nationality, customs, heritage, lifestyles, and socioeconomic status. While similarities among the groups do exist, particularly in language (Spanish) and religion (Catholic), deeply embedded dissimilarities among the different groups in background and life experiences will influence health. This means caution should be taken in making broad generalizations about the Hispanic/Latino population.

HISTORY OF THE HISPANIC AMERICANS

The ancestors of today's Hispanics arrived at the New World's shores through various routes. Christopher Columbus first landed on the island later named Puerto Rico over five centuries ago. The European colonization of North America began with Spanish settlements in Mexico and what is now the South and Southwestern United States. Today, although U.S. Hispanics are concentrated in the West, Southwest, and New York, New Jersey, Massachusetts, Illinois, Florida, and Puerto

Rico, they have become an integral element of state populations nationwide. Of the total U.S. Hispanic population, the majority are Mexican American, followed in size by Central and South Americans, Puerto Ricans, and Cuban Americans.

Due to its relative youth and rapid growth, the Hispanic population in the early twenty-first century will become the largest ethnic minority in the United States supplanting African Americans for that distinction. This growth has been particularly rapid since 1950, when the Hispanic population, totaling 2.3 million, represented only 1.5 percent of the overall U.S. population. By the year 2000, Hispanics numbered about 32.5 million and comprised 11.8 percent of the population. It is projected that by 2050 the Hispanic population will reach 98.2 million, or almost one-quarter of the country's population. In Canada, the portion of the population classified as Latin American in 1996 numbered 176,975.

Mexican Americans. After its independence from Spain in 1821, Mexico continued active colonization of its northern territory, which ranged from California to Texas and as far north as southern Wyoming. Following the Mexican War in 1847, the United States obtained most of the present-day Southwest, and residents of Mexico in this region found themselves living in U.S. territory. Over the past 150 years, Mexico has been a major departure site for immigration to the United States. In 1999, Mexican Americans comprised about two-thirds of all Hispanics in the U.S. population.

Central and South Americans. Since the 1960s, immigration from countries neighboring Mexico and from South America has increased dramatically, primarily as a result of political, civil and/or economic turmoil and hardship in countries such as the Dominican Republic, Guatemala, El Salvador, and Nicaragua. Central and South Americans have settled in numerous locations across the United States, most notably in California, New York, Washington, D.C., New Jersey, and Florida. These ethnic subgroups reflect a strong diversity of culture, background, and educational and socioeconomic levels. Central and South Americans represented 14.3 percent of the U.S. Hispanic population in 1999.

Puerto Ricans. Another major source of Hispanic Americans over the past century is Puerto

Rico, which was ceded to the United States following the Spanish-American War in 1898. Puerto Ricans were granted U.S. citizenship as a result of the Jones Act of Congress in 1917. The end of World War II marked the beginning of a significant migration of Puerto Ricans to the mainland, primarily to New York. The open migration between the island of Puerto Rico and the mainland has presented an assimilation process that is unique among Hispanic Americans, because Puerto Ricans freely operate in two divergent societies. Individuals from Puerto Rico comprised 9.6 percent of the U.S. Hispanic population in 1999.

Cuban Americans. While small Cuban settlements in the Tampa area of Florida and in New York date back to the early 1900s, the major migration from this island came as a result of Fidel Castro's rise to power in 1959. The large majority of immigrants settled in Miami, creating an urban sector known as Little Havana. The Cuban arrivals during this period represented the upper and middle classes, which afforded them a very different immigration experience from those who came from Mexico and Puerto Rico. However, the next major exodus, of 125,000 people in 1980, came primarily from the working classes of Cuba. About 4 percent of the 1999 U.S. Hispanic population were Cuban Americans.

SOCIODEMOGRAPHIC INFLUENCES ON HEALTH

Among the most striking demographic influences is the relative youth of the Hispanic population. Overall, the median age of Hispanic Americans in 1999 was 26.1 as compared to 36 for the general population. Closer inspection, however, reveals some wide variations in age among Hispanic population groups. The median ages of Mexican Americans (24.2) and Puerto Ricans were the lowest (27.5), while that of Cuban Americans was much higher (41.3). Not surprisingly, the proportion of the Cuban-American population over age 65 (17.8%) was considerably higher than the percentage found in Mexican Americans (4.4%) and Puerto Ricans (6.5%). Such age structure differential among the ethnic groups explains variations in the prevalence of chronic diseases seen more in the elderly, including cancer, diabetes, and cardiovascular disease. Since the age profile of the Cuban-American population more closely resembles that

of non-Hispanic whites, the rates of major diseases for these populations are similar.

Among Hispanic in general, lower socioeconomic and education levels provide additional influences on health status. For example, economic status directly relates to the availability of health insurance and access to care. In 1998 the median income for Hispanic households was \$28,330, considerable lower than the \$42,439 median income for their non-Hispanic white counterparts, and poverty rates among Hispanics were over three times higher (25.6% versus 8.2%). Education levels, which are associated with economic levels and health status, are also lower among Hispanics than other populations. In 1999, 56.1 percent of Hispanics age twenty-five and older had finished high school, compared to 87.7 percent of non-Hispanic white adults.

CHRONIC DISEASES AMONG HISPANICS

Disease mortality rates are lower overall for Hispanics than for non-Hispanics, and considerably lower for the two major killers, cardiovascular disease and cancer. Diabetes, however, claims more lives among the Hispanic population.

Cardiovascular Disease. Although cardiovascular disease among Hispanics is increasing, rates of death for this disease are substantially lower for Hispanics than for non-Hispanics. Few studies include Puerto Ricans and Cuban Americans, and most of the Hispanic cardiovascular disease statistical data reflect findings in studies of Mexican Americans. These studies show lower heart disease mortality rates among Mexican-American men than among non-Hispanic white males.

Cancer. Compared with non-Hispanics, cancer rates are lower overall and lower for the major sites—lung, breast, prostate, and colorectal—among Hispanics. For lung cancer, the reduced incidence and mortality (60 to 80% lower than for non-Hispanics) extends to each of the major Hispanic ethnic groups. Breast cancer incidence is 30 to 50 percent lower among Hispanic women. Among Hispanic males, the frequency of prostate cancer is significantly lower only in Mexican Americans; incidence rates for Puerto Ricans and Cuban Americans are comparable to those of non-Hispanic white men. Colorectal cancer rates are also lower for all of the Hispanic ethnic groups. Hispanics are

at greater risk for cancers of the cervix, stomach, gallbladder, and liver. Among Mexican-American and Puerto Rican women, cervical cancer incidence is two to three times higher than in non-Hispanic white women.

Diabetes. Diabetes is a primary health concern for Hispanics. This has been particularly documented among studies involving Mexican Americans, in which the risk of type II diabetes mellitus is two to three times higher than those of non-Hispanic whites. While risk appears to vary among Hispanic groups in different areas of North, Central, and South America, the greatest risk is apparently associated with an increased proportion of Native American genetic admixture. Among Mexican-American adults in Texas, about 15 percent have type II diabetes mellitus. The comparatively high level of undiagnosed diabetes among Hispanics is particularly disturbing because diabetes is one of the major killer diseases for this population.

A DIVERSE POPULATION

The diversity of the Hispanic population in terms of background, culture, and sociodemographic characteristics renders broad generalizations difficult and, in many cases, meaningless. This diversity impacts the health of the Hispanic groups, which is reflected in wide-ranging incidence and mortality rates for the major chronic diseases. In addition, the implications for knowledge, attitudes, and behaviors with regard to the broad spectrum of health issues are profound. For the Hispanic population in general, and for the ethnic subgroups in particular, public health needs include improved data collection, increased population and chronic disease research, and greater emphasis on training culturally sensitive health care providers.

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(SEE ALSO: *Cultural Appropriateness; Cultural Identity; Ethnocentrism; and articles on specific diseases mentioned herein*)

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HISTORICAL DEMOGRAPHY

Historical demography is the quantitative study of the size and structure of past populations, the components of population change (fertility, mortality, and migration), and the factors that influenced them. In its broadest sense, historical demography covers the entire history of the human species, but for prehistoric populations, estimates of population size and structure must rely on intelligent guesswork, based on archaeological studies of material remains such as skeletons, dwellings, and cooking utensils. Even in the case of populations with written records but with no census of population or registration of births and deaths, population size can only be estimated approximately, using inscriptions on gravestones, legal documents, and taxation records.

In Europe, ecclesiastical records of baptisms, marriages, and funerals serve as proxies for civil registration from the sixteenth century onward. For certain towns (e.g., London), summaries of these were published and were analyzed by John Graunt, one of the first demographers. John Rickman, the official in charge of the first census of England and Wales in 1801, arranged for abstracts of parish registers to be made. These were used by Rickman and by many subsequent demographers.

Beginning in 1952, French demographers began detailed studies of ecclesiastical records in selected parishes. By linking the names on the registers of baptisms, marriages, and funerals, they were able to reconstitute the histories of cohorts

of families over the years. This method of family reconstitution has since been used in several European countries and in Quebec. The technique has proved extremely fruitful and, for many demographers, the term “historical demography” is restricted to this micro-demographic approach.

Estimates, by various scholars, of the trend in the size of the world population by continent were summarized by J. N. Biraben in 1979. Later estimates are available from the publications of the United Nations and international agencies such as the World Bank. Table 1 shows these estimates for the world as a whole, and, to reduce the effect of migration, for two continental aggregates: Europe (including Russia) plus the continents where people of European descent predominate (North America and Oceania); and the remaining continents. As well as the estimates of population size (in millions), Table 1 shows the annual growth rates, expressed as increase per thousand per year. The impact of these growth rates can be appreciated by relating them to the doubling time they imply. An annual growth rate of one per thousand would require 694 years to double the population. Rates of 10 or 20 per thousand have doubling times of 70 or 35 years respectively.

During the period from 500 to 900 C.E., there was very little growth in the world population, but between 900 and 1300 C.E. the population doubled, the growth rates being slightly higher in Europe than elsewhere. During the fourteenth century, there was a fall in population associated with the Black Death, a pandemic plague that spread from the Gobi desert to China, India, the Middle East, and Europe. This was followed by a period of restrained growth for three hundred years.

Beginning in the eighteenth century, the size of the world population entered a period of accelerated growth. At first the acceleration was more marked in the European population, reaching a peak growth rate of 10 per thousand per year in the second half of the nineteenth century. During the twentieth century, the growth rate among the European populations slackened and was overtaken by a rapid acceleration in the growth rate in other continents, which reached 21 per thousand per year in the last fifty years of the millennium. Between 1900 and 2000 C.E. the population of the world increased by 277 percent; the European

Table 1

World Population 500-2000 A.D.						
Year	European		Other		Total	
	N ¹	R ²	N	R	N	R
500	44		163		207	
600	36	-2	172	5	208	1
700	35	0	171	0	206	0
800	38	1	186	1	224	1
900	42	1	180	0	222	0
1000	46	1	207	1	253	1
1100	54	2	245	2	299	2
1200	71	3	329	3	400	3
1300	91	3	340	0	431	1
1400	70	-3	305	-1	375	-1
1500	90	3	371	2	461	2
1600	117	3	461	2	578	2
1700	130	1	550	2	680	2
1750	152	3	619	2	771	3
1800	202	6	752	4	954	4
1850	315	9	926	4	1,241	5
1900	518	10	1,116	4	1,634	5
1950	754	8	1,776	9	2,530	9
2000	1,162	9	5,006	21	6,168	18

¹Size of population in millions
²Annual increase per thousand

SOURCE: Bos, E.; Vu, M. T.; Levin, A.; and Bulatao, R. A. *World Population Projections, 1992-93 Edition: Estimates and Projections with Related Demographic Statistics*. Baltimore: The World Bank and Johns Hopkins Press, 1993.

component increased by 124 percent, and the remainder by 349 percent.

The recent micro-demographic technique of family reconstitution provides a more detailed analysis of the surge in the European population during the eighteenth century than is possible from the macro-demographic estimates in Table 1. Michael Flinn has collated the results of such studies in Belgium, England, France, Germany,

Scandinavia, and Switzerland. In-depth analyses of the parish registers in England have been published by E. A. Wrigley and Roger Schofield. Table 2 is derived from these books and from that edited by Tommy Bengtsson and colleagues.

The size of a population that is closed to migration is the product of the number of live births per year and the average number of years lived (expectation of life at birth). In eighteenth-century Europe, less than 5 percent of live births were illegitimate, so it is reasonable to focus on the number of legitimate births. The latter is the product of the proportion of women who marry before menopause and the average number of live births per marriage. The first row of Table 2 suggests that the proportion of women marrying increased during the eighteenth century, though the data are available only from English parishes, and in proxy form—the proportion of those between forty and forty-five years of age of both sexes who were married. The second row of the table shows that the average number of live births per marriage remained high during the eighteenth century but fell slightly in the early nineteenth century. The third row shows that the expectation of life at birth increased considerably during the eighteenth century, a trend that continued into the nineteenth century.

The fourth column of Table 2 shows the percentage of increase of these statistics between the early eighteenth and early nineteenth centuries. The small changes in the proportion marrying (minus 9%) and the average number of live births per marriage (6%) are outweighed by the large increase in the expectation of life at birth (29%). This is consistent with the hypothesis that the spurt in the European population during the eighteenth century was due to a fall in mortality rather than an increase in fertility, though the question of the role of fertility is still a matter for debate. The reduction in the average number of live births per marriage over the century, despite the increase in the proportion marrying, can be explained by the increase in the average age at first marriage among women, shown in the fourth row of Table 2. Since a woman's fertility reduces with increasing age, even small increases in the average age at first marriage can reduce the average number of births. The last two rows of Table 2 show that most of the gain in expectation of life at birth was due an increase in the proportion of infants surviving

Table 2

	Early 18th C (a)	Late 18th C	Early 19th C (b)	Percent ¹ Change
Percent marrying before age 50	88	94	93	6
Live births per marriage (mean)	8.7	8.8	7.9	-9
Expectation of life at birth (years)	31	34	40	29
Mean age at first marriage (women)	25	26	27	8
Survival from birth to age 25 (percent)	48	51	64	33
Expectation of life at age 25 (years)	41	43	42	2
¹ 100 x ((b - a)/a)				
SOURCE: From Flinn, M. W.				

long enough to marry. Very little was due to change in the expectation of life at age twenty-five. After the eighteenth century, death rates in Europe continued to fall, and in the nineteenth century the fertility changes seen in Table 2 accentuated, leading to a compensating fall in the birth rate.

Before the introduction of organized public health programs in the nineteenth century, high levels of mortality were caused by the correlated effects of war, famine, and pestilence. The precise manner in which mitigation of these factors led to the fall in mortality in the eighteenth century is still debated by historians, but the debate has been considerably enriched by the studies subsumed under the term historical demography.

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(SEE ALSO: *Bills of Mortality; Birthrate; Demography; History of Public Health; Mortality Rates; Population Pyramid*)

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HISTORY OF PUBLIC HEALTH

Public health was defined by the American public health leader, Charles-Edward A. Winslow, in 1920 as, "the science and art of preventing disease, prolonging life, and promoting physical health and efficiency through organized community efforts for the sanitation of the environment, the control of community infections, the education of the individual in principles of personal hygiene, the organization of medical and nursing service for the early diagnosis and preventive treatment of disease, and the development of the social machinery which will ensure to every individual in the community a standard of living adequate for the maintenance of health." Although a modern nosologist would add *mental* to *physical* aspects of health, Winslow's definition has not been superseded. It provided the basis for the World Health Organization's definition of health: "A state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity" (1948).

THE DAWN OF HISTORY TO THE FALL OF ROME

Elements of Winslow's concept of public health can be found in the earliest evidence of communal living. Paleopathology, the study of fossils and

other artifacts, reveals that early *Homo sapiens*, who were hunter-gatherers, suffered from essentially the same diseases that afflict people today.

In remote parts of the world—in the Amazon, Indonesia, Australia, and Africa—isolated communities exist that anthropologists believe follow lifestyles typical of prehistoric populations. These peoples share the belief that diseases are caused by malevolent supernatural forces. To diagnose, treat, and, in some cases, prevent the spread of these malevolent forces, all primitive societies have created a class of "shamans"—persons specially trained to intervene on the spiritual and physical level. Thus, the most primitive societies provide an "organized" approach to the recognition and management of disease.

The social structure of the earliest primitive villages was probably not very different from that of the earlier hunter-gatherer tribes, and physical amenities were, no doubt, similarly unchanged. However, the establishment of cities brought about major developments. Archaeologists have found that all the great cities of antiquity in Asia, Europe, Africa, and South America had municipal water supplies and sewerage systems. The culmination of ancient sanitary engineering was accomplished in Rome, where aqueducts supplied the city with water in amounts comparable to many modern municipal systems and sewers and drains carried away the wastewater. Part of the great central drain of ancient Rome, the *Cloaca Maxima*, still serves as part of the sewerage of the modern city.

It was the exigencies of urban living, not considerations of health and disease, that necessitated sanitary engineering. Supernatural explanations of disease did not evoke or require an environmental origin for disease. However, in the fifth and fourth centuries B.C.E., in Greece, an empirical explanation of disease was proposed by the physician Hippocrates and his followers who described diseases in objective terms, and rejected supernatural causes. In his book *On Airs, Waters, Places*, the relations of disease to physical, social, and behavioral settings are presented for the first time. This book served as a guide for decisions regarding the location of urban sites in the Greco-Roman world, and may be considered the first rational guide to the establishment of a science-based public health.



Aqueducts in Rome supplied the city with potable water. Sewers and drains carried wastewater away. (Archive Photos)

THE DARK AGES AND THE MEDIEVAL PERIOD

During the Dark Ages (about 500–1000 c.e.), Western Europe experienced a period of social and political disintegration. Large cities disappeared, replaced by small villages surrounding the castles of feudal chiefs. The only unifying force was Christianity, and it was in the monasteries that the learning and culture of the Greco-Roman world was preserved. Furthermore, in many of these institutions, piped water supplies, sanitary sewers, privies, bathing facilities, and heating and ventilation were provided. In addition, some monasteries constructed hospices to shelter travelers and sick persons, though the medical care provided in them was primitive at best. In Eastern Europe and Asia Minor, however, feudalism did not exist, and medicine advanced and became centered in major secular hospitals established in Byzantium, Baghdad, and Cairo.

The most important disease of the period was leprosy, manifested by a continent-wide epidemic

beginning in the sixth century and lasting through the fifteenth. Lepers were excluded from communities and segregated. Elaborate rules and regulations were set up to diagnose the disease and isolate cases. Leper houses (leprosaria) were established, and it is estimated that by the end of the twelfth century there were 19,000 such houses throughout Europe. Isolation of cases of leprosy in medieval times represents the earliest application of a public health practice still in use.

By about 1000 c.e., the stagnation in the West gave way to change. Feudal fiefdoms were being consolidated into nation states, cities and towns were growing, education was beginning to be secularized, and the Crusades were bringing increased interaction between the Islamic East and the Christian West. As these changes occurred, the responsibility for communal functions was transferred from the feudal lords and ecclesiastic authorities to lay councils presided over by a hierarchy of hereditary or appointed officials. Public health activities, such as overseeing the water supply and sewerage, street cleaning, and supervision of the markets, fell under the jurisdiction of the councils.

The establishment, in Salerno, Italy, of the first organized medical school was indicative of the changes occurring in Western Europe. This institution, founded in the eleventh or twelfth century, was particularly remarkable for two reasons: It was a lay organization, independent of the church, and it welcomed students of any race or creed. Its faculty included women, who apparently dealt with obstetric issues, and the renowned peripatetic scholar, Constantine the African (1020–1087), who translated many important Arabic works into Latin. Its most prominent literary product was the *Regimen Sanitatis Salernitanum*, a lengthy poem, prescribing healthy habits from birth to old age. Drawing on the whole corpus of Greco-Roman and Arabian medical writings the *Regimen* emphasized personal hygiene, diet, exercise, and temperance. It was the first “health guide” for the masses.

THE RENAISSANCE AND THE PLAGUE CENTURIES

It was during the Renaissance, a period of great commercial, scientific, cultural, and political development, that the bubonic plague, or “Black Death,” swept over Europe and the Near East killing an estimated one-fourth to one-third of the

population between 1347 and 1351. For the following two-and-a-half centuries, periodic epidemics of plague decimated these populations.

There were other epidemics as well. In the sixteenth century two new diseases, syphilis and the “English sweat,” an ill-defined condition, possibly a form of influenza, were widespread in Europe. The ever-present smallpox was transported to the Americas, where it decimated the native populations. These catastrophic events precipitated the three most important contributions to public health of the Renaissance: the organization of boards of health, the promulgation of a theory of contagion, and the introduction of health statistics.

With the recurrence of plague epidemics, it finally became apparent in the cities of northern Italy that the ad hoc arrangements of the city councils were inadequate to deal with these episodes. By the middle of the fifteenth century, the major cities of the region had established permanent boards of health who were responsible for determining the existence of plague, establishing quarantine, issuing health passes, arranging for the burial of plague victims and the fumigation of their residences, and the management of *lazarettos* (houses and institutions of quarantine). The boards maintained close relations with the local physicians who provided medical care and prophylactic advice. As time passed, the boards expanded their purview to the control of markets, sewage systems, water supplies, cemeteries, and the cleanliness of streets; and they took jurisdiction over the professional activities of physicians and surgeons, the preparation and sale of drugs, and the activities of beggars and prostitutes. With the disappearance of plague at the end of the seventeenth century, the boards of health of northern Italy withered away. Nevertheless, they provided a model for nineteenth-century organization of public health activities.

Although vague theories of the contagious nature of certain diseases had existed since ancient times, it was the Italian physician and scholar, Girolamo Fracastoro (who had written an epochal description of syphilis, giving the disease its name), who, in 1546, published *On Contagions and the Cure of Contagious Diseases*. Fracastoro proposed that many diseases are caused by transmissible, self-propagating, disease-specific agents called “germs” (*seminaria*), which propagate themselves in tissues

of the infected host and cause disease by setting up chemical processes. Most importantly, Fracastoro proposed that germs are spread by direct contact (person to person), by contact with fomites (inanimate objects), and by distant transmission.

By early in the fifteenth century, the Italian boards of health instituted a system of death registration, first for contagious diseases and subsequently for all diseases. The resulting bills of mortality have provided continuous data on mortality in Italy from the Renaissance to the present. In seventeenth-century London, analysis of bills of mortality by John Graunt in his epochal treatise *Natural and Political Observations . . . Made Upon the Bills of Mortality* (1662) laid the basis for the modern use of statistics for the planning and evaluation of public health activities.

THE ENLIGHTENMENT AND SANITARY REFORM

The Enlightenment (the period from 1750 until the mid-nineteenth century) was characterized by unprecedented industrial, social, and political developments, and the resulting societal impacts were immense, culminating in the Industrial Revolution. It was in Germany that the first major contribution of the period to public health occurred. Between 1779 and 1816, Johann Peter Frank, a leading clinician, medical educator, and hospital administrator, published a six-volume treatise, *System of a Complete Medical Policy*, in which he proposed a sweeping scheme of governmental regulations and programs to protect the population against disease and to promote health. His proposals covered the entire life span from birth to death. The actions that he advocated ranged from measures of personal hygiene and medical care to environmental regulation and social engineering.

Meanwhile, in England, Jeremy Bentham (1748–1832) was enunciating a similar humanitarian social philosophy and consequent political reform. In *Introduction to the Principles of Morals and Legislation* (1789), Bentham argued, among other ideas, that society should be organized for the greatest benefit for the greatest number (Utilitarianism). In his *Constitutional Code* (1830), Bentham proposed radical new legislation dealing with such issues as prison reform, the establishment of a

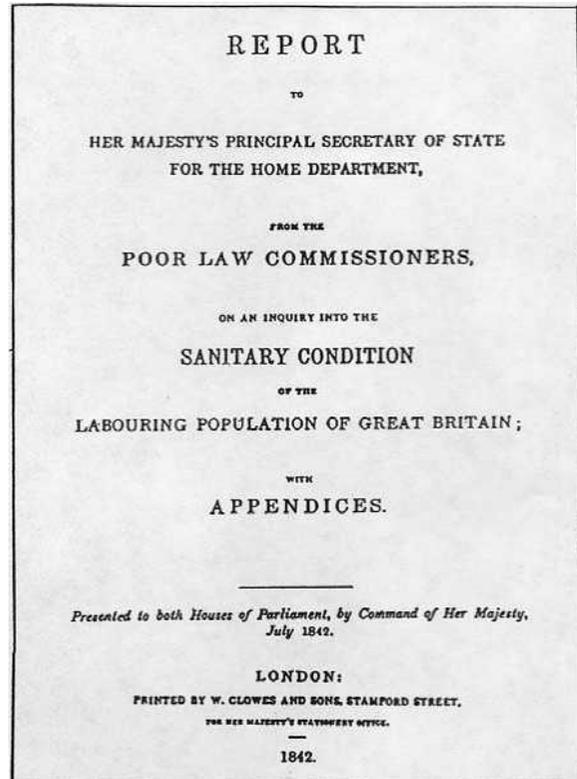


In 1546, Girolamo Fracastoro was the first to identify how germs are spread. (Photo Researchers Inc.)

ministry of health, birth control, and a variety of sanitary measures.

Implementing these concepts in the mid-nineteenth century fell to Bentham's disciples, particularly Edwin Chadwick. Chadwick had been secretary of England's Poor Law Commission, established in 1834 to effectuate the New Poor Law, and was aware of the pervading interaction of disease and poverty. Thus, when the Commission undertook a special study in 1839 of the prevalence and causation of preventable diseases, particularly of the working poor, Chadwick took the lead. The resulting publication, *General Report on the Sanitary Condition of the Labouring Population of Great Britain* (1842), is considered one of the most important documents of modern public health.

Chadwick documented the status of housing of the working population, the lack of sewerage and adequate supplies of water, the unhygienic circumstances of places of work, the life expectancy of various social classes, the economic impact of unsanitary conditions, and the evidence for



The General Report on the Sanitary Condition of the Laboring Population of Great Britain documented the general health conditions of the British working class.

the beneficial health effects of preventive measures. As a result, sewerage, potable and plentiful water supplies, refuse disposal, proper ventilation of residences and places of work, supervision of public works by qualified professionals, and legislative authorization of measures to obtain these results were put forward.

Chadwick's report was widely circulated and carefully considered. In the United States, it stimulated a similar survey based on more sophisticated survey methods and with more comprehensive recommendations. The *Report of a General Plan for the Promotion of Public and Personal Health* (1850), authored by the organizer and first president of the American Statistical Association, Lemuel Shattuck, put forward fifty recommendations (many still worthy of implementation but not yet realized) and a model state public health law. Although both of these reports impacted national and local legislation, their more enduring effect was to define the purview and establish the organizational

framework of the field of public health in the late nineteenth and early twentieth centuries.

BACTERIOLOGY

With the discoveries of pathogenic bacteria by Louis Pasteur in France and Robert Koch in Germany in the late 1870s and early 1880s, the science of microbiology was born. Consequent developments in immunology and parasitology provided epidemiologists and other public health workers with the tools to study and understand epidemic phenomena. Sanitation could become science-based and the development of vaccines promised the prevention of many infectious diseases. A new era of rational public health was established.

COLONIALISM AND PUBLIC HEALTH

From the sixteenth through the nineteenth century, European countries had competitively colonized most of the tropical world. The contagious diseases they brought with them frequently ravaged indigenous populations. Conversely, the prevalent diseases of colonized areas threatened the invaders. Colonial sanitation and medical care was originally designed to serve the interests of the colonists. However, after the establishment of biomedical science, there was enhanced incentive to control the major tropical diseases that were interfering with the economic development of the colonies (e.g., malaria and yellow fever). In India, in 1897, Ronald Ross identified the mosquito vector of malaria, leading to the partial control of the world's most prevalent endemic disease and vastly increasing the agricultural output and, incidentally, the population of the subcontinent. In Cuba, in 1900, Walter Reed and his colleagues identified the mosquito vector of yellow fever. Subsequently, William C. Gorgas, by extensive application of larvicide, eradicated the disease from Cuba and controlled it, along with malaria, in Panama. This action permitted the construction of the canal that had previously been abandoned because of the devastating impact of these diseases.

When these colonies gained independence, mostly during the twentieth century, much of the public health infrastructures put in place by the colonial powers were transferred intact to the new nations. The ability to effectively utilize these resources has varied considerably, contributing to

the development of international public health organizations.

THE EARLY TWENTIETH CENTURY

Although the Sanitary movement of the nineteenth century and the development of bacteriology substantially lowered death rates from enteric diseases, other serious health problems still existed. One was the appalling and ubiquitous rate of infant mortality. First in Europe, then in Britain and in the United States, maternal and child health programs were initiated with an emphasis on nutrition, medical care, and, eventually, health inspection in schools. Muckraking journalists exposed disgraceful conditions in the food processing industry, leading to the imposition of widespread governmental regulation. High rates of occupational diseases and industrial injuries led to programs for industrial hygiene and occupational health. Mental health was identified as a public health issue, and specific nutritional deficiencies were recognized as risk factors for a spectrum of diseases. Furthermore, pioneering studies of pellagra, a vitamin-deficiency disease, by Joseph Goldberger and Edgar Sydenstricker, revealed the complex environmental, social, and biological interactions responsible for the occurrence and distribution of such diseases.

The growing scope and complexity of public health concerns led to the establishment of academic programs to expand research and train relevant technical personnel. At the University of London, a school of Tropical Medicine was established in 1905 and, in the United States, a School for Health Officers was created jointly by Harvard University and the Massachusetts Institute of Technology in 1913. The first school of public health in the United States was established in 1916 at Johns Hopkins University with a grant of \$267,000 from the Rockefeller Foundation. Subsequently, the Foundation supported the establishment of schools of public health at Harvard, the University of Michigan, the University of London, and in several other locations around the world.

By midcentury, the basic activities of public health had been widely recognized in the industrialized world. These components were: communicable diseases control, environmental sanitation,

maternal and child health services, health education, occupational and industrial hygiene, nutrition, and, in most developed countries, the provision of medical care. In the United States, only medical care for the indigent, the aged, and for certain diseases (e.g., tuberculosis) were considered within the purview of public health.

An important role has also been played by the philanthropic foundations and voluntary health organizations. For example, the Rockefeller Foundation provided the impetus and financial resources to initiate public health professional education and the Milbank Fund pioneered the establishment of local health departments in New York State by carrying out demonstration projects around the state. Other important foundations include the Julius Rosenwald Fund, the Russell Sage Foundation, and the Twentieth Century Fund.

Voluntary health agencies evolved in the late nineteenth and early twentieth centuries in Europe and North America, growing out of the failure of public health organizations to fully apply knowledge created by the new biomedical sciences, and by the continuing deplorable condition of the urban poor. Organizations like the Pennsylvania Society for the Prevention of Tuberculosis (which evolved into the American Lung Association) took on the task of public education, case counseling, financial aid, and advocacy for relevant legislative action, while organizations like the Henry Street Settlement in New York City and Hull House in Chicago provided social and medical services in slum neighborhoods. By the mid-twentieth century there were more than 20,000 voluntary health agencies in the United States alone.

THE LATE TWENTIETH CENTURY

In the last half of the twentieth century, public health continued to expand its established roles. However, new forces were at work to further broaden its purview. Among these were the aging of the populations in industrialized regions, recognition of the importance of behavioral factors in determining the health of populations, exacerbation of social inequalities in health, increasing violence (at the domestic level as well as at the civil and international level), and globalization.

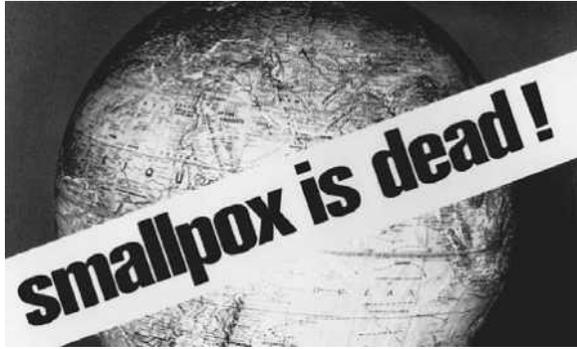
As infant and child mortality declined in the industrialized countries, life expectancy and the

proportions of the elderly in populations increased. Consequently, diseases such as heart disease and cancer became more important. After World War II, epidemiological research concentrated on identifying risk factors for these and other chronic diseases. A prominent role for behavioral factors was readily demonstrated. Particularly, cigarette smoking was identified as a major etiological factor for heart disease and for several cancers, particularly lung cancer. Other behavioral factors, such as diet, exercise, and obesity, were found to be causally associated with several other diseases. Ameliorating adverse behavioral risk factors has become a major function of public health agencies.

Since the mid-nineteenth century, the relationship between socioeconomic status and health has been widely recognized. However, in the late twentieth century epidemiological research has pointed out additional differences in health status between gender, ethnic, and occupational groups. Such inequalities appear to be increasing and are being recognized as a major challenge for modern public health.

Domestic violence, gang warfare, ethnic conflicts and genocide, and civil wars and wars between nations have resulted in substantial mortality and a vast disruption of societies. In some countries, including the United States, homicide has become a major cause of death among those under twenty years of age. Around the world, many millions of displaced persons live in enormous refugee camps with minimum medical and public health facilities. Clearly, the health effects of war and violence demand to be addressed.

Increased globalization and technological advances have resulted in worldwide economic, political, and social interdependence. However, recognition of the interdependence of regions and nations with respect to health and disease was institutionalized in 1902, when the Pan American Health Organization was established to coordinate communicable disease surveillance and quarantine in the western hemisphere. By the end of the century, the major global public health problems included the manifold consequences of atmospheric warming; pollution of the oceans and fresh waters of the world and the depletion of fisheries; the rapid growth of the world's



The World Health Organization announced the eradication of smallpox in 1977. (AP/World Wide Photos)

population; the emergence of new infectious diseases, including HIV/AIDS (human immunodeficiency virus/acquired immunodeficiency syndrome); and the increased production and use of addictive drugs. These are daunting challenges for the World Health Organization and other international agencies.

Nevertheless, in 1977, public health registered its greatest historical feat. In that year, the eradication of one of the human species' most dreaded and lethal diseases, smallpox, was completed. The last case occurred in 1977 in the East African nation of Somalia and the eradication was certified by a Commission of the World Health Organization in 1979.

WARREN WINKELSTEIN, JR.

(SEE ALSO: *Bills of Mortality; Chadwick, Edwin; Contagion; Epidemiologic Transition; Filth Diseases; Fracastoro, Girolamo; Frank, Johann Peter; Goldberger, Joseph; Graunt, John; Health; Hippocrates of Cos; Koch, Robert; Miasma Theory; Pan American Health Organization; Pasteur, Louis; Reed, Walter; Ross, Ronald; Shattuck, Lemuel; Smallpox; Snow, John; Social Health; Sydenstricker, Edgar; Theories of Health and Illness; Winslow, Charles-Edward Amory; World Health Organization; and articles on specific diseases mentioned herein*)

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HIV/AIDS

Acquired immunodeficiency syndrome, or AIDS, is the final, life-threatening stage of infection with any of the human immunodeficiency viruses (HIV-1, its many subtypes, or HIV-2), which are transmitted from person to person sexually (including via anal, oral, and vaginal intercourse, both heterosexually and homosexually), through contact with blood (mainly via equipment used to inject illicit drugs and, rarely, via medical uses of blood), and perinatally (from mother to fetus or newborn during pregnancy, labor, and delivery, or after birth through breast-feeding).

ORIGIN AND HISTORY

HIV-1 and HIV-2 both appear to have been transmitted to humans from primates in Central and West Africa, probably to hunters or processors of carcasses of primates consumed as food (referred to as “bush meat”). Beginning as simian viruses, they became human viruses once they achieved sustained transmission from person to person. This appears to have occurred at least four times in history: three times from chimpanzees (*Pan troglodytes*); (possibly in the 1930s), representing the three major strains of HIV-1, and once from sooty mangabeys, representing HIV-2. Social and technological changes in Africa resulted in transmission of HIV to larger and larger numbers of adults as roads were built and river transport developed, making travel to cities, with their better economic opportunities, far easier and more rapid. A silent heterosexual epidemic occurred and spread via travelers to industrialized nations of Europe and North America, where the new syndrome was initially recognized as a distinct clinical entity in 1981, even though the number of cases then was minuscule. By 1983, epidemiologists had discerned the routes of transmission and pointed the way for laboratory investigators to identify the etiologic agents. In 1984, the laboratory culturing of HIV was described in the scientific literature, as was the first serologic test for detecting the HIV antibody, which has been used to screen blood donations since 1985. Originally given three different names by the French (1983) and two American (1984) research teams that “discovered” the virus, the name HIV was agreed upon in 1986.

EPIDEMIOLOGY

HIV-1 has spread worldwide, infecting more than 36 million people by 2001. HIV-2, which seems to be less clinically severe and possibly less transmissible from person to person, has mainly been a public health problem for West African nations. Originally epidemic in African and urban settings, HIV and AIDS are now among the most common serious infections globally, including in the Americas and Eurasia and in rural settings. All ages, racial and ethnic groups, and persons of all sexual orientations have been infected.

VIROLOGY

HIVs are all members of the family known as retroviruses, so named because of their unique method of reproduction which uses the enzyme (protein catalyst) reverse transcriptase (RT) to incorporate its genetic material (RNA) into the DNA of the infected host's cells. HIV infects specific white blood cells of the host's immune system, known as T-helper lymphocytes (often referred to as CD4+ cells), and destroys them. Even though the immune system produces millions of new CD4+ cells every day, HIV destroys them just as rapidly. The genetic material of HIV has been sequenced, providing a database useful for research on vaccine and antiviral drug development. Many subtypes of HIV-1 have been characterized, but all are transmitted via the same routes and result in the same immunodeficiency.

SYMPTOMS, DIAGNOSIS, AND TREATMENT

Persons initially infected with HIV may develop an “acute retroviral syndrome” characterized by fever, lymph node enlargement, and flu-like symptoms. If symptoms are present, they clear spontaneously, but all infected persons, both with and without symptoms, remain infected and infectious to others indefinitely. The incubation period is highly variable, averaging about a decade, but ranging from a few months or years to possibly longer than two decades. When sufficient damage to the immune system has been sustained, measured either by laboratory cell counts of the T-helper cells or by onset of opportunistic infections, the patient is said to have AIDS. Common

manifestations of HIV infection include tiredness, lymph node enlargement, fever, weight loss, and yeast infections of the mouth and vagina.

HIV infection is diagnosed by laboratory detection of evidence of infection, usually identification of HIV-specific antibodies in a blood, oral fluid, or urine specimen. AIDS can be diagnosed in HIV-infected persons in several ways, based on either laboratory evidence of immunodeficiency (lowered levels of CD4+ cells), or clinically by onset of any one or more of a specific list of opportunistic diseases. Opportunistic diseases are those that occur only, or most severely, in patients whose immune systems are impaired. The most common opportunistic diseases in AIDS patients are *Pneumocystis carinii* pneumonia, Kaposi's sarcoma, toxoplasmosis of the brain, tuberculosis and other mycobacterial infections, and severe herpes, cytomegalo virus, and yeast infections.

As of 2001, all of the more than seventeen antiviral drugs used to treat HIV infection act by interfering with one of the enzymes that HIV needs to complete its life cycle. No treatments result in a cure for HIV infection. The antiviral drugs prevent HIV from growing and further damaging the host's immune system. Thus, the goal of treatment is to preserve the patient's health. Patients must take several antiviral drugs daily. Research on more and better antiviral drugs, and on methods to reconstitute the impaired immune system, is ongoing. A key part of treatment is the prevention of opportunistic infections with specific vaccines and antibiotics.

PREVENTION

Prevention of HIV infections is deceptively simple: Refrain from having sexual contact and from sharing drug-injecting paraphernalia with anyone who is infected. However, the rapid and continuing global spread of HIV, despite its well-known and severe clinical consequences, points out how difficult it is to change risky sexual and drug-taking behaviors. Many successful educational and social interventions have been demonstrated, but sustaining them in large populations for long periods requires extensive resources and a strong public health commitment. For example, latex condoms effectively prevent sexual transmission of HIV, but

making them available and educating infected persons or their sex partners to use them correctly and consistently has been accomplished only with extraordinary efforts in a few nations or settings. Some prevention efforts are considered controversial or are opposed by religious or other groups who interpret prevention efforts to reflect an acceptance of behaviors they do not condone on moral grounds.

The research effort to develop a vaccine to prevent HIV infection has been intense, but the biologic obstacles to success are immense and unprecedented. Because HIV permanently infects cells of the immune system, infection of a single cell results in lifelong infection for the host. Thus, a completely effective vaccine would need to prevent even a single cell from becoming infected. No such vaccine exists for any infection, so HIV will require a new vaccine paradigm. Possible lines of research include stimulating the immune system to detect and eliminate HIV-infected cells, or genetically transforming the HIV in an infected person so as to render it nonvirulent.

Further information on HIV and AIDS is widely available in many user-friendly and scholarly formats. The Internet is a rich source of information, with sites sponsored by public health agencies, such as the Joint United Nations Programme on HIV/AIDS (<http://www.unaids.org>) and the Centers for Disease Control and Prevention (<http://www.cdc.gov>) particularly recommended. Several texts, popular books, and scholarly journals have been devoted exclusively to AIDS public health issues and scientific research. The first of December has been designated World AIDS Day, and many governments, schools, and organizations sponsor community and educational events to coincide with that date each year.

D. PETER DROTMAN

(SEE ALSO: *Behavioral Change; Condoms; Contagion; Epidemics; Prevention; Sexually Transmitted Diseases*)

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HOLISTIC MEDICINE

The words "holism" and "holistic" are derived from the Greek word *holos*, meaning "whole." Jan Christian Smuts coined the term "holism" in a book published in 1926 titled *Holism and Evolution*. Holism is based on an understanding that the whole is greater than the sum of its parts. Practitioners of holistic medicine focus on the whole person, not just a specific disease, and believe that mind, body, and spirit are inseparable. They also believe that good health is not merely the absence of disease, that the body has an innate power to heal itself, and that lifestyle factors contribute to health and illness.

MARY JO KREITZER

(SEE ALSO: *Alternative, Complementary, and Integrative Medicine; Theories of Health and Illness*)

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HOLMES, OLIVER WENDELL

Oliver Wendell Holmes was born in Cambridge, Massachusetts, in 1809 and died in Boston in 1894. Known primarily as a writer and poet, Holmes embarked on a medical career in 1830. Three years later, he traveled to Paris to obtain more advanced training. He remained in Paris for two years before returning to finish his degree at Harvard Medical School in 1836. Holmes worked as a professor of anatomy at Dartmouth Medical College and as a private practitioner before obtaining

a position as a professor of anatomy at Harvard in 1847, a post he held until his retirement in 1882. During his time in Paris, Holmes's instructors had introduced him to the importance of the microscope for medical studies, and he regularly instructed his students in the use of the instrument in anatomical study.

Holmes made his most significant contribution to public health in the area of maternal health. Puerperal fever, a disease that surfaces following childbirth, claimed a significant number of women's lives, and physicians were unable to predict when it would strike or what caused it. Holmes became intrigued by several presentations on the topic at the Boston Society for Medical Improvement and initiated his own study on the subject that resulted in his seminal work, *The Contagiousness of Puerperal Fever*, which he read before the Society in 1843 and subsequently published. His investigation convinced him that physicians were themselves responsible for carrying the disease from one patient to another. Consequently, Holmes advocated the washing of hands, changing of clothes, and a twenty-four-hour period between handling corpses and treating patients.

Holmes's directions, however, were met with derision by some who would not believe that physicians could be the source of disease, and, even when followed, his suggestions did not always work. Yet, his protocols offered some response to a pressing public health concern and questioned the relationship between disease, patients, and physicians.

JENNIFER KOSLOW

(SEE ALSO: *Antisepsis and Sterilization; Maternal and Child Health; Pregnancy; Semmelweis, Ignaz*)

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HOME TESTING

Home testing generally refers to the use of a test or procedure outside of a professional medical care setting—usually within the privacy of one's own home—to acquire medical knowledge about one's own health. The test might be a laboratory test using a small amount of bodily fluid like saliva, blood from a finger prick, or urine. Perhaps the most commonly used home tests are pregnancy tests and various tests of urine or blood for monitoring diabetes. Because the use of home tests appeals to people who want to be involved in the management of their own illnesses, a large number of tests have been developed and marketed. In addition to home pregnancy and diabetes tests, there are tests for monitoring cholesterol levels, diagnosing urinary tract infections, and for HIV (human immunodeficiency virus) and hepatitis C infections.

Home testing may involve the use of a procedure or medical instrument to monitor health status. For example, people can be taught to take their own blood pressure to monitor treatment for hypertension, or to measure the functioning of their lungs if afflicted with asthma. More recently, home studies of sleep disorders have been carried out by individuals who report their results by computer to their physician for diagnosing or monitoring their conditions.

There are two basic types of home testing. Home collection involves the use of a kit to collect a sample in a person's own home. The sample is then mailed to a professional laboratory for processing. Results are provided to the individual through a confidential telephone service that may include counseling to help the patient interpret the results. Only one HIV and one hepatitis C home collection kit are currently approved by the Food and Drug Administration and available commercially in the United States. The second type of home testing involves doing the test in the home and interpreting the results through a change in color on a test strip, or some other simple device. Tests of this kind include home pregnancy tests and urinary tract infection tests.

There are many advantages to the use of home tests. Individuals can be empowered to take responsibility for their own health, and the immediate results help reinforce the measures used to control an illnesses, such as diabetes. Home testing also ensures privacy and confidentiality, which are important in the case of pregnancy or HIV testing. When there is social sensitivity associated with a disease such as HIV, home collection testing may appeal to certain individuals who wish to remain anonymous and do not want to obtain results in a health care setting.

In addition, health care costs may be reduced, since visits to the physician and the use of expensive laboratory tests can be curtailed. There are disadvantages to home testing, however. Many studies have demonstrated that the performance of tests in the home are subject to more error than those done in a controlled laboratory setting. Even approved and reliable home tests can generate false positive results (a positive/abnormal result when the individual is well) or false negatives (a negative/normal result when the patient is not well) when used by unskilled or untrained individuals. The misinterpretation of test results may generate unnecessary anxiety and stress for the individual.

RONALD K. ST. JOHN

(SEE ALSO: *Asthma; Blood Pressure; HIV/AIDS; Pregnancy*)

HOMELESSNESS

One of the most characteristic and consistent human behaviors over thousands of years is that humans build shelters. Homes offer protection from the elements and from a variety of health hazards and provide basic amenities such as a secure place to eat and sleep, to keep one's possessions, to raise a family, and be part of a community. Housing is a basic human need, yet the 1997 Human Development Report notes that more than 1 billion people—one-quarter of the world's population—live without shelter or in unhealthy and unacceptable conditions. Over 100 million people around the world have no shelter whatsoever. The health consequences of this level of homelessness are profound.

HOMELESSNESS IN NORTH AMERICA

Homelessness is a matter of concern anywhere in the world, but it is a particular cause for concern—and shame—when it occurs in the richest nations in the world. Sadly, homelessness is a significant problem in both the United States and Canada. Accurate statistics on the level of homelessness are hard to come by. In part, this is because definitions of homelessness vary. It includes not only those who are living on the streets or in shelters and hostels but also those who are living in temporary accommodation or in housing that is unfit for human habitation. Estimates of the number of people without homes in the United States vary from 230,000 to 3 million, including between 50,000 and 500,000 children. The U.S. Department of Housing and Urban Development estimated in 1999 that “there are at least 600,000 homeless men, women, and children in the United States on any given night,” adding that roughly one-third of this population is composed of families with children. In its 1997 position paper on eliminating homelessness, the American Public Health Association (APHA) noted that “as many as 7.4 percent of Americans (13.5 million people) may have experienced homelessness at some time in their lives.” Homelessness increased in the 1990s, and the fastest growing segment of the homeless population was homeless families.

In Canada, it was estimated in 1986 that 130,000 to 250,000 Canadians were homeless or living in substandard housing, while a one-night census by the Canadian Council for Social Development in 1987 found 10,672 people in emergency shelters—undoubtedly an undercounting of the true homeless. Up to half of the homeless in Canada now are believed to be families with children.

A wide array of factors contribute to homelessness, but they can be thought of as falling into one of two categories: structural problems and individual factors that increase vulnerability. Structural problems include a lack of affordable housing, changes in the industrial economy leading to unemployment, inadequate income supports, the deinstitutionalization of patients with mental health problems, and the erosion of family and social support. Added to this are factors that increase an individual’s vulnerability, such as physical or mental illness, disability, substance abuse, domestic

violence, or job loss. Reducing homelessness will mean addressing issues such as these.

THE HEALTH EFFECTS OF HOMELESSNESS

The health effects of homelessness include higher rates of infectious diseases, mental health problems, physical disorders, disability, and premature death. A United Kingdom report noted that those sleeping on the street on average lived only to their mid-to-late forties. Higher rates of infectious disease result from overcrowding, damp and cold living conditions, poor nutrition, lack of immunization, and inadequate access to health care services. There has been a particular concern with increased rates of tuberculosis (TB), particularly multiple drug-resistant TB. It has been reported, for example, that 48 percent of the homeless in Toronto test positive for TB. Another factor leading to increases in TB and other infectious diseases is the higher prevalence of AIDS (acquired immunodeficiency syndrome) in those segments of the homeless population involved in drug abuse and prostitution.

The conditions in which homeless people live also make them more prone to trauma. A study of street people in Toronto found that 40 percent had been the victims of assault in the previous year, while 43 percent of the women reported sexual harassment and 21 percent reported they had been raped in the previous year. These street people were also more than five times more likely to have been involved (as pedestrians) in a motor vehicle accident than the general population, and one in twelve of them had suffered frostbite in the previous year.

Homeless people are also more likely to suffer from cardiovascular, respiratory, arthritic, gastrointestinal, and skin disorders. The Toronto study found that arthritis and rheumatism were twice as frequent, emphysema and bronchitis five times as frequent, asthma two and one-half times as frequent, gastrointestinal problems twice as frequent, and epilepsy six times as frequent as in the general population.

Mental health problems contribute to and result from homelessness. The United Kingdom

report noted that 9 to 26 percent of those living on the street have serious mental health problems (compared to 0.5 to 2% in the general population), while Canadian estimates are that 20 to 40 percent of those using shelters have substance abuse or psychiatric problems. Alcohol abuse and dependency is also very common in this population. But while such substance abuse and mental health problems contribute to homelessness, homelessness also contributes to these problems. The Toronto study, for example, found that one-third of the street people interviewed had feelings of worthlessness, that more than one in four (and almost two-thirds of the women) had contemplated suicide in the past year, and that one in twelve (and almost one in three of the women) had attempted suicide in that same period.

The increase in homelessness among families in recent years has focused increasing attention on the serious health problems faced by children living in hostels and temporary accommodation. These problems include disturbed sleep, mood swings, depression, and developmental delays, as well as increased rates of obesity, anemia, infections, injuries, and other health problems.

HEALTH SERVICES FOR THE HOMELESS

Not surprisingly, given all their health problems, homeless people make significant demands on the health care system. The Toronto study found that in the previous year, two-thirds of street people had seen a physician, more than half had used emergency rooms, and one-quarter of them had been admitted to hospital. But at the same time, homeless people—both those living on the street and those living in hostels and temporary shelters—experience significant barriers in accessing care. These barriers include procedural barriers such as the need to have a home address or a health card, economic barriers in terms of purchasing necessary medications, medical supplies, or appropriate foods, and—perhaps worst of all—prejudice and rude treatment on the part of health care providers. It is particularly unfortunate that a group that is so vulnerable and has such high needs should suffer further indignity and prejudice from what are supposed to be the caring professions.

Homelessness is a significant public health and health care issue. But more than that, as the

APHA position paper concludes, “The persisting numbers of homeless people in America are an indictment of our collective failure to make basic ingredients of civilized society accessible to all citizens.”

TREVOR HANCOCK

(SEE ALSO: *Built Environment; Economics of Health; Healthy Communities; Social Health*)

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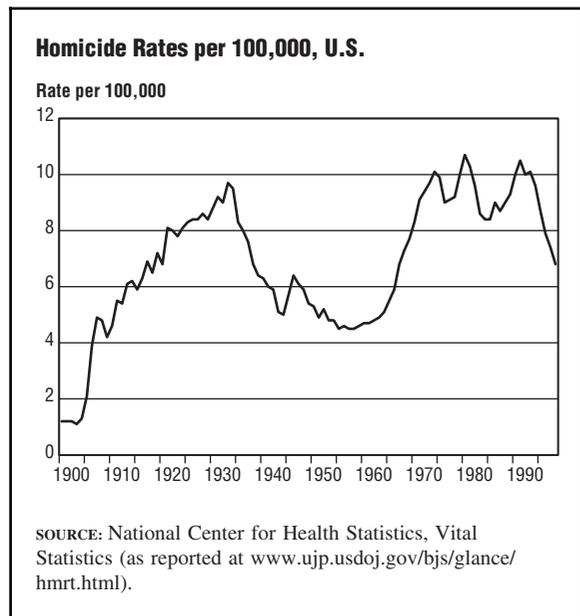
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HOMICIDE

Homicide is a long-standing threat to a community's health, although it began to be widely recognized as a public health issue only in the 1990s. Homicide has traditionally been viewed through the lens of crime, though both criminal justice and public health approaches can be useful in efforts to reduce homicide.

Public health descriptions of homicide are based largely upon information provided on death certificates. In the United States, death certificate

Figure 1

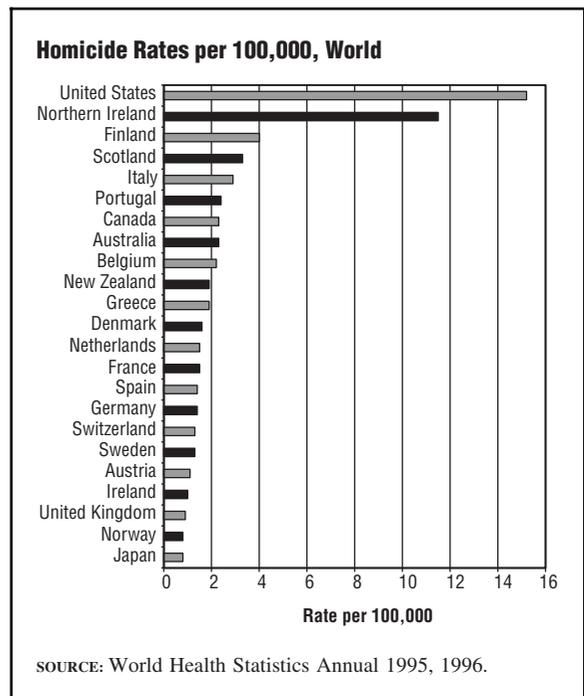


information is reported to each county by funeral directors, physicians, and coroners. Each county reports the information to the state, which, in turn, reports it to the National Center for Health Statistics. These data cover every death (regardless of cause of death) for which there is a body. In vital statistics data, and for public health purposes, a homicide is defined as the death of a person at the hands of another.

Law enforcement data about crime are gathered by police and sheriff's officers at the local level, reported to a central agency at each state, and then forwarded on to the Federal Bureau of Investigation. Participating in The Uniform Crime Reports (UCR) is a voluntary process, and about 85 percent of police departments—covering 96 percent of the U.S. population—participated in UCR as of 1991. The data about homicides are reported in the Federal Bureau of Investigation's (FBI) *Supplementary Homicide Report*. The FBI defines a homicide as murder—the willful (nonnegligent) killing of one human being by another.

In addition to murders, the public health definition of homicide includes legally sanctioned killings (e.g., executions or homicides in self-defense). The law enforcement definition, however, is limited to criminal homicides. Because the

Figure 2



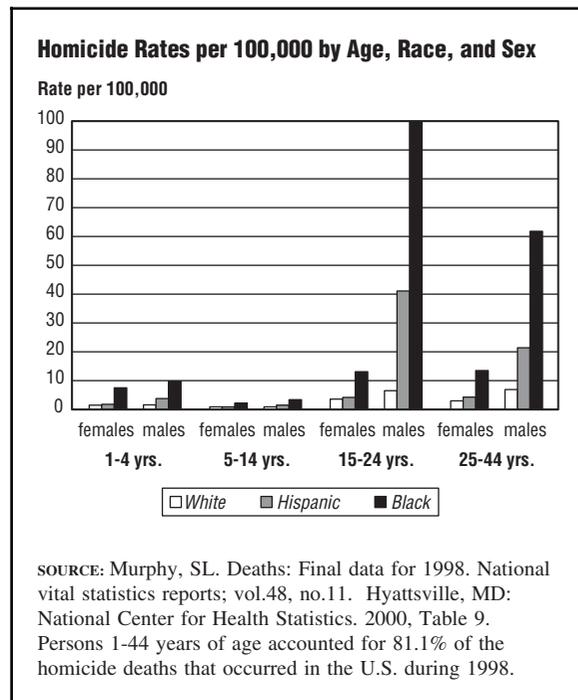
definitions differ, the numbers of homicides reported by each system also differ. The overall patterns of risk, however, are the same.

EXTENT OF THE PROBLEM

Homicide rates in the United States peaked in 1993, dropped substantially, and the homicide rate in 1998 was the same as that in 1968 (see Figure 1). Although people were alarmed at the high homicide rates in the early 1990s, these rates have vacillated throughout the twentieth century. Historians believe that homicide rates were probably even higher in the Middle Ages in Europe.

The United States has a much higher homicide rate than other industrialized countries (see Figure 2). Although not included in the chart, it may be useful to note that among those countries reporting rates to the World Health Organization, Colombia actually has the highest rate by far—146.5 homicides per 100,000 males. The discrepancy appears to be largely due to the much higher number of deaths due to firearms in the United States. Even when compared to other countries where firearms are relatively common, homicide

Figure 3



rates in the United States are higher, possibly because firearms in the United States are much more likely to be handguns, whereas in other countries the guns are most likely to be rifles and shotguns. Handguns are the leading method of homicide in the United States.

HOMICIDE RISK

Some people are at higher risk than others of becoming a homicide victim. Homicide victimization rates are highest for adolescents and young adults. Although the number of young people who are homicide victims has dropped since 1993, as it has for all age groups, adolescents and young adults continue to be the age group at highest risk of homicide. As shown in Figure 3, risk is higher for young men than young women, and risk is highest for young minority men, especially young African-American men.

Homicide is a major cause of mortality among infants and toddlers. In fact, homicide is the third leading cause of death of persons under five years of age. In most of these deaths, the assailant is the primary caretaker of the child—either a parent,

stepparent, or partner of one of the parents. The most common method of death is by beating with personal weapons (i.e., hands, fists, or feet).

Although homicide rates are much higher among men than women, the rank of homicide as a cause of death is similar for men and women at all age groups. Firearms are the most common method of homicide for both male and female victims. The assailant and the location of the homicide differ by gender, however. Men are most likely to be killed by a friend or an acquaintance in a public place such as the street or a bar. Despite a general concern about “stranger danger,” women are most likely to be killed by a current or former male intimate (i.e., a husband, boyfriend, ex-husband, or former boyfriend) in the home. Research using data from the mid-1970s through the mid-1980s found that a woman is more than two and one-half times as likely to be shot by her male intimate as to be shot, stabbed, strangled, bludgeoned, or killed in any other way by a stranger.

Research indicates that having a gun in the home increases the chances that a person will become a victim of a homicide in the home and that a person will become a perpetrator of homicide, though more scientific research is needed before such risks can be assessed with confidence.

HOMICIDE AND PUBLIC HEALTH

Public health approaches to homicide are based largely in one of two frameworks: injury prevention and, for lack of a more specific descriptor, social change. Injury prevention traces its roots to Hugh De Haven, a World War I pilot who, after surviving an airplane crash, spent many years studying the dynamics of traumatic force upon the body. Subsequent work focused on motor vehicle crashes. Researchers found that trying to change human behavior (e.g., trying to get drivers to “drive defensively”) did not work very well. In fact, some efforts, such as drivers’ training, did not reduce crash or injury rates at all. Strategies that focused on the environment and the vehicle itself proved to be more successful. Roads were designed not just to get from point A to point B, but with injury prevention in mind. For example, rigid signposts and bridge abutments have been modified so that even if a vehicle veers off the roadway, an injury is not inevitable. Vehicles are now

equipped with collapsible steering wheels, reinforced side doors, seat belts and airbags, and antilock brakes. In other words, efforts switched from preventing a crash from occurring to preventing an injury if a crash occurred.

Injury prevention practitioners and researchers took this same model from unintentional injury (i.e., car crashes, drownings, and other “accidents”) into their work with homicide. They set their sights clearly and specifically on one question: If the violence cannot be stopped, how can the violence be made less lethal? Given that guns (handguns in particular) are used in most homicides, it is not surprising that injury prevention efforts related to homicide focus mainly on handguns. Public health efforts to reduce gun fatalities have focused largely on the manufacture of guns (e.g., “smart guns” that are personalized so that only an authorized user can shoot the weapon). Policies related to the marketing and advertising, sale, possession, and use of guns also are points of intervention.

The social change, or social justice, approach emphasizes the inequalities that might give rise to lethal violence. The epidemiological data presented in the figures document how risk differs across nations and across groups in the United States. The social justice approach tries to understand why these differences might exist, and to identify ways to remedy the situation. For example, why do minorities have a much greater risk than white people of dying of homicide? Areas of investigation include differences in socioeconomic status (e.g., income and education), limited opportunities (e.g., inner-city schools that are more likely to be attended by minorities generally are less well funded than suburban schools), and the effects of institutional racism (e.g., racial profiling by law enforcement).

Social change approaches seek to expand educational, recreational, and employment opportunities, especially for young people. Related approaches have attempted to increase adolescents’ problem-solving and anger-management skills so that violence becomes an option, not an inevitability. Evaluations of such programs have produced inconsistent results. Some, such as W. R. Hammond and B. R. Yung, say certain programs are effective, whereas others, including D. W. Webster, find few positive effects.

The injury prevention and social change approaches need not be in competition, although they are sometimes cast that way. Efforts to reduce homicide will likely be more successful if a multifaceted approach, rather than one single strategy, is taken.

SUSAN B. SORENSON

(SEE ALSO: *Domestic Violence; Public Health and the Law; Violence*)

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HOOKWORM

Hookworm infections are caused by intestinal nematodes (roundworms), with most human infections being caused by either *Necator americanus* or *Ancylostoma duodenale*. Less frequently, human hookworm infections may be caused by *A. ceylanicum* or *A. caninum*. Occasionally, animal hookworms such as *A. brasiliensis* cause disease in humans. Hookworm infection is widely distributed throughout tropical and subtropical regions of the world. Favorable conditions for the spread of infection include warm temperatures, high humidity, shade, and contamination of soil with human feces.

It is estimated that up to one-fifth of the world's population is infected with hookworms. Humans harbor the adult worms in their small intestine. Eggs are passed in stool and will hatch within twenty-four to forty-eight hours if conditions are favorable. After hatching, the larvae molt twice in soil and, in approximately ten days, become infective filariform larvae. When a barefoot human walks in contaminated soil these filariform larvae penetrate the skin, migrate through the blood stream to the lungs, break through pulmonary capillaries into the alveoli, and then travel up the tracheobronchial tree to the epiglottis. The larvae are then swallowed and reach the small intestine where they mature into adult worms. Eggs will appear in the stool within one to three months. Female worms will lay between 5,000 and 10,000 eggs a day for up to ten years; the average adult lifespan is four to six years.

Larval penetration of skin may cause local itching and a papulovesicular rash, sometimes called "ground itch." Nonhuman hookworm infections classically produce a very pruritic migratory linear rash. As human hookworm larvae migrate through the lungs there may be mild pulmonary symptoms, usually a cough or wheezing. There may also be gastrointestinal symptoms such as nausea, abdominal pain (peptic ulcer-like symptoms), or diarrhea during the intestinal phase; however, the infection is usually asymptomatic. The major problems attributable to hookworms are iron deficiency, anemia, and protein deficiency,

which are frequently seen in malnourished individuals who are infected with a large number of worms. Each hookworm consumes approximately 0.03 to 0.15 milliliters of blood each day. A large number of worms can remove enough blood to cause an anemia severe enough to result in growth retardation in children. Anemia does not usually occur in those with normal iron intake.

Diagnosis is made by finding the characteristic eggs in stool. Treatment involves the elimination of the worms and correction of anemia and protein deficiency, if present. Medications that are effective against hookworm include albendazole, mebendazole, and pyrantel pamoate.

Humans are the only reservoir of infection for *N. americanus* and *A. duodenale*. Prevention of hookworm infection involves good sanitation systems and public education regarding the risks of contamination of soil with human feces and the importance of wearing shoes in endemic areas.

Elimination of hookworm infection in a population would reduce levels of anemia and malnutrition and result in improved physical and intellectual development. All members of a community are at risk of infection, but certain groups are more vulnerable to the effects of chronic infection, including preschoolers, school-age children, and women of child-bearing age. Community control programs are often targeted specifically at these groups.

Humans do not develop an immunity to hookworm infection and can be reinfected with subsequent exposures. For this reason, eradication programs such as mass treatments of a population need to be repeated on a regular basis.

MARTHA FULFORD
JAY KEYSTONE

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HOSPITAL ADMINISTRATION

The 1998 edition of *Hospital Statistics* published by the American Hospital Association reported that 6,021 hospitals existed in the United States. These included acute care general hospitals; federal, state, and local hospitals; psychiatric hospitals; and specialty hospitals such as children's hospitals, rehabilitation hospitals, and chronic disease hospitals. There were 5,015 short-term, acute care general facilities. Short-term, general hospitals are defined as those for which a patient stay is thirty days or shorter and which provide general medical and surgical care. General hospitals often provide additional services including prevention, treatment, rehabilitation, obstetrics, substance abuse, health education, and screening for cancers and other diseases.

Modern hospitals derive historically from the monastic "hospes" of tenth-century medieval England at which travelers stopped to rest. Later, in the thirteenth century, the hospice became a place for vagrants, invalids, and the infirm.

Benjamin Franklin founded the first hospital in the United States, the Pennsylvania Hospital, which was chartered in 1757. Hospitals during this period provided refuge and homes for the poor, ill, and infirm who had no other place to live. Nineteenth- and early-twentieth-century hospitals in the United States were primarily for the treatment of communicable disease, such as tuberculosis or leprosy, for which people were quarantined. Most people generally preferred to be treated for acute illness at home. Before the discovery of germ theory, the home was actually a healthier environment than the hospital. Later, as scientific medical practice developed, hospitals became more technical places of diagnosis and treatment for those who could afford to be hospitalized and pay for the new scientific technologies.

As a result of their increasing role in health care, hospitals became important community resources. The community not-for-profit hospital continued the role of providing charity care for

the poor. After World War II, the Hospital Survey and Construction Act of 1946 (Hill-Burton Act) provided funding for communities across the country to build not-for-profit community hospitals and to modernize old ones. This legislation was critical to locating hospitals in previously underserved rural areas. Society has long viewed the hospital as a social service organization. Public hospitals serve an important public health function in caring for vulnerable and underserved populations, including the poor, immigrants, and the uninsured.

TYPES OF HOSPITAL OWNERSHIP

Government hospitals at the federal, state, or local level generally care for specified groups of individuals or diseases. This includes the military, the mentally ill, or the uninsured, among others. In addition, this includes educational or academic hospitals where medical education is taught. Private not-for-profit hospitals are usually owned by corporations, which are founded by private organizations. For-profit or investor-owned hospitals are those in which the shareholders receive dividends or financial distributions based on the profits made by the hospital or the hospital's corporation.

Regardless of ownership, most hospitals are *community* hospitals, which provide care for a wide range of acute episodes of illness. Acute episodes are serious short-term illnesses for which patients require immediate care and are then returned to their homes or community.

ORGANIZATION AND FUNCTION OF HOSPITALS

Hospital administration encompasses organizing and supporting the patient's total medical care during an episode of illness in the hospital, and is responsible for integrating the various functions and services. A hospital is a multifaceted organization comprising many committees, departments, types of personnel, and services. It requires highly trained employees, efficient systems and controls, necessary supplies, adequate equipment and facilities, and, of course, physicians and patients. It is a business as well as a caring, people-oriented institution and it has a similar structure and hierarchy of authority as any large business.

Board of Trustees. The “board of trustees,” or governing board, operates the hospital in trust for the community and has a fiduciary duty to protect the assets of the hospital through efficient operation. The trustees are responsible for establishing the hospital’s mission and establishing its bylaws and strategic policies. Trustees select the administrative leader of the hospital and delegate the hospital’s daily operations and budgeting to the appointed executive. They ensure the quality of medical care through the selection of qualified physicians and by delegating quality assurance responsibilities to the medical staff.

Executive Administration. The chief executive officer (CEO) reports to the governing board and provides leadership in implementing the strategic goals and decisions set by the Board. The CEO also represents the hospital to the external environment and the community. In these tasks, the CEO must coordinate the collective effort of the hospital’s personnel. The CEO delegates the clinical care and administrative duties to highly trained individuals and teams.

The Medical Staff. The physician is the leader of the clinical team and the major agent working on behalf of the patient. The physician’s responsibility is to diagnose the patient’s condition accurately and to prescribe the best and most cost-effective treatment plan.

The medical staff is a formally organized self-governing unit within the hospital, primarily comprised of physicians, but may also include other doctoral level health care professionals such as dentists or psychologists. Responsibility for the quality of medical care is exercised through the medical staff, whose major purpose is to ensure the highest quality of medical care to the patients. This is done through four functions: “Credentialing” determines and assesses the qualifications of physicians seeking to practice at the hospital. “Privileging” determines the specific types of care that individual physicians will be allowed to practice at the hospital. “Peer review” monitors how well a physician is performing. “Reappointment” ascertains whether a specific physician should be permitted to continue practicing at the hospital.

Nursing Services. Nursing services employees are responsible for carrying out the treatment plan developed by the physician. Nursing services, also

called patient care services, is the largest component of the hospital. It is also the largest health care occupation in the United States. Nursing services provide round-the-clock health maintenance, treatment, and support of the patient. Important roles of nurses today also include those of patient advocate and health educator.

Members of the nursing staff represent a wide range of training and experience. A nurse manager has overall responsibility for the care of patients on a particular unit, including supervising other nursing and clerical staff, and for coordinating the services of departments such as social work and discharge planning. A nursing supervisor may have overall management responsibility for several units. A clinical nurse-specialist has specific expertise or competence in a particular field of nursing. These nurses are helped by licensed practical nurses (LPNs) and certified nurses aides (CNAs), who perform routine nursing functions.

Allied Health Services. A number of departments perform support functions that help with diagnosis and treatment. The clinical laboratory is a diagnostic center that performs a variety of functions, including autopsy, clinical cytology, and clinical pathology. Medical technologists perform most of the work of the laboratory under the supervision of a pathologist, who is a physician.

The radiology department provides radiographs to aid with diagnosis and performs radiation therapy for the treatment of some medical disorders.

Rehabilitation services provides assistance in enhancing the optimal physical, mental, and social functioning of the patient following an episode of illness. Physical and occupational therapy are the primary specialties in this service.

Clinical Support Services. The hospital pharmacy purchases and dispenses all the medications used to treat patients in the hospital. The pharmacist works directly with the medical staff in establishing a formulary, the listing of drugs chosen to be included in the pharmacy. Clinical pharmacy consists of communicating with patients, counseling patients and other members of the health care team, and consulting with regard to detailed drug information.

Social services integrates the patient, the medical team, and the community. The primary objective

is to ensure that all environmental and emotional barriers to the patient's recovery are mitigated. Social services helps coordinate needed community-based services, and sometimes discharge planning. Hospital dietitians play an important therapeutic role in providing the patient with the appropriate food and nutrition, consistent with the treatment plan prescribed by the physician.

Administrative Support Services. Nonmedical administrative services are necessary to the hospital's business and physical plant management. The CEO leads these administrative services and is directly responsible for the day-to-day operations of the facility.

Business services manages the hospital's admitting and discharge functions, records charges to a patient's account, and handles accounts receivables with third-party payers such as insurance companies. The finance department advises the CEO on financial policy and long-range planning, establishes procedures for accounting functions, receives and deposits all monies received by the hospital, and approves the payments of salaries and other expenditures.

Accounting is central to the hospital's financial business. Detailed and sound accounting practices are fundamental to maintaining important organizational statistics for administrative decision-making. The accounting department is responsible for maintaining the general ledger and summarizing all the financial transactions performed by the hospital, preparing and dispensing the payroll, tracking and recording costs to enable appropriate reimbursement for services from insurance companies, and preparing the capital and operating budgets.

Admitting services is often where the patient first has contact with the hospital. The sensitivity and efficiency of this department can greatly influence the patient's perception of the quality of care received.

Information services and medical record maintenance are core functions of hospital management. Medical records have recently been designated a source of revenue as they have a direct bearing on reimbursement from insurance companies. Medical records are maintained on all admitted patients and they are indexed according to physician, disease, and operation.

The human resources department interacts with all departments in the hospital to ensure the quality and motivation of personnel working at the hospital. Human resources performs job analyses, develops job descriptions, and establishes competitive compensation for specific positions, as well as providing training to new employees and opportunities for growth and self-actualization for all employees.

Other important administrative and business functions may include marketing and planning, public relations, plant and materials management, fund-raising, housekeeping, and security.

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(SEE ALSO: *Careers in Public Health; Economics of Health; Health Administration, Career in; Health Maintenance Organization [HMO]; Nurse; Physician*)

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HOTLINES, HELPLINES, TELEPHONE COUNSELING

Cigarette smoking, poor diet, lack of exercise, and heavy use of alcohol and drugs are growing causes of early death and disability in most countries. There are programs available to help people change these behaviors, but it has been an ongoing challenge to get these programs to those who would

benefit from them. Telephone helplines and individual counseling programs delivered by telephone are key strategies for reaching large numbers of people. In smoking cessation, for example, state-wide hotlines provide support for quitting and offer referrals to community-based programs. Many smoking cessation programs are delivered by telephone rather than by having people attend group sessions. The availability of these resources can be easily advertised through the mass media, making it more likely that people will know about them and take advantage of them.

SUSAN J. CURRY

(SEE ALSO: *Communication for Health; Community Organization; Mass Media; Smoking Cessation; Substance Abuse, Definition of*)

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HOUSEHOLD SURVEYS

See National Health Surveys; Survey Research; and Surveys

HOUSING

See Regulations Affecting Housing

HUMAN DEVELOPMENT INDEX

Human development can be viewed as the process of achieving an optimum level of health and well-being. It includes physical, biological, mental, emotional, social, educational, economic, and cultural components. Only some of these are expressed in the Human Development Index, a composite scale that has three dimensions: life expectancy at birth, adult literacy rate and mean years of schooling, and income as measured by real gross domestic product per capita. Like all one-dimensional scales that attempt to measure multiple complex variables, it is flawed by inherent inaccuracies, but it is

nonetheless a useful comparative measure of the well-being of a population.

JOHN M. LAST

(SEE ALSO: *Assessment of Health Status; Health Measurement Scales*)

HUMAN GENOME PROJECT

The Human Genome Project (HGP) is an international research program that aims to spell out the complete genetic inheritance of human beings and selected experimental animals. The HGP's goal is to decode the complete DNA inheritance, or genome, of human beings by 2003; following completion of a draft in 2000 that charted 90 percent of the human DNA inheritance. In addition to decoding human and animal DNA, the HGP trains scientists, develops techniques for analyzing genomes, and examines the ethical, legal, and social implications of human genetics research.

DNA is the long thread of a molecule that carries genes. Each strand of DNA, packaged as a chromosome, bears thousands of genes. Each gene contains the instructions for making a single component of the body, usually a protein. The hereditary instructions embedded in DNA are written with a four-letter alphabet (A, G, C, and T). A single misspelling in the DNA code can lead to the production of a defective protein, which can cause disease.

Understanding the human genome, the complete set of genes, sheds light on how the human body works at the fundamental level of molecules. Genes orchestrate the many fantastic and elegant features of life, like the development of embryos, while variations in gene sequence influence each person's susceptibility to diseases, including common illnesses like cancer and heart disease. The HGP will ultimately answer a wide range of scientific and medical questions, including: How do cells work? How do complex organisms develop from single cells? How are living beings related to each other? How do diseases arise?

The HGP was officially launched in 1990, as a joint project of the U.S. government and international partners. It was established as a large-scale, coordinated research project, marshaling

the collaborative effort of hundreds of researchers. Between 1990 and 2003, the HGP is expected to reveal the sequence of approximately 3 billion "letters" that make up human DNA to identify all of the approximately 100,000 genes in human DNA, and to make all this information accessible to anyone with access to the Internet. The tools the HGP has built, including increasingly detailed maps of the human genome, helped genetic researchers navigate the genome and discover scores of disease genes in the 1990s. By 2003, a 99.99 percent-accurate listing of the letters that make up the DNA in all the human chromosomes is expected; that readout of the human genome, along with catalogs showing how DNA sequences vary among individuals, will help scientists tease out the genetic basis for complex diseases like diabetes, Alzheimer's disease, cancer, and heart disease—illnesses whose origins can be traced to the effects of multiple genes, as well as social and environmental factors.

By helping reveal the molecular foundations of disease, the HGP is expected by some to transform health care. Genetic technologies are becoming increasingly available. For example, genetic tests are being used to confirm diagnoses for some conditions, and to help define prognoses. Other tests predict the risk for future health problems. In time, more detailed understanding of the molecules involved in disease is expected to promote more rational drug design, making for increasingly precise, in some cases individualized, pharmacologic therapies that will minimize side effects or even avoid them altogether. Ultimately, understanding the molecular origins of disease may reveal ways of preventing many diseases entirely, perhaps by circumventing molecular glitches that can lead to illness or by repairing the altered molecules outright.

While genetic information and technology are likely to create great opportunities for promoting health and preventing disease, some risks are likely to accompany these powerful technologies. Genetic information can be misinterpreted or misused. As knowledge about individuals' genetic backgrounds becomes increasingly widespread, some insurers and employers may use predictions about future health to limit or deny access to health care or employment. Therefore, protecting the privacy of genetic information and preventing genetic discrimination will be crucial. To tap the full benefits

of genetics, the medical profession and the public will need to become better equipped to evaluate the meaning of genetic information and to make decisions about the use of the new genetic technologies. At the same time, proper oversight will be necessary to ensure that gene tests and technologies are valid and reliable, sensitive, and specific, and used in appropriate situations.

Genetics, which was largely confined to research laboratories during the twentieth century, is expected to pervade everyday life in the twenty-first century. In the arena of public health, it may be used to access individuals' risks for health problems and to develop programs of preventive health care. Knowing their susceptibility to various health risks, individuals may be able to adopt a schedule of surveillance, perhaps take medications that will prevent health problems, and ideally become motivated to adopt lifestyle measures that will minimize their risks.

Most observers argue that the goal of public health genetics programs should be phenotypic prevention—preventing the emergence of disease—rather than genotypic prevention which is trying to change the genes people inherit. To attempt to prevent the transmission of particular genetic traits to future generations as a public health measure would tread into eugenic territory. Instead, public health goals should be designed to forestall the clinical manifestations of genetic risks.

FRANCIS S. COLLINS
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(SEE ALSO: *Genes; Genetic Disorders; Genetics and Health; Medical Genetics*)

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National Human Genome Research Institute site on the World Wide Web: <http://www.nhgri.nih.gov>.

HUMAN PAPILLOMAVIRUS INFECTION

Genital human papillomavirus (HPV) infection is a common sexually transmitted disease (STD) caused by human papillomavirus. This is a group of more than one hundred viruses, at least thirty-five of which can infect the genital tissues. HPV is spread by direct contact of infected tissue with uninfected tissue during vaginal, anal, or oral sex. An estimated 50 percent of sexually active adults have been infected with one or more of the HPV types that cause genital infections. At any time, an estimated 20 million Americans have genital HPV infections. About 5.5 million Americans get a new genital HPV infection each year.

Most types of HPV that infect genital tissues do not cause any symptoms. Certain types of HPV cause genital warts that usually appear as soft, moist, pink, or red swellings that grow quickly. Several types of genital HPV infection (not usually the types that cause warts) can increase the risk of cervical cancer in women and other genital cancers in both women and men. A small percentage of women with certain types of abnormal cells will develop cancer if these cells are not removed. Frequent Pap smears and careful medical follow-up, with treatment if necessary, can help ensure that precancerous cells caused by HPV infection do not develop into life-threatening cervical cancer. Treatment can eliminate genital warts, but it does not necessarily eliminate genital HPV infection.

Latex or polyurethane condoms can help protect both the male and the female partner from most STDs. However, genital HPV, including genital warts, may be present in areas not covered by the condom, resulting in transmission of infection to a new person.

ALLISON L. GREENSPAN
JOEL R. GREENSPAN

(SEE ALSO: *Sexually Transmitted Diseases*)

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HYPERLIPIDEMIA

The term "hyperlipidemia" describes an extreme elevation in any of several lipid (fatty) substances in the bloodstream, as in conditions such as hypercholesterolemia and hypertriglyceridemia. Most of these disorders cause an increased risk for atherosclerosis, which is a buildup of plaque within the arterial wall that can lead to heart attacks, strokes, and gangrene. An elevated high-density (healthy) cholesterol, however, is a hyperlipidemia that protects from plaque buildup. To be called a hyperlipidemia, the value of the lipid elevation generally has to be greater than 95 percent above the average level for a person of the same age and gender in the population. Most hyperlipidemias are acquired through genes transmitted from one or both parents, although some persons may acquire a hyperlipidemia through dietary means.

DONALD A. SMITH

(SEE ALSO: *Atherosclerosis; Blood Lipids; Cholesterol Test; Fats; HDL Cholesterol; LDL Cholesterol; Lipoproteins; Triglycerides; VLDL Cholesterol*)

HYPERSENSITIVITY PNEUMONITIS

Hypersensitivity pneumonitis, also called extrinsic allergic alveolitis, is an inflammatory condition of the lung caused by the inhalation of small organic or, less commonly, inorganic particles in susceptible individuals. Some thirty different varieties of the condition have been described, the most common of which is known as "farmer's lung." Hypersensitivity pneumonitis represents an important category of occupational lung disease. The inhaled particles are usually fungal spores or bacteria that are found in moldy or rotting material, including hay, compost, bark, wood dust, and

grains. Hypersensitivity pneumonitis affects the tissue of the lung where gas exchange occurs and is distinguished from bronchial asthma, which affects the lungs' airways. The condition may be acute or chronic. Treatment consists of avoiding exposure and, in severe cases, the administration of corticosteroid drugs.

JOHN L. STAUFFER

(SEE ALSO: *Asthma; Occupational Lung Disease*)

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HYPERTENSION

See Blood Pressure

HYPERTHYROIDISM

Hyperthyroidism is the condition that reflects excessive concentrations of thyroid hormones, due to any cause. The resulting hypermetabolic state causes increased heat production and accelerates many of the bodies' processes. Common causes are Graves' disease, hyperfunctioning benign thyroid tumors, and thyroid inflammations. Untreated, patients may have severe and progressive disability that includes weight loss, muscle weakness, loss of mineral from their bones, and increased risk for dangerous heart arrhythmias. Available treatments include one of several "antithyroid drugs," such as methimazole and propylthiouracil, that prevent overproduction of thyroid hormones, and radioactive iodine (I-131) treatment or surgery, which either destroy or remove the thyroid tissue.

MARTIN I. SURKS

(SEE ALSO: *Goiter; Hypothyroidism; Thyroid Disorder*)

ders; Thyroid Function Tests)

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HYPOGLYCEMIA

See Diabetes Mellitus and Nutrition

HYPOTHYROIDISM

Hypothyroidism is the condition that reflects decreased concentrations of thyroid hormones, due to any cause. The resulting hypometabolic state causes decreased heat production and generally slows many of the bodies' processes. Its prevalence is 1 to 3 percent of young to middle-aged adults, mainly women, and its incidence rises with age. Severe hypothyroidism occurs in 2 to 4 percent of women older than seventy years of age, and milder forms of disease in 8 to 15 percent. Outside of North America, iodine deficiency is a major cause of hypothyroidism. In the United States, causes include Hashimoto's disease and treatment of hyperthyroidism—either by surgery or radioactive iodine (I-131). Treatment for hypothyroidism consists of hormone supplementation, generally synthetic l-thyroxine, taken once per day.

MARTIN I. SURKS

(SEE ALSO: *Goiter; Hyperthyroidism; Iodine; Thyroid Disorders; Thyroid Function Tests*)

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I

ILLNESS AND SICK-ROLE BEHAVIOR

Generally, health-related behaviors of healthy people and those who try to maintain their health are considered as behaviors related to primary prevention of disease. Such behaviors are intended to reduce susceptibility to disease, as well as to reduce the effects of chronic diseases when they occur in the individual. Secondary prevention of disease is more closely related to the control of a disease that an individual has or that is incipient in the individual. This type of prevention is most closely tied to illness behavior. Tertiary prevention is generally seen as directed towards reducing the impact and progression of symptomatic disease in the individual. This type of prevention is highly related to the concept of sick-role behavior. In general, illness and sick-role behaviors are viewed as characteristics of individuals and as concepts derived from sociological and sociopsychological theories.

ILLNESS BEHAVIOR

The concept of illness behavior was largely defined and adopted during the second half of the twentieth century. Broadly speaking, it is any behavior undertaken by an individual who feels ill to relieve that experience or to better define the meaning of the illness experience. There are many different types of illness behavior that have been studied. Some individuals who experience physical or mental symptoms turn to the medical care

system for help; others may turn to self-help strategies; while others may decide to dismiss the symptoms. In everyday life, illness behavior may be a mixture of behavioral decisions. For example, an individual faced with recurring symptoms of joint pain may turn to complementary or alternative medicine for relief. However, sudden, sharp, debilitating symptoms may lead one directly to a hospital emergency room. In any event, illness behavior is usually mediated by strong subjective interpretations of the meaning of symptoms. As with any type of human behavior, many social and psychological factors intervene and determine the type of illness behavior expressed in the individual.

Considerable research exists showing the importance of age and gender in illness behavior. Illness behavior, as shown in the use of medical services, is far greater in women. Many studies have linked illness-behavior variation to ethnicity, education, family structure, and social networks. Illness behavior is also shown to be related to health care coverage and insurance. Most importantly, illness behavior is highly related to socioeconomic status. Classic studies done in the 1950s powerfully demonstrated that socioeconomic class influenced how symptoms were acted on, with lower-class individuals (lower in socioeconomic status) most likely to delay seeking professional health care even when presented with severe symptoms.

While much of the early work on illness behavior was seen in the context of understanding patient help-seeking behavior, the large research

literature on illness behavior has gone well beyond this more narrow medicalized view. Many studies have considered the different perspectives of illness behavior held by individuals and health care practitioners. The differing worldviews of patients and practitioners are now seen as highly relevant to illness behavior. The medical practitioner and the individual experiencing symptoms go through very different appraisals of the meaning of the symptoms. Increasingly in the literature there is the recognition of the strong relationship between the physical and mental experience of symptoms and the meaning of that experience for illness behavior. David Mechanic, a pioneer in the study of illness behavior, best summarizes the current perspective on illness behavior: "Illness behaviors arise from complex causes, including biological predispositions, the nature of symptomatology, learned patterns of response, attributional predispositions, situational influences, and the organization and incentives characteristic of the health care system that affect access, responsiveness and the availability of secondary benefits" (Mechanic, 1995).

SICK-ROLE BEHAVIOR

The sick role is a concept arising from the work of the important American sociologist Talcott Parsons (1902–1979). Parsons was a structural functionalist who argued that social practices should be seen in terms of their function in maintaining order or structure in society. Thus Parsons was concerned with understanding how the sick person related to the whole social system, and what the person's function is in that system. Ultimately, the sick role and sick-role behavior could be seen as the logical extension of illness behavior to complete integration into the medical care system. Parsons' argument is that sick-role behavior accepts the symptomatology and diagnosis of the established medical care system, and thus allows the individual to take on behaviors compliant with the expectations of the medical system. Basically, Parsons defined the "sick role" as having four chief characteristics. First, the sick person is freed or exempt from carrying out normal social roles. The more severe the illness, the more one is freed from normal social roles. Everyone in society experiences this; for example, a minor chest cold "allows" one to be excused from small obligations such as attending a social gathering. By contrast, a

major heart attack "allows" considerable time away from work and social obligations. Second, people in the sick role are not directly responsible for their plight. Third, the sick person needs to try to get well. The sick role is regarded as a temporary stage of deviance that should not be prolonged if at all possible. Finally, in the sick role the sick person or patient must seek competent help and cooperate with medical care to get well. This conceptual schema implies many reciprocal relations between the sick person (the patient), and the healer (the physician). Thus the function of the physician is one of social control.

The complicated theoretical explanations of Parsons yielded a voluminous research literature in the second half of the twentieth century, and they continue to stimulate much research today. In particular, there has been much study of the norms and values that define the behaviors of both the sick and those providing treatment. These studies form the basis for present-day research on the patient-physician relationship. They inform the various strategies undertaken by behavioral scientists to intervene in this relationship to bring about positive behavioral changes in both patient and practitioner that will lead to better health outcomes.

There are many research issues attendant to understanding this complicated relationship between patient and practitioner. One paramount issue is that of the differential power of the participants in the relationship. According to this view, the superior power of the physician, in terms of technical expertise and status, will more effectively induce the patient toward a positive medical outcome. It is this superior power that helps make possible the often painful procedures to which the patient concedes.

CONCEPTS OF ILLNESS BEHAVIOR AND SICK-ROLE BEHAVIOR IN PUBLIC HEALTH

In present-day public health practice, which is based on population and community-based approaches with an emphasis on participation, the research from these concepts of behavior has helped immensely in clarifying critical approaches to public health. The concept of diversity in populations

has been greatly enhanced through the articulation of the concepts of illness behavior and the sick role. Researchers now have a significant body of research showing the wide variation in these behaviors with respect to all the key demographic variables. For example, there has been excellent work showing how the presentation of symptoms to a physician is highly dependent on gender, ethnic background, and other sociocultural characteristics. Research on the sick-role concept has elucidated the issue of power and its many manifestations in doctors' offices, hospitals, and other medical settings. It would be difficult, given this literature, for a practicing health educator not to consider the role of power in patient-physician interactions.

Present-day health education has also been heavily influenced by the research on illness and sick-role behavior. These concepts have helped inform part of the scientific basis for the educational and environmental approach to health promotion planning elucidated by L. W. Green and M. W. Kreuter in their widely used PRECEDE-PROCEED model. At the same time, the conceptual components of illness and sick-role behavior continue to be explored in narrative analyses of the written and spoken traditions of peoples to describe their experiences of illness and sickness.

DAVID V. McQUEEN

(SEE ALSO: *Behavior, Health-Related; Health Belief Model; PRECEDE-PROCEED Model; Psychology, Health; Self-Care Behavior; Social Determinants*)

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IMMIGRANTS, IMMIGRATION

Immigration is a major historical, yet current influence and integral part of how nations continue to grow and change in population and diversity. M. Fix and J. S. Passel (1994) list the principal goals of U.S. immigration policy as: social, economic, cultural, moral, and national and economic security (includes protection from infectious and animal-borne diseases, environmental hazards, food safety, terrorists, and various criminal acts). Canadian and European policies encompass similar goals, but with greater emphasis on the economic impact of immigration. In 1999 over 16 million legal immigrants in Western Europe earned more than \$460 billion. However, despite the projection indicating that European countries face a dramatic population decline over the next 50 years, many European countries want to restrict immigration on the basis of economic reasons, including the fear of exacerbating the already significant problem of unemployment. Immigration policies are the responsibility of national governments, while the policies regarding how countries deal with immigrants are shared by the various levels of government—national, state, and local.

At the federal level in the United States, for example, several agencies play key roles in developing and implementing national immigration and immigrant policies. The principal immigration agencies are: the United States Department of Justice Immigration and Naturalization Service (INS), which is responsible for enforcing the laws regulating the admission of foreign-born persons (i.e., aliens) to the United States and for administering various immigration benefits, including naturalization and resettlement of refugees; and the Department of Treasury U.S. Customs Service, which is the primary enforcement agency protecting the nation's borders. Other federal agencies

deal more directly with the public health dimension of immigration and immigrants. Although many countries have organizations dealing with immigrants and immigration issues, there are international agencies that act as important brokers regarding migration among countries. The International Organization for Migration (IOM) is an intergovernmental body that is committed to the principle that humane and orderly migration benefits migrants and society. Since 1951, the IOM has acted with member countries (currently 79) to assist in meeting operational challenges of migration, to advance understanding of migration issues, to encourage social and economic development through migration, and to uphold human dignity and well being of migrants.

The United Nations High Commissioner for Refugees (UNHCR) is another international agency which, since 1951, has played a significant role in responding to the world's growing refugee predicament. As one of the world's principal humanitarian organizations, the UNHCR provides international protection to refugees and seeks durable solutions to their plight. For the year 2000, there were about 22.5 million refugees and other persons of concern to the UNHCR.

HISTORY AND DEMOGRAPHICS

Immigration policies have directly influenced the demographic composition of the immigrating populations over the lives of the nations. The first immigration office in the United States and Canadian federal governments were created in the nineteenth century by laws intended mainly to encourage immigration. Later, the U.S. Immigration Act of 1891 provided for deportation of aliens living unlawfully in the country. About this same time, in 1882, the U.S. Congress asserted the first broad federal regulatory power regarding immigration by passing the Chinese Exclusion Act, which suspended immigration of Chinese laborers for ten years. In Canada, although there was no law passed to exclude any particular group of immigrants, careful procedures were developed to ensure most applications submitted by black people were rejected. From the late nineteenth century to the year 2000, most North American, European, and Australian immigration policies have shifted from a focus on qualities of individuals (e.g., excluding illiterates, criminals, those with

illnesses) to a focus on countries of origin with a more inclusionary focus using preference categories, to a sharpened humanitarian approach in admitting those in need (such as refugees) through permanent and systematic assessments. In European countries, various approaches for integrating immigrants are at work. Germany has developed special institutions and programs for foreigners, while France tends to stress general rather than foreigners-only programs. The European Union recognizes that immigrants are needed for demographic and economic reasons.

Census data indicate that the percent of foreign-born persons in the total U.S. population has waxed and waned from a high of 14.8 percent in 1910 to a low of 4.7 percent in 1970. In July 1999, the foreign-born resident population estimates totalled about 25.8 million, or about 9.5 percent of the total U.S. population. Likewise, Canada's peak year for immigration (1913) saw the arrival of about 400,000 people. Its 1996 census showed a continued growth in immigration with 17.4 percent of Canadian residents being first-generation immigrants. From 1990 to 1999, the United States foreign-born population increased. Hispanics increased from 8 to 11 million persons, and the Asian and Pacific Islander groups increased from 4.5 to 6.3 million. More than 60 percent of the Asian and Pacific Islander populations in the United States and about 35 percent of Hispanics are foreign-born.

These statistics reveal how changes in immigration policies, especially within the past fifty years, have influenced the makeup of the foreign-born populations in the United States. For France, there have been several immigration priority shifts over the years. Initially priority was given to members of France's colonies, subsequently, to Italians, Spaniards, Portuguese, and, more recently, to North African guest workers. A shift of immigration priorities also occurred in Canada when, after its 1976 Immigration Act was passed, immigrants from Africa, Asia, the Caribbean, and Latin America were welcomed.

The late nineteenth century and the early twentieth century provided a different country-of-origin profile for immigration to the United States. Since 1820, Germany has been the greatest source of immigrants to the United States, with Mexico

ranking second, Italy third, and the United Kingdom and Ireland a close fourth and fifth, respectively. Changes were evident in 1996 when the country-of-origin profile for immigration showed that of the top ten nations, four were Asian nations, three Latin American nations, two from the former Soviet Union, and one from the Caribbean. The United States Immigration Reform and Control Act of 1986 provided an amnesty for undocumented persons living in the United States under certain conditions, which resulted in about 2.8 million persons attaining legal status—the majority of whom were Hispanic. The 1996 count used by the INS for “illegal alien populations” or undocumented persons is about 5 million, with about 2.7 million estimated to be from Mexico. Other countries in Europe indicate that 300,000 to 1,000,000 “unauthorized immigrants” reside within their borders.

Immigrant populations in the United States from the Asian and European countries have more years of education than immigrants from Latin American countries. Further 1999 estimates of the average age of foreign-born racial and ethnic groups range from seven to eleven years older than the U.S. total population estimates for the respective groups. The occupations of immigrants depend on their education and their proficiency in speaking English. It was estimated that in 1990 about 40 percent of immigrants were either operators/laborers/fabricators or service workers. Immigrants contribute to the U.S. economy not only in terms of labor force participation rates but also in terms of taxes paid and earnings spent for goods and service on their local economies. On the other hand, in 1997, the unemployment rates for immigrants were much higher in France than for French nationals. The French nationals’ rate was 12 percent compared with 31 percent for immigrants from non-European Union countries and 50 percent among North Africans.

Geographic distribution of the foreign-born within the United States from the 1990 census indicates that most live in the West and are from Mexico. Immigrants settle and reside mainly in metropolitan areas such as New York City, Los Angeles, and Miami; this is also consistent with the living patterns of Hispanic and Asian populations in the United States. Projections of the immigrant populations by the Census Bureau at the low, middle, and highest series indicate that the largest

growth will be in the Asian and Pacific Islander populations over the next fifty years. Using the 1990 base for population projections, the Census estimates that by the year 2045, foreign-born populations will grow to about 13.5 percent of the total population, compared to 9.5 percent in 1999. The distribution of immigrant ethnic groups in Canada shows people from the British Isles as the majority throughout Canada with the exception of Quebec where the French dominate. The West and prairie provinces include about 15 percent German and significant numbers (9 to 11 percent) of Ukrainians.

IMPLICATIONS FOR PUBLIC HEALTH

Although immigration policies are complex, much of the work of responsible public health professionals and organizations is to consider how best to serve the immigrant populations who arrive. As noted above, there are several public health agencies in the United States responsible for the health of the entering populations. Other nations and international organizations also help with caring for the education, social, and health needs of immigrants. For refugees, in particular, the resettlement process in the United States includes the federal agency working with local providers to ensure health services are provided. Other than refugees and asylees, immigrants must ensure that they do not become a “public charge,” that is, dependent on the government for subsistence. Based on determinations of INS in consultation with the Department of Health and Human Services, United States federal health services programs can be provided to immigrants without being considered “public charges.” There are other restrictions to public benefits that are part of the Personal Responsibility and Work Opportunity Reconciliation Act of 1996 (PRWORA), which restricts access by some legal immigrants to certain programs and denies access by undocumented/unauthorized immigrants to many government funded programs. Federal and state programs affected under this law include Medicaid, the Children’s Health Insurance Program, Temporary Assistance for Needy Families, Supplemental Security Income, and food stamps.

For public health purposes, the state’s restriction of certain public benefit programs must not

inhibit the public health system in serving immigrant populations with interventions and services that target at-risk populations. Knowing the populations within the community is a fundamental requirement in public health. Assessments of immigrant populations must take into account the country of origin and its socio-political context, language use and level of language proficiency, age and educational profile, cultural nuances including specific gender practices and protocols, time in the country and familial ties, particular health practices and beliefs that may be common to the population, social and religious beliefs and practices, and the economic conditions of employment. Such assessments then include not only a quantitative epidemiological approach, but also a qualitative ethnographic inquiry as complementary data.

Policies developed for public health systems are critical in addressing the particular characteristics and needs of immigrant populations. Being consistent in serving the populations establishes a trusting environment for newly arrived and foreign-born populations who may have emigrated from countries where governments were not trustworthy. In keeping with the United States *Healthy People 2010* report's second goal of eliminating health disparities, policies will also need to be flexible and allow for interpretation in the field.

Providing the proper interventions and services through culturally competent systems becomes a major challenge for the public health community, not just the public health government agencies. Generally, immigrants are not familiar with the variety of places (both private and public) from which services and promotion of healthy practices are derived. Getting to know the different sources of services is much more complex than immigrant populations may have experienced in the past. (Moreover, it is not unlikely that in some countries the systems are such that even the native-born populations are still unfamiliar with how their public health systems work.) Such coordination requires collaborative trust among providers and their respective organizations, and will help to build more confidence in the use of the system by the immigrant populations.

As a final point for the public health community in refining experiences with immigrant populations, there is the need to keep up with what

potential public health issues are occurring globally, nationally, statewide, and, of course, locally. Experience has shown that refugees and other immigrants can quickly be placed in a community due to some type of international disturbance. Keeping informed of immigrant populations as part of the community allows for better decisions on what health improvements may be needed, and what actions should be taken when more immigrants arrive.

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(SEE ALSO: *Acculturation; Cross-Cultural Communication, Competence; Ethnicity and Health*)

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IMMUNIZATIONS

Immunization is the induction of immunity against an infectious disease by a means other than experiencing the natural infection. The term is usually used interchangeably with vaccination. Active immunization involves administration of an antigenic substance that then induces development of protective antibodies by the person immunized. This protection usually lasts for years, even for life. Passive immunization refers to temporary immunity resulting from antibodies developed by someone else, either through administration of immune globulin (e.g., gamma globulin, rabies immune globulin) or through the natural transfer across the placenta of antibodies developed by the mother, which provide protection to the newborn infant. Passive immunity usually lasts only a few weeks to a few months.

Substances used for active immunization include vaccines and toxoids. Vaccines may contain living, weakened (attenuated) organisms (measles), killed whole organisms (whole cell pertussis, influenza), portions of organisms (subunit influenza), purified components of organisms (acellular pertussis, pneumococcal polysaccharide), or they may be manufactured artificially (hepatitis B produced by recombinant DNA technology). For some diseases, vaccines may be available in more than one form (live attenuated and inactivated [killed] poliovirus vaccines, whole cell and acellular pertussis vaccines). Toxoids are made by preparing the toxins excreted by microorganisms and inactivating them physically or chemically. Diphtheria and tetanus are the most commonly used toxoids. Vaccines and toxoids may also contain adjuvants, substances that enhance the immune response, as well as preservatives.

Some vaccines (particularly live, attenuated vaccines) provide long-term, even lifelong protection following administration of only a single dose. Others (particularly inactivated vaccines and toxoids) may require administration of more than one dose in order to induce long-lasting immunity. Some vaccines (diphtheria, tetanus) require periodic booster doses in order to maintain immunity. Many vaccines may be inactivated by changes in temperature, particularly heat, and must be kept refrigerated or frozen from the time of manufacture until just before being administered. The need for this "cold chain" makes it difficult to carry out immunization programs in developing countries where refrigerators and freezers are not commonplace.

The rate of development of new vaccines has been accelerating as a result of improved knowledge of immunity and improvements in biotechnology. It was nearly one hundred years between Edward Jenner's first use of smallpox vaccine in 1796 and Louis Pasteur's development of the second vaccine (against rabies) in 1885. In the last twenty years of the twentieth century, many new or improved vaccines were developed and introduced, including vaccines directed against *Haemophilus influenzae* type b (Hib), hepatitis A, hepatitis B, Japanese encephalitis, meningococcal meningitis, pertussis, typhoid, and varicella (chicken pox). Dozens of other vaccines are under development.

Repeated economic analyses have shown that vaccines are among the most cost-effective health interventions available. For most of the vaccines used in infants and young children, the economic benefits of vaccination (avoidance of costs of medical care, hospitals, etc.) far outweigh the costs of vaccination, and the vaccines are truly cost saving. For others, the cost to prevent an illness or death is quite small and is substantially smaller than the cost to treat or cure the condition.

VACCINE RECOMMENDATIONS

In the United States, recommendations for vaccine use are made by the Public Health Service Advisory Committee on Immunization Practices, in conjunction with the American Academy of Pediatrics, American Academy of Family Practice, American College of Physicians (representing adult medicine specialists), and other professional organizations. Some vaccines are recommended for

use in all persons (typically infants and young children, since most communicable diseases primarily strike them) and others are recommended for specific persons or groups who are at increased risk of contracting the particular disease. Vaccines currently recommended for use in all infants and children in the United States are DTP/DTaP (diphtheria and tetanus toxoids and pertussis [or acellular pertussis] vaccine), IPV (inactivated poliovirus vaccine), MMR (measles, mumps, and rubella vaccine), Hib vaccine (*Haemophilus influenzae* type b vaccine), hepatitis B vaccine, and varicella (chicken pox) vaccine. Several of these vaccines require more than one dose. The recommended schedule of immunizations in the year 2000 for infants and young children is shown in Figure 1.

Adolescents and adults also need vaccines, including MMR and hepatitis B if they have not already received them, as well as periodic boosters of tetanus and diphtheria toxoids. In addition, in the United States it is recommended that all persons sixty-five years of age or older receive a single dose of pneumococcal polysaccharide vaccine and annual doses of influenza vaccine because of the increased risk of complication or death if infected. Individuals younger than sixty-five who have chronic illnesses should also receive pneumococcal and influenza vaccines. Some vaccines recommended for persons at increased risk include yellow fever, hepatitis A, typhoid, meningococcal, and Japanese encephalitis vaccines for travelers to certain developing countries; rabies vaccine for veterinarians and persons working with potentially rabid animals; and hepatitis B vaccine for health care workers and others who might come in contact with body fluids.

VACCINE SAFETY

Although modern vaccines are safe and effective, they are neither perfectly effective nor perfectly safe. Some persons who have been vaccinated may still be susceptible to the disease, and some persons who receive the vaccine may suffer an adverse event caused by the vaccine. In developing a vaccine, major efforts are made to maximize effectiveness and minimize the risk of adverse events.

In determining whether to use a vaccine, it is necessary to balance the benefits of the vaccine against the risk of the disease and the risks from the vaccine. This balance may change over time.

Figure 1

Recommended Childhood Immunization Schedule, United States, January – December 2000

Vaccines¹ are listed under routinely recommended ages. **Bars** indicate range of recommended ages for immunization. Any dose not given at the recommended age should be given as a "catch-up" immunization at any subsequent visit when indicated and feasible. **Ovals** indicate vaccines to be given if previously recommended doses were missed or given earlier than the recommended minimum age.

Age → Vaccine ↓	Birth	1 mo	2 mos	4 mos	6 mos	12 mos	15 mos	18 mos	24 mos	4–6 yrs	11–12 yrs	14–16 yrs
Hepatitis B ²	Hep B											
Diphtheria, Tetanus, Pertussis ³		Hep B		Hep B			Hep B			DTaP	Hep B	
<i>H. influenzae</i> type b ⁴			DTaP	DTaP	DTaP		DTaP ³				Td	
Polio ⁵			Hib	Hib	Hib	Hib				IPV ⁵		
Measles, Mumps, Rubella ⁶		IPV	IPV	IPV ⁵			IPV ⁵			MMR ⁶	MMR ⁶	
Varicella ⁷					MMR		MMR				MMR ⁶	
Hepatitis A ⁸					Var		Var				Var ⁷	
									Hep A ⁸ – in selected areas			

Approved by the Advisory Committee on Immunization Practices (ACIP), the American Academy of Pediatrics (AAP), and the American Academy of Family Physicians (AAFP).

On October 22, 1999, the Advisory Committee on Immunization Practices (ACIP) recommended that Rotashield® (RRV-TV), the only U.S.-licensed rotavirus vaccine, no longer be used in the United States (MMWR, Volume 48, Number 43, Nov. 5, 1999). Parents should be reassured that their children who received rotavirus vaccine before July are not at increased risk for intussusception now.

¹ This schedule indicates the recommended ages for routine administration of currently licensed childhood vaccines as of 11/1/99. Additional vaccines may be licensed and recommended during the year. Licensed combination vaccines may be used whenever any components of the combination are indicated and its other components are not contraindicated. Providers should consult the manufacturers' package inserts for detailed recommendations.

² **Infants born to HBsAg-negative mothers** should receive the 1st dose of hepatitis B (Hep B) vaccine by age 2 months. The 2nd dose should be at least one month after the 1st dose. The 3rd dose should be administered at least 4 months after the 1st dose and at least 2 months after the 2nd dose, but not before 6 months of age for infants.

Infants born to HBsAg-positive mothers should receive hepatitis B vaccine and 0.5 mL hepatitis B immune globulin (HBIG) within 12 hours of birth at separate sites. The 2nd dose is recommended at 1–2 months of age and the 3rd dose at 6 months of age.

Infants born to mothers whose HBsAg status is unknown should receive hepatitis B vaccine within 12 hours of birth. Maternal blood should be drawn at the time of delivery to determine the mother's HBsAg status; if the HBsAg test is positive, the infant should receive HBIG as soon as possible (no later than 1 week of age).

All children and adolescents (through 18 years of age) who have not been immunized against hepatitis B may begin the series during any visit. Special efforts should be made to immunize children who were born in or whose parents were born in areas of the world with moderate or high endemicity of hepatitis B virus infection.

³ The 4th dose of DTaP (diphtheria and tetanus toxoids and acellular pertussis vaccine) may be administered as early as 12 months of age, provided 6 months have elapsed since the 3rd dose and the child is unlikely to return at age 15–18 months. Td (tetanus and diphtheria toxoids) is recommended at 11–12 years of age if at least 5 years have elapsed since the last dose of DTP, DTaP, or DT. Subsequent routine Td boosters are recommended every 10 years.

⁴ Three Haemophilus influenzae type b (Hib) conjugate vaccines are licensed for infant use. If PRP-OMP (PedvaxHIB® or ComVax® [Merck]) is administered at 2 and 4 months of age, a dose at 6 months is not required. Because clinical studies in infants have demonstrated that using some combination products may induce a lower immune response to the Hib vaccine component, DTaP/Hib combination products should not be used for primary immunization in infants at 2, 4 or 6 months of age, unless FDA-approved for these ages.

⁵ To eliminate the risk of vaccine-associated paralytic polio (VAPP), an all-IPV schedule is now recommended for routine childhood polio vaccination in the United States. All children should receive four doses of IPV at 2 months, 4 months, 6–18 months, and 4–6 years. OPV (if available) may be used only for the following special circumstances:

1. Mass vaccination campaigns to control outbreaks of paralytic polio.
2. Unvaccinated children who will be traveling in <4 weeks to areas where polio is endemic or epidemic.
3. Children of parents who do not accept the recommended number of vaccine injections. These children may receive OPV only for the third or fourth dose or both; in this situation, health-care providers should administer OPV only after discussing the risk for VAPP with parents or caregivers.
4. During the transition to an all-IPV schedule, recommendations for the use of remaining OPV supplies in physicians' offices and clinics have been issued by the American Academy of Pediatrics (see Pediatrics, December 1999).

⁶ The 2nd dose of measles, mumps, and rubella (MMR) vaccine is recommended routinely at 4–6 years of age but may be administered during any visit, provided at least 4 weeks have elapsed since receipt of the 1st dose and that both doses are administered beginning at or after 12 months of age. Those who have not previously received the second dose should complete the schedule by the 11–12 year old visit.

⁷ Varicella (Var) vaccine is recommended at any visit on or after the first birthday for susceptible children, i.e. those who lack a reliable history of chickenpox (as judged by a health care provider) and who have not been immunized. Susceptible persons 13 years of age or older should receive 2 doses, given at least 4 weeks apart.

⁸ Hepatitis A (Hep A) is shaded to indicate its recommended use in selected states and/or regions; consult your local public health authority. (Also see MMWR Oct. 01, 1999/48(RR12); 1–37).

SOURCE: CDC. "Recommendations of the Advisory Committee on Immunization Practices."

For example, oral polio vaccine (OPV, Sabin vaccine) is made from live, attenuated polioviruses. Rarely, the person who receives the vaccine or someone who is in close contact with him or her may develop paralysis. Vaccine-associated paralysis occurs with a frequency of approximately one case for every million doses of OPV administered. By contrast, the inactivated polio vaccine (IPV, Salk vaccine) has no such risk of paralysis. However, OPV has advantages over IPV because it may be spread from the person who receives the vaccine to family members or other persons in contact with the vaccinee, thereby protecting them. Because it provides greater intestinal immunity than IPV, it protects against the spread of wild poliovirus if the vaccinated individual is exposed to wild poliovirus. The relative advantages of OPV have resulted in its being the vaccine chosen by virtually all countries of the world to control and eradicate polio. However, as the risk of wild poliovirus becomes smaller, the rare complications associated with OPV assume greater prominence. In the United States, the marked decline in risk of exposure to wild poliovirus as a result of global polio eradication efforts led in 1999 to a change in policy to favor use of IPV rather than OPV.

Assessment of adverse events associated with vaccines can be quite difficult. Pre-licensure trials typically involve a few thousand individuals and cannot be expected to detect reactions that occur with a frequency as low as (or lower than) one in 100,000. Consequently, it is important to maintain surveillance for adverse events after vaccines are licensed and introduced for widespread use. It may be very difficult to determine whether an event that occurs after vaccination was caused by the vaccine rather than occurring by chance, particularly if the event is known to occur in that age group. For example, sudden infant death syndrome (SIDS) is the leading cause of death in children two to four months of age. Since children typically receive DTP vaccine at two and four months, it is inevitable that on occasion a child will die of SIDS in the twenty-four hours following vaccination (or in the twenty-four hours preceding planned vaccination). The question is whether there is an increased incidence of SIDS following vaccination. Several studies have demonstrated that the incidence of SIDS is not increased following DTP vaccination.

IMPACT OF VACCINES IN THE UNITED STATES

Immunization provides protection both to the individuals immunized and to the community because immunized individuals do not transmit disease. If a high proportion of the population is immunized, the risk of exposure is reduced both for those who have not been immunized and those who have received vaccine but have not been protected. This "herd immunity" has led to the disappearance of disease in defined geographic areas, even though not everyone has received vaccine.

Introduction and widespread use of vaccines has had a dramatic effect on the occurrence of many diseases in the United States. Table 1 demonstrates the maximum number of cases of specified diseases ever reported in the United States, the number of cases reported in 1998, and the proportion reduction in incidence. Declines of greater than 95 percent are the rule. Similar dramatic reductions have been seen from deaths due to these diseases. Smallpox is not shown on this table as smallpox has been eradicated from the world. Most industrialized countries have seen comparable declines in illnesses and deaths due to vaccine-preventable diseases. Most developing countries have not yet experienced the same level of decline because they have not achieved the same level of immunization coverage.

In the United States, immunization levels in young children are at record highs and reported incidence of vaccine-preventable diseases are at record lows. Nonetheless, several factors threaten this continued success, including the birth every day of eleven thousand infants who will all need to be immunized, the changing immunization schedule, the movement of children between health care providers (25% of U.S. 2-year-olds have received vaccines from two or more providers), continued overestimation of coverage by parents and providers, and the absence of disease as a continuing reminder of the need for immunization (even though the causative organisms are still in circulation).

Because of the continuing birth of susceptible infants, unless communicable diseases are eradicated it will be necessary to continue immunizing

Table 1

Maximum Reported Morbidity and 1998 Provisional Morbidity Vaccine-Preventable Diseases of Childhood United States			
Disease	Maximum Reported Morbidity	Provisional (1998) Morbidity	Decrease
Diphtheria	206,939	1	99.99%
Pertussis	265,269	6,279	97.63%
Tetanus	1,733	34	98.04%
Poliomyelitis (paralytic)	21,269	0	100%
Measles	894,134	89	99.99%
Mumps	152,209	606	99.60%
Rubella	57,686	345	99.40%
Congenital rubella syndrome	20,000*	6	99.97%
<i>Haemophilus influenzae</i> type b	20,000*	54	99.73%

*estimated

SOURCE: Centers for Disease Control and Prevention

against them indefinitely. Several examples exist in industrialized countries (including England and Japan) where epidemic resurgence of pertussis (whooping cough) has occurred as a consequence of declining use of pertussis vaccine. In the United States, a resurgence of measles resulted from the diversion of effort from measles vaccination to rubella vaccination following introduction of rubella vaccine in 1969 (at that time it was not combined with measles vaccine).

Several techniques have been demonstrated to be highly effective in improving and maintaining immunization coverage, including improving access to immunization, developing reminder and recall systems to notify parents and providers about needed or overdue immunizations, assessing immunization coverage in individual facilities, and linking immunization services with other services. By providing accurate, up-to-date information to health care providers, immunization registries (confidential, computerized information systems that contain information about immunizations and children) can make it easier to carry out the demonstrably effective immunization strategies. All states are currently in the process of establishing population-based immunization registries containing information on all children within their borders.

In the United States, infants and children may receive immunizations from private providers (typically in conjunction with other well-child services) or from public sector sites such as local health departments (in which case immunizations might be the only services provided) or community health centers. Traditionally, vaccines provided in the public sector have been free, whereas private providers have charged for the vaccines. Consequently, lower-income families typically went to public sector facilities to receive vaccine, even though they might have been using a private physician for other care. Until the middle of the 1990s, it was estimated that approximately one-half of all U.S. children received immunizations from private providers and one-half from the public sector. Enactment of the Vaccines For Children (VFC) program in 1994 made free vaccine available to private providers for use in uninsured or under-insured children and led to a major shift in immunization provision. In 1998, approximately 70 percent of all childhood vaccines were administered in the private sector and 30 percent in the public sector, meaning that more children were receiving immunizations in their “medical home” than had been the case previously.

IMMUNIZATIONS WORLDWIDE

Since 1979, the World Health Organization (WHO) has coordinated an Expanded Program on Immunization (EPI), which seeks to bring vaccines against six diseases—diphtheria, measles, pertussis (whooping cough), poliomyelitis, tetanus, and tuberculosis—to all children in the world. An abbreviated immunization schedule has been developed that calls for a dose of BCG (Bacille Calmette-Guerin) at birth; three doses of DTP (combined diphtheria and tetanus toxoids and pertussis vaccine) and OPV (oral polio vaccine) given at six, ten, and fourteen weeks of age; and a single dose of measles vaccine at nine months of age. BCG protects infants against severe forms of tuberculosis (such as tuberculous meningitis) but does not alter the overall transmission of tuberculosis.

The EPI succeeded in reaching immunization coverage levels of approximately 80 percent in the world’s children by 1990 (the year of the Children’s Summit), but levels have been relatively stagnant since that time, even decreasing in some areas. Coverage varied markedly among (and

within) countries. Some of the reasons for the lack of further progress include: the overall economic situation in many countries, the fragile nature of the countries' health services, lack of political support, and problems in management of immunization programs. In 1991 a recommendation was made to administer hepatitis B vaccine to all children (three doses: at birth, six weeks, and fourteen weeks; or along with the DTP vaccine) but this has not been widely implemented in most developing countries. Introduction of other (newer) vaccines such as Hib is problematic. These vaccines are considerably more expensive than traditional vaccines, there are few manufacturers (sometimes only one, as a result of innovation and patent protection), and purchase of vaccines may require hard currency, which may be difficult for some developing countries to obtain. The development of the Global Alliance for Vaccines and Immunization and the Global Children's Vaccine Fund in early 2000 give hope that mechanisms may be developed to facilitate introduction of important new vaccines in developing countries.

ERADICATION OF VACCINE— PREVENTABLE DISEASES

Global eradication of smallpox in the late 1970s is probably the greatest single achievement in health to date. Although both William Jenner and Thomas Jefferson predicted eventual eradication at the end of the eighteenth century, it took nearly two hundred years to accomplish. The intensive global effort for eradication began in 1967 with the result that the last naturally occurring case of smallpox occurred in 1977. The World Health Assembly certified eradication in 1980. The initial strategy to achieve eradication was mass vaccination of the population, but over time this was refined to a strategy of search and containment—search for cases of smallpox and containment of transmission through vaccinating all persons who might have been exposed in a geographic area.

An effort is currently underway to eradicate polio from the world by the end of 2000. The strategy for eradication involves attaining high levels of coverage with routine vaccination with OPV, special immunization campaigns, and vigorous surveillance to detect and investigate possible cases of polio. The special immunization campaigns typically occur as National Immunization

Days, semiannual events in which all children in the country less than five years old are given OPV on a single day, regardless of their previous vaccination status. Significant progress is being made: no locally arising cases of polio have occurred in the Americas since 1991, none in the Western Pacific Region of the World Health Organization (including China) since 1997, and none in the European Region since 1998. At the beginning of 2000, the major problems remaining were in South Asia and sub-Saharan Africa. Whether the target will be met on schedule is not clear. It is clear that eradication is technically feasible—the uncertainties relate to political will and financial support.

Other diseases that are potential candidates for eradication through appropriate use of vaccines include measles, mumps, and rubella. Measles is the most serious of these, still accounting for nearly 900,000 deaths a year (half of them in sub-Saharan Africa), and there is substantial support for consideration for elimination or eradication. The public health impact of rubella and mumps is not as widely recognized and there is not the same degree of enthusiasm for their eradication, although it is estimated that more than 100,000 cases of congenital rubella syndrome occur each year around the world. Although all three conditions could be attacked simultaneously by using MMR (combined measles-mumps-rubella) vaccine, the additional vaccine costs would be substantial.

FUTURE VACCINES

Recent advances in biotechnology and understanding of the immune process make it likely that the pace of vaccine development and introduction will accelerate. Although this will mean that there is greater opportunity for prevention of disease and death, it will have additional consequences, such as increasing complexity of the immunization schedule and the need for additional injections. Development of combination vaccines can help alleviate this problem but, since there is at least a theoretical issue of incompatibility and interference between different vaccines, each combination must be tested thoroughly before it can be approved. Additionally, the prospective availability of combined vaccines from different manufacturers with slightly different components may add further complexity to the schedule and to decision making about what a given individual needs.

The biotechnology revolution has made it possible to explore novel approaches to immunization, such as incorporating into other microorganisms the antigens that elicit protective antibodies (another way of making combination vaccines) or even incorporating antigens into foodstuffs such as potatoes or bananas. Additionally, the prospect of administering vaccines by aerosol or using transdermal patches is being investigated, as is the possibility of using purified DNA from the causative organism as the means to induce immunity. Because of the potential for transmission of infectious diseases (e.g., hepatitis B, HIV/AIDS) through reuse of needles or inadvertent needle-sticks, disposal of needles has become a significant problem and has led to the development of “auto-destruct” syringes and needles that cannot be used more than once. Most designs to date do not prevent inadvertent needlesticks, however. Consequently, needleless approaches to administration are being pursued, including pressure injection of liquid or powder vaccine, aerosol/inhalation, and use of transdermal absorption.

CONCLUSION

Immunizations have been among the most successful public health interventions to date. Through appropriate use of vaccines, smallpox has been eradicated from the earth, poliomyelitis is on the verge of eradication, and there have been dramatic reductions in morbidity and mortality due to with many other diseases. Recent scientific advances give promise that even more diseases can be brought under effective control. A remaining challenge is to ensure that all people of the world benefit from immunizations.

ALAN R. HINMAN

(SEE ALSO: *Hepatitis A Vaccine*; *Hepatitis B Vaccine*; *Influenza*; and articles on specific diseases mentioned herein)

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IMPARTIALITY AND ADVOCACY

Science is based on systematic observations and experiments to discover the truth about natural phenomena. Good science uses methods that are fully disclosed and as free as possible from biases and confounding factors. It is objective, and therefore it ought to be impartial. When all the pertinent facts about a scientific issue have been discovered and verified they are displayed unemotionally in the public domain in a suitable peer-reviewed scientific publication. In these respects, science, including all the public health sciences, can claim to be value-free or value-neutral.

The interpretation of much scientific fact, however, and conclusions based on interpretation, often involve value judgements, which are influenced by nonscientific factors such as emotions, economic considerations, and political positions. For example, the interpretation of the scientific evidence on the effects of cigarette smoking, and the sometimes confusing and equivocal scientific evidence on health consequences of exposure to chemical substances in the environment, and in particular whether these chemicals can cause cancer, congenital malformations and the like, has led to much debate and controversy.

Epidemiologists, environmental toxicologists, and other public health scientists often discover dangers to health. Does their role change at this point, from public health scientist to public health advocate? Many public health scientists are willing to become advocates, taking a public position in favor of actions that will reduce or eliminate risks to health that their scientific studies have disclosed. But many other public health scientists are

not prepared to become advocates, arguing that by doing so they would compromise their scientific objectivity. They assert that if they become public health advocates they cease to be impartial and thereby compromise future scientific studies that they may undertake. Some put it more strongly, asserting that a conflict of interests will arise if they become advocates for a particular cause in public health practice. Scientific objectivity is often equated with impartiality, which, by definition, is incompatible with advocacy, which necessarily adopts a position in favor of or against a particular cause. This is a difficult balance, and can be one of the most challenging ethical problems in public health science.

JOHN M. LAST

(SEE ALSO: *Conflicts of Interests; Ethics of Public Health; Health Promotion and Education; Virchow, Rudolph*)

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IN VIVO AND IN VITRO TESTING

The underpinning of safety assessment has, for decades, been the *in vivo* testing programs that use laboratory animals. Starting in the early 1970s, *in vitro* testing was initiated and added to the battery of tests used to assess the safety of various substances. *In vivo* tests are carried out in several animal species for the development of drugs, food additives, pesticides, and industrial chemicals, and in humans primarily for drugs. *In vivo* studies range in duration from short-term dosing to lifetime exposure. They include studies to assess the potential for inducing birth defects, as well as multigenerational studies for assessing adverse reproductive outcomes. These studies are usually conducted under the Good Laboratory Practices (GLP) guidelines. These guidelines, promulgated by the U.S. Food and Drug Administration (FDA) and other regulatory agencies, lay out the boundaries within which toxicity studies that are to be used for regulatory purposes will be conducted. Most laboratories conduct toxicology studies within

the spirit of the GLP guidelines even if the studies are not going to be used for regulatory purposes.

Short-term, acute studies are usually conducted in one or more rodent species with the purpose to determine the dose range for lethality of a particular substance, and to determine the shape of the dose-response curve. In addition to the LD50 (the dose lethal to half the animals), the results of the acute studies are used to set doses for longer-term, subchronic experiments. Acute studies can determine toxicity, time of onset of toxic signs, and recovery in the surviving animals. This information is extremely critical in an emergency situation where humans or domestic animals are exposed to high concentrations of a chemical. Occasionally, acute toxicity studies are used to establish antidotes to a given toxicant.

Subchronic studies are generally conducted in both sexes of two laboratory animal species, one of which is a nonrodent species. These studies are of longer duration, generally three to six months, and are conducted using multiple doses. The purpose of the subchronic study is to determine target-organ toxicity, to determine the effects of prolonged dosing, and to help establish margins of safety for food additives and drugs. At the end of a study all animals are autopsied, with complete gross and microscopic examination of tissues. Complete blood chemistries are evaluated and an overall clinical assessment is made on each animal.

The next level of toxicity study is the chronic bioassay. Again, the study is conducted in multiple species, in both sexes, and for a duration that approaches the lifespan of the animal. These are very large and complex studies that necessitate a great deal of day-to-day management. There are multiple intermediate clinical evaluations, including daily observations, weekly food and water consumption, and body weight determinations. At the termination of the study, or at times of interim sacrifices, all animals are autopsied.

Chronic toxicity studies provide a thorough examination of the dose effect of a given chemical on homeostasis, bodily function, induced diseases, and the effect on lifespan. Chronic toxicity studies provide the bulk of the preclinical information used for assessing safety and risk. Cancer potential can be determined in some of the aforementioned studies, but for many chemicals a definitive cancer bioassay is conducted. This bioassay is conducted

in rodents and lasts for the major part of the natural lifespan of the animal. The study is generally carried out using at least two dose levels, and it is usually designed to mimic the route of human exposure.

The potential to induce adverse birth outcomes is tested in several species. Rodents, rabbits, and sometimes dogs are used depending on the end use of the candidate chemical. The studies are designed to determine if the chemical alters the reproductive cycle of the female or spermatogenesis in the male. The studies also examine the effects of the chemical during the first, second, and third trimester of pregnancy, and during parturition and lactation. Multigenerational studies are conducted to determine the overall effects of a given chemical on the parent generation, the offspring, and on the ability of the offspring to reproduce normally.

In the early 1970s, *in vitro* studies to determine the potential of a chemical or a mixture to induce point mutations in engineered strains of bacteria indicated that the mutagenic potency of a chemical was a reasonable predictor of its carcinogenic potential. The overall hypothesis was later shown to be less predictive than first thought, depending on the class of chemical tested, but the strength of the tests kept them in the battery of safety evaluation tests. Subsequently, *in vitro* tests have been developed to assess potential immunotoxicity, hormone action, eye irritation, and cellular and molecular events that are correlated with end-stage disease. The advantages of *in vitro* tests are that they are quick, relatively inexpensive, and specific mechanisms of action can be tested. The disadvantage of these tests is that the homeostatic mechanisms and pathways found in animals are not present. Hence, it is difficult, if not impossible, to determine injury repair in the same system in which toxicity is tested.

A tier testing approach has emerged that allows for an in-depth toxicity evaluation of a chemical, starting with *in vitro* and acute studies and ending with multigenerational studies and carcinogenesis bioassays. Specialty testing paradigms have also been developed to handle unique toxicology questions. An example of specialty testing is the battery of tests used to determine the potential for endocrine disruption (EDSTAC). The results of these studies are coupled with exposure

assessments to the chemical, and the data are used to develop a safety evaluation, or a cancer risk assessment.

MICHAEL GALLO

(SEE ALSO: *Ames Test; Food and Drug Administration; Maximum Tolerated Dose; Toxicology*)

INCIDENCE AND PREVALENCE

The words “incidence” and “prevalence” have precise yet different meanings. Incidence means the number of new episodes of an illness, injury, or other health-related event that commence during a specified period of time in a specified population. Incidence is therefore customarily expressed as a rate. If the notification of new cases of malignant melanoma to cancer registries in an area is complete, all diagnoses are accurate, and the number and age of people at risk of getting malignant melanoma is known, then the incidence rate can be calculated, fluctuations from year to year can be discerned, and the groups or localities where the incidence is unusually high can be identified.

Prevalence means the total number of health-related states or events that exist in a specified population at a particular point in time, regardless of when these began or how long they have existed. Because a “point” has no dimensions, it is illogical to allude to a prevalence “rate.” However, the term “period prevalence” (e.g., annual prevalence) is used to describe states or events that have occurred at some time during a designated period (e.g., a year). The term “lifetime prevalence” is a useful way to express the concept of the total number of people (or the proportion of all people) who get a particular condition, such as diabetes or breast cancer, during the course of an average lifetime.

JOHN M. LAST

(SEE ALSO: *Rates*)

INCINERATION

See Hazardous Waste

INCUBATION PERIOD

The time that elapses between the invasion of a susceptible host by an infectious agent and the onset of symptoms of the disease caused by that agent is called the incubation period. The term is also used to describe the comparable period in the life cycle of parasitic pathogens that have an intermediate host. In such cases the phase is sometimes referred to as an extrinsic incubation period; while this time period in a human host is called an intrinsic incubation period. The length of the incubation period varies greatly; it could be a few hours in the case of staphylococcal food poisoning, many months for a disease such as rabies, or even years for leprosy. The latent period in the mosquito intermediate host of the malaria parasite is temperature-dependent; some pathogens (including malaria parasites) can survive during the prolonged hibernation of the insect vector during the cool dry season.

JOHN M. LAST

(SEE ALSO: *Latent Period*)

INDIGENOUS POPULATIONS

In considering indigenous, or aboriginal, populations the terms “indigenous” and “aboriginal” must be framed within a larger context of human adaptation, migration, and colonization. Despite controversy over human origins, many paleoanthropologists uphold the “Out of Africa hypothesis,” which states that contemporary humans are descendants from a single line of *Homo sapiens* that developed in Southeast Africa between 50,000 and 100,000 years ago. From Africa human populations migrated to many areas of the world, sometimes settling among other hominid groups that had arrived earlier. This migration occurred approximately 40,000 years ago for Northwest Africa; 30,000 years ago for western Europe and Australia; and 20,000 years ago for North America (Foley, 1991). Human populations since these first migrations have been highly mobile and exogamous, thus confounding any simple notion of “original” or “native” inhabitants.

Accepted usage of “indigenous” and “aboriginal” refers to an individual or a people

whose ancestors inhabited a region before the arrival of colonists in a period starting close to 1400 c.e., corresponding to the beginnings of European imperialism and colonialism. This definition includes peoples of North America, such as American Indians and Alaska Natives, Canadian Indians (First Nations) and Inuit, and Mexican Indians. It also includes but is not limited to Native Hawaiians, South Pacific Islanders, New Zealand Maoris, Australian Aborigines, peoples of Latin America, and tribal peoples of India. These are broad descriptors, used to simplify communication. It is conceded that the appropriateness of any given term falls to the groups being discussed, and therein lie many group and individual differences.

HEALTH STATUS DISPARITIES

Controversy about origins and nomenclature does not extend to dispute over the health status of indigenous people, now numbering some 300 million worldwide. Indigenous populations, relative to nonindigenous populations as well as other disadvantaged minority groups, have more of just about every category of disease. Disparities in health are widening in many regions. Relative to national population averages, indigenous people die ten to thirty years earlier, have infant mortality rates two to three times greater, and experience significantly greater morbidity and mortality from infectious and noncommunicable diseases. Patterns of health and sickness have shifted in indigenous populations in industrialized countries from acute, infectious disease to that of a chronic and degenerative nature (Young, 1994). A high prevalence of risk factors for disease and a greater rate of development of disease and conditions with a substantial behavioral component (e.g., diabetes, hypertension, and some cancers) need to be framed in the context of social risk conditions that affect the expression of individual-level risk factors.

The health issues confronting indigenous populations did not rise out of an historical vacuum (Campbell, 1989). Under the hegemony of European colonization, indigenous populations underwent rapid environmental changes through which their cultures were diluted by and made dependent on “western” ways of living and external resources incompatible with traditional patterns. Political, economic, and social subjugation, along with warfare and genocide, led to voluntary and

involuntary adoption of elements of an external culture. Loss of land and control over living conditions, displacement of political institutions, restricted economic opportunity, weakening of social institutions, suppression of beliefs and spirituality, and breakdown of cultural rules and values resulted in individual and collective loss of identity. Anomie and marginalization led to social pathologies including injuries, suicide, violence (interpersonal and self-inflicted), mental illness, and alcohol and substance abuse. Inasmuch as environmental and behavioral or lifestyle factors are reciprocal in their relations to each other, the health of indigenous populations cannot be understood or targeted for improvement without concomitant attention to social risk conditions.

IMPROVING INDIGENOUS HEALTH

Poverty, limited education, cultural barriers, discrimination, jurisdictional problems, and power imbalances with historic precedents are the basis of the health and social problems facing indigenous people at the start of the twenty-first century. Means for improving indigenous health require the development of personal skills and individual and collective capacities and the strengthening of community action at local and national levels. This means supporting the aspirations of indigenous people for self-determination together with attempts to change behavior at the individual level and by organizational and environmental support for behavioral interventions. Culture is of great importance to such initiatives. Indigenous logics often recognize a reciprocal relationship between the health of individuals and communities. Individual health is perceived as a state in which the entire being—spirit, mind, and body—is in balance, with sickness seen as an outcome of disharmony, lack of holism, or imbalance. Cultural values, beliefs, and attitudes can be drawn upon and used by public health initiatives as powerful influences on health and reciprocal determinants of change in behavior and environment.

MARK DANIEL
G. FLETCHER LINDER

(SEE ALSO: *American Indians and Alaska Natives; Cultural Norms; Ethnicity and Health; Folk Medicine; Minority Rights; Traditional Health Beliefs, Practices*)

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INEQUALITIES IN HEALTH

It is natural for there to be considerable variation in health status in any population. Some people die young; some suffer chronic disease or disability; others live to a ripe old age. It is not these differences *per se* that comprise the theme of inequalities in health, however. Instead, it is the finding that such contrasting experiences do not occur at random. Health levels have been analyzed by region; by race, gender, and age; and by social indicators such as income, education, and occupation. All of these show systematic patterns in the distribution of health within and between societies—patterns that clearly show that at birth not every person shares an equal prospect for a long and healthy life. Among the most striking of these inequalities in health is the almost universal tendency for people in lower socioeconomic groups to die younger and to suffer more illness during their lifetime when compared to those in higher socioeconomic groups.

Because of the contrasts in income, climate, and natural resources between countries, it is perhaps not surprising that there are international inequalities in health. What is striking (and politically unacceptable) is both the level of the disparities, and the fact that improvements in the world economic situation have not greatly diminished the health gap between rich and poor nations. To illustrate the type of international inequalities that exist, Table 1 shows statistics on wealth, life expectancy, and infant mortality from seven countries. While the data on the comparison is drawn from the different years, the rates shown generally remain stable from year to year.

Table 1

Country	Gross national product per capita in U.S. dollars (1997)	Life expectancy (1999)		Infant mortality rate per 1,000 births (1996)
		Males	Females	
Bangladesh	270	57.5	58.1	77
Cameroon	650	49.9	52.0	54
Jordan	1,570	58.8	69.9	30
Malaysia	4,680	67.6	69.9	11
New Zealand	16,480	73.9	79.3	6
France	26,050	74.9	83.6	5
Japan	37,850	77.6	84.3	4

SOURCES: Economic information and infant mortality from the World Bank's *World Development Report, 1998/99*. Life expectancy data from the World Health Organization's *World Health Report, 2000*.

As seen in the table, infant mortality rates decline steeply as a nation's gross national product (GNP) rises to about \$5,000 (U.S.) per capita, then decline more slowly until about \$10,000, and remain low thereafter. There is also a marked rise in life expectancy as a nation's GNP increases. Although the GNP dollar values have changed, the essential pattern of this relationship has remained unaltered over the past fifty years. There have, however, been some changes in international inequalities in health, commonly reflecting political and social changes. For example, Central and Eastern European nations currently have a shorter life expectancy than countries in Western Europe, although there was a period after the second World War when the life expectancy in these areas converged.

If some differences between countries may be expected, the level of health inequalities *within* countries are less readily accepted. Inequalities exist between the genders (e.g., women live longer than men on average) and between racial groups. Whether these differences represent biological or genetic, as opposed to environmental, factors is open to debate. Much of the contrast, however, can be attributed to social status and inequalities in wealth. However social status and health are measured, the general pattern remains—poorer people die younger and experience less adequate health status than wealthier people. To illustrate

Table 2

Occupational class	1970-72	1979-80, 1982-83	1991-93
I (professional)	48.7	36.5	28.0
II (intermediate)	51.9	42.2	31.6
III (skilled non-manual)	65.0	53.9	45.7
III (skilled manual)	66.0	58.0	50.5
IV (partly skilled)	75.6	67.7	52.8
V (unskilled)	103.0	105.8	93.3

SOURCE: Blane and Drever (1998). *British Medical Journal*.

the typical pattern, Table 2 shows data from England and Wales summarizing years of potential life lost for different types of occupation. This statistic counts deaths, but also reflects how prematurely a person died. In this instance the data refer to men aged 20 through 64, so a death occurring at age 40 would contribute 25 years of potential life lost (the choice of 65 is arbitrary, but raising it would not alter the essential pattern of results). In 1970-1972, men in occupational class I lost an average of 48.7 years of potential life per 1,000 population for men aged 20 to 64 while unskilled workers lost an average of 103 years per 1,000 men. The results indicate a clear gradient across the occupational groups, but perhaps even more provocative is the finding that, although premature deaths are declining, the improvement is greatest among the socially advantaged, so the social inequality in years of potential life lost is actually increasing. The inequality ratios across the occupational groups rose from 2.1 in 1970-1972, to 3.3 in 1991-1993.

In an extension of such analyses, mortality has been compared not against the average wealth in a community, but against the level of dispersion of wealth in the community—the gap between rich and poor. Both R. G. Wilkinson and I. Kawachi have shown that mortality is highest in those communities with the greatest disparities in wealth; this relationship is stronger than that between mortality and the actual level of wealth.

To what may such inequalities be due? For the most part, occupation or income themselves are not the causes, although they may suggest directions for investigating the root causes. Potential

explanations consider a broad range of factors, including social and political environments, cultural factors, nutrition, and patterns of health behaviors. Aspects of individual psychology are also often cited, leading to new disciplines of study that lie at the interface between psychology and biology; such as psycho-neuro-immunology.

However they may be explained, inequalities are politically significant in that they point to a failure of national health planning. Socioeconomic disparities cannot readily be dismissed as biological facts or historical inevitabilities. Furthermore, those who are disadvantaged are often motivated to demand better access to health. Democratic societies view good health as a right to which all persons should have access, and principles of equity and justice demand that inequalities be reduced. In addition, economists note a triple benefit to addressing inequalities: Expenditures on medical care would be reduced if all groups were to share the experience of those currently most favored; the drain on disability insurance and pensions would be reduced; and a healthier workforce would bring greater economic prosperity.

IAN McDOWELL

(SEE ALSO: *Access to Health Services; Cultural Factors; Economics of Health; Equity and Resource Allocation; Ethnicity and Health; Gender and Health; Health; Infant Mortality Rate; International Health; Life Expectancy and Life Tables; Poverty and Health; Race and Ethnicity*)

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INFANT HEALTH

See Child Health Services; Infant Mortality Rate; and Well-Baby Clinics

INFANT MORTALITY RATE

The infant mortality rate (IMR) is the ratio of the number of deaths among children less than one year old during a given year to the number of live births during the same year. An infant must adapt to a rapidly changing environment, and death may occur if this adaptation is not successful. Traditionally, this has been expressed by stating that the most dangerous times in the life of a human being are "the first day, the first week, the first month, the first year," in that order. In many regions of the world, the risk of dying within the first year of life will only be matched at the ages of eighty and beyond.

The death of an infant is often dependent on external factors, especially in developing countries. Poor water quality, an inadequate food supply, substandard health services, and a high level of infectious diseases such as malaria all contribute to a high IMR. The IMR is therefore considered a good indicator of the level of health in a community. The current worldwide average is just under sixty per thousand live births. In developed countries, IMR values as low as four deaths per thousand live births are recorded from Finland, Japan, Norway, Sweden, and Singapore. The United States has an IMR of seven per thousand (as of 1998), the same as Cuba and higher than the average for industrialized countries. In developing countries, however, the infant mortality rate can reach as high as 150 per thousand (see Table 1). The IMR is usually higher for male than for female infants. Within a given country or society, IMR values show marked differences among geographical, social, and economic subsets of the population. Table 2 shows IMR figures for urban and rural areas in selected countries.

Due to the correlation with external factors, the causes of infant death also vary by region. In developed countries, congenital anomalies, prematurity, and respiratory infections are the main contributors to infant mortality. In developing countries, however, infectious and preventable diseases such as malaria, neonatal tetanus, and

Table 1

IMR for selected regions and countries, 1998	
Region or country	IMR per thousand live births
Singapore	5
Norway	5
Sweden	5
Japan	6
Finland	6
Australia	6
Austria	6
France	6
UK	6
Netherlands	6
Cuba	7
USA	7
Liberia	157
Afghanistan	165
Haiti	169
Angola	170
Sierra Leone	182

SOURCE: UNICEF (2000) *The State of the World's Children*.

diarrheal diseases also play a major role in the death of infants. In these areas, efforts to reduce infant mortality are often difficult to implement, even though the underlying causes are easily identified. Programs to provide safe water, immunization against communicable diseases, improved health facilities, and health education are costly and face many internal obstacles.

High infant mortality rates are often associated with high levels of mortality in young children (two to five years of age). In some regions, up to half the children born alive die before their fifth birthday, and up to 40 percent of all deaths are of children under five years of age. Many decision-makers in the developing world have been exposed to the traditional mental image of death in the West as associated with old age and the end of a long life—this may color their perceptions of mortality and the ensuing decisions. Perceptions of death may need to be re-evaluated to counter this instance of “cultural imperialism.”

MICHEL C THURIAUX

(SEE ALSO: *Child Mortality; Child Welfare; Maternal and Child Health; Mortality Rates*)

Table 2

Rural/urban differences in IMR, selected regions and countries, c1998		
Region or country	IMR rural (per 1000 live births)	IMR urban (per 1000 live births)
Chile	11	16
Israel	6.2	7.4
Hungary	9.8	12.4
Romania	18.5	25.6

SOURCE: World Development report, 1997

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INFANTILE PARALYSIS

See Poliomyelitis

INFECTION

See Antisepsis and Sterilization and Contagion

INFERTILITY

See Reproduction

INFLUENZA

Influenza is a potentially severe acute respiratory illness caused by various strains of the influenza virus. The different strains all produce characteristic symptoms, and because major outbreaks are associated with increased mortality, occurrences can be identified in history. Outbreaks consistent with influenza can be traced back at least to the court of Elizabeth I. Some have speculated that the Plague of Athens described by Thucydides was influenza complicated by bacterial superinfection. The influenza syndrome, commonly known as the flu, with its fever, cough, rapid onset and body

aches, is not only typical enough to be recognized in the past, but it also allows physicians to recognize it, especially when it is known that the virus is circulating. Unfortunately, death is the other consistent phenomena associated with influenza. Mortality statistics are the principal way the intensity of an influenza outbreak is quantified, and are so characteristic that viral identification of etiology is not required.

THE VIRUS AND ITS ANTIGENS

The influenza viruses contain RNA (ribonucleic acid) and are somewhat unusual in that they have a segmented genome, which means that there are eight distinct segments to the single-stranded RNA. Influenza types A and B are the only strains with epidemic potential; type C viruses are difficult to work with in the laboratory and are one of the multiple agents able to cause the common cold. While the viruses are classified into type A and B on the basis of their internal components, it is the surface antigens that are important in eliciting antibodies that will protect against future infection. These surface antigens and their changes make influenza challenging to control. Two types of changes are recognized.

One change occurs in both type A and B viruses and is a result of point mutations in the segments of the genome coding for two specific surface antigens (the neuraminidase [N] and the hemagglutinin [H] segments). These mutations are the reason that both type A and B viruses change regularly from year to year, though type A changes somewhat more rapidly than type B. Such changes are referred to as “antigen drift.” Another change is more dramatic, only occurring with type A viruses, and is an example of “antigen shift.” It takes place when one or two gene segments are replaced in a circulating virus. The same two antigens, or proteins, are involved in both types of change. The various influenza A viruses are categorized into subtypes by the differences in those two antigens, such as A (H₁N₁) or A (H₃N₂).

The most widely accepted theory explaining this antigen shift is that the segments come from animal influenza viruses. Type B influenza is confined to humans, while type A exists in numerous species of birds and domestic animals. There are

fifteen types of hemagglutinin in the influenza virus of birds, but only three in human viruses, which gives an ample opportunity for the segment coding for the hemagglutinin to move from avian viruses to human. This has apparently happened in the past, and is likely to occur in the future, either directly or through pigs. In 1997, in Hong Kong, an avian virus infected humans directly, but did not become adapted to humans by exchange of gene segments. If it had, a pandemic undoubtedly would have resulted.

PANDEMICS: HISTORY AND IMPACT

While some trace influenza pandemics back to ancient Greece, the first documented occurrence was in 1889 (see Table 1). In that and subsequent years, outbreaks of influenza were reported in many areas of the world, and in the United States, deaths reported in the state of Massachusetts for the first time demonstrated the U- or J-shaped mortality curve—an elevated mortality in young children, low mortality until age forty-five, followed by gradually increasing mortality with a relatively sharp inflection upward at age sixty-five (see Figure 1). By testing blood specimens of persons who lived through this period, researchers have been able to hypothesize about the strain of virus that caused this pandemic. In 1899, there was an apparent antigen shift, but this was determined serologically, not on the basis of an observed pandemic.

It is now certain that a virus resembling one isolated from pigs in the 1930s caused the devastating 1918 pandemic. No influenza viruses were isolated until the 1930s, so that any identification of viruses responsible for events occurring before that time has traditionally been done by testing the blood of people living through the period of an outbreak. Confirmation of this approach has recently taken place using modern molecular technique involving tissue of individuals who died during the 1918 pandemic. The virus is now termed A(H₁N₁). The estimated death toll from this pandemic has been revised upwards from 20 million to 40 million, since large segments of the world—mainly the current developing countries—were originally omitted from the counts. The lethality of this pandemic was related in large part to the death of an unexpectedly large number of healthy

Table 1

Pandemics caused by type A influenza			
Year	A Subtype	Popular Name	Impact
1889	H ₂ N ₂	—	Severe
1899	H ₃ N ₃	—	Not recognized
1918	H ₁ N ₁	Spanish flu	Catastrophic
1957	H ₂ N ₂	Asian flu	Severe
1968	H ₃ N ₂	Hong Kong flu	Intermediate
1977	H ₁ N ₁	Russian flu	Pandemic in younger people
1998	H ₅ N ₁	Avian flu	Cluster of human cases

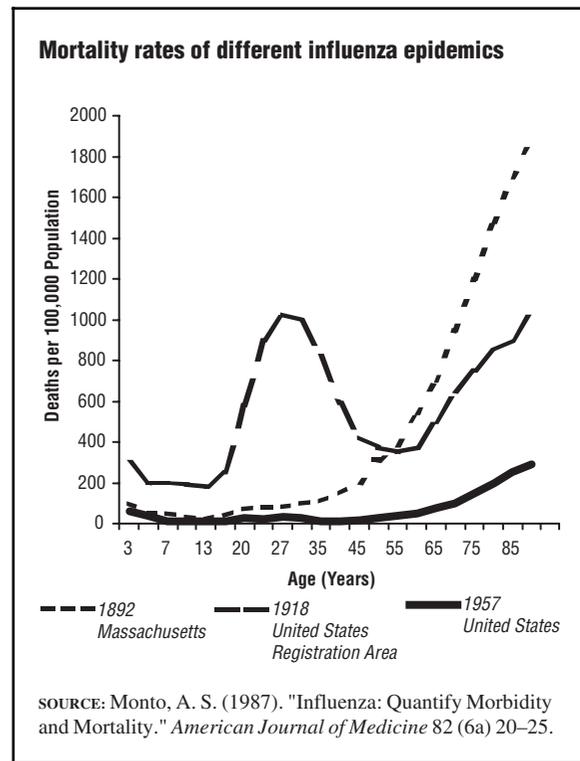
SOURCE: Courtesy of author.

young adults. This resulted in a W-shaped age-specific mortality curve (see Figure 1). It is hoped that genetic research with lung tissue, either stored or recovered from bodies, will enable epidemiologists to predict the potential behavior of future pandemic strains of influenza when they are identified. However, this has not as yet been possible, so it is only by observing the epidemiology of infection that the age-specific pattern of illness can be determined.

The first influenza viruses were isolated from humans in the early 1930s. However, the next pandemic did not occur until 1957, when the A(H₂N₂) virus appeared in South China (see Figure 1). The pandemic that resulted was the most severe since 1918, but again exhibited the more typical U-shaped mortality curve, concentrated in very young children and older individuals. A little more than ten years later, in 1968, the hemagglutinin changed and the resulting pandemic was similar to 1957 in age distribution, but more moderate in overall impact.

Two more episodes have occurred since 1968 that had the potential to be full pandemics. In 1977, the A(H₁N₁) virus returned, with outbreaks occurring first in China and then in the former Soviet Union. Since the virus had circulated twenty or more years before, when worldwide outbreaks occurred, these epidemics were confined to younger individuals. This virus has continued to circulate, along with the A(H₃N₂) and B viruses. Finally, in 1997, A(H₅N₁) moved from chickens to humans in Hong Kong. There were eighteen confirmed cases, with six deaths that were not restricted to older individuals. Fortunately, this avian virus did not

Figure 1



become fully adapted to humans. No human-to-human transmission was observed, but this episode showed how a catastrophic pandemic might have occurred had such adaptation taken place.

PREVENTION AND CONTROL OF INFLUENZA

A vaccine for the prevention of influenza was developed during World War II in order to maintain military readiness. This was done in recognition of the high morbidity that could result among troops exposed to the virus. A similar inactivated vaccine is still in use, improved in both potency and lack of side effects. It is known to be 70 to 90 percent efficacious in healthy young adults as long as the vaccine viruses resemble those circulating. This necessitates updating the viruses in the vaccine each year. For this and other reasons, the vaccine must be given annually. Since vaccination programs must be sustained, the goal in most countries has been to reduce influenza mortality by vaccinating older individuals and those with chronic underlying diseases. An exception to this

has been Japan, where, for a time, school-age children were vaccinated in an effort to control influenza morbidity. It has been repeatedly demonstrated that the inactivated vaccine is effective in preventing hospitalization and death in older individuals and, as such, is also cost effective. The inactivated vaccine is cost effective in healthy adults only when the attack rates are above 12 percent. A live attenuated influenza vaccine has been used in the former Soviet Union for many years, and another is in development in the United States. Because of its delivery—intranasally rather than by injection—it may prove to be particularly useful in children and younger adults.

Antiviral drugs have been available both for treatment and prophylaxis. Two of these are active only against type A viruses. A new group of drugs, acting as neuraminidase inhibitors, is active against both type A and B viruses. These drugs have been shown to have a prevention efficacy similar to vaccines. They start protecting more quickly than the vaccine, but have to be taken daily to continue protection. Therefore, vaccination will continue to be the usual means of prophylaxis. The neuraminidase inhibitors also significantly shorten the duration of illness, reducing severity and preventing complications. Influenza can be debilitating, even in the absence of complications, so that the drugs will be used for treatment during defined influenza outbreaks. They are likely also to be useful prophylactically, especially for outbreak control in nursing homes.

ARNOLD MONTO

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INFORMATION SYSTEMS

The organization, delivery, and financing of health care services in the United States is complex, comprising an interdependence of the private and governmental sectors of the economy. This pluralistic health care economy, with its pragmatic mix of public and private organizations, has produced a wide range of databases that help to monitor the health of the nation.

Health care spending has risen rapidly in the United States, claiming a larger and larger share of national resources. In 1965, \$41.1 billion was spent for health care, constituting 5.7 percent of the gross domestic product (GDP). In 1998, health care expenditures totaled \$1.1 trillion, an average

of \$4,094 per person and 13.5 percent of the GDP. Almost 11.5 million civilians—8.8 percent of employed civilians—were employed in the health services industry in 1998.

The growth of the health care industry in the United States has been accompanied by significant achievements in public health, including advances in prevention and, since 1950, significant declines in death rates for cardiovascular diseases, diseases of the heart, and stroke. There has been great success in monitoring these and other morbidity and mortality trends through the growth and development of our health information systems.

There is general agreement that data are needed to monitor the health of the nation; to plan and develop better health services; to deliver those services in an effective, efficient, and equitable manner; to measure their effectiveness, to make decisions on resource allocation; and to conduct research. Data also are needed to facilitate effective policymaking, planning, management, and evaluation. The federal government needs a variety of data to support its role in improving health and medical care delivery systems throughout the nation. State and local government agencies also play key roles in disease prevention, delivery of health services, and health planning and evaluation, all of which require timely and reliable health statistics. Private organizations of health professionals, health-service providers, health insurance, and many others have important interests in the collection and use of health data.

The statistical and information needs of the American pluralistic health care economy have grown enormously in the years since the enactment of the Medicare and Medicaid programs in 1965. The rapid growth of public and private health insurance, the expansion of the health care industry, and the concomitant public health, medical, and technological advances to meet the needs of a growing population have contributed to the growth of health information systems. Trends that require close monitoring include the aging of the population, the emergence of the chronic illnesses as the leading causes of morbidity and mortality, and the growing health care needs of subpopulation groups, including minorities, the uninsured, immigrants, and persons with disabilities and low incomes.

HEALTH SURVEYS AND ORGANIZATIONS

Health surveys go back to the Hagerstown morbidity studies conducted by the U.S. Public Health Service in the early 1920s. However, sample surveys did not become dominant until the rise of probability sampling in the 1930s. The U.S. Public Health Service conducted the first National Health Survey in 1935–1936, funded by the Works Projects Administration (WPA). In 1953 the National Opinion Research Center began a series of surveys, separated by five-year intervals, on consumers' use of medical care, the degree of health insurance protection, and expenditures for care.

In October 1953 a subcommittee of the U.S. National Committee on Vital and Health Statistics recommended that a national health survey be established on a permanent basis. The National Health Survey Act of 1956 called for a continuing survey and special studies on the nation's health. It also provided for studying methods and survey techniques for obtaining this statistical information and for disseminating the results of these surveys and studies. The National Health Survey, later renamed the National Health Interview Survey (NHIS), began in 1957. In 1960 the National Center for Health Statistics (NCHS) was created by combining the National Health Survey and the National Office of Vital Statistics. Responsibility for vital statistics had been transferred to the U.S. Public Health Service from the Bureau of the Census.

The NCHS is the federal government's principal health statistics agency. The NCHS congressional mandate addresses the full spectrum of health concerns from birth to death, including overall health status; environmental, social, and other health hazards; the onset and diagnosis of illness and disability; health resources; and the use, cost, and financing of health care. The NCHS also has the mandated responsibility for assisting state and local health agencies in meeting their costs of data collection.

Many other federal agencies have responsibilities for health-data collection. For example, within the U.S. Department of Health and Human Services (USDHHS), thirteen agencies have such responsibilities, including the National Institutes of Health (NIH), the Centers for Disease Control and

Prevention (CDC), the Substance Abuse and Mental Health Services Administration (SAMHSA), the Office of the Assistant Secretary for Planning and Evaluation (OASPE), the Agency for Health Care Policy and Research (AHCPR), the Health Care Financing Administration (HCFA), and the Health Resources Services Administration (HRSA). In addition, other federal agencies have health statistic operations in support of their programs, including the Bureau of the Census, the Bureau of Labor Statistics, and the Departments of Agriculture, Defense, Commerce, Transportation, and Veterans Affairs.

The production of health statistics is clearly a multiorganizational responsibility. No one agency or organization can produce all of the health statistics needed to monitor the health of the nation. Following is a summary of the major types of health statistics, who produces them, and how they contribute to monitoring the health of the nation.

VITAL STATISTICS

Birth, death, and fetal-death statistics are kept through the National Vital Statistics System of the NCHS. This program, together with the Bureau of the Census decennial census, immigration, and emigration data, provide information on the dynamics and growth of the population. This information is used in making population projections, in fertility analysis, in planning for health services, for projecting school needs, and for other purposes. It is essential in the teaching and application of demography, epidemiology, sociology, medicine, and public health.

The historical roots of the vital statistics registration system go back to the earliest American settlements, when colonies such as Massachusetts and Virginia, following the English custom, required that records be kept of christenings, weddings, and burials. Lemuel Shattuck was the leading proponent of registration. He demonstrated that the health of the residents of the city of Boston was deteriorating, as measured by mortality levels. The *Report of the Sanitary Commission of Massachusetts*, authored by Shattuck, recommended the creation of a state board of health based on complete registration and vital statistics. However,

it was not until 1933 that all states had similar registration programs.

Vital statistics are provided through state-operated registration systems. Standard forms for the collection of data and model procedures for the uniform registration of events are developed and recommended for use through cooperative activities of the states and the NCHS. The NCHS shares the costs incurred by the states in providing vital statistics for national use. Additional programs related to the National Vital Statistics System include the Linked Birth and Infant Death Data Set, the National Maternal and Infant Health Survey, the National Mortality Followback Survey, and the National Death Index. The introduction of the National Death Index (NDI), a computerized index of death record information beginning with 1979 deaths, has made enormous contributions to more efficient epidemiologic and health studies. Researchers can go to one source, the NCHS, to obtain mortality information on their study participants. Prior to the establishment of the NDI, each state had to be contacted separately for such information.

The vital statistics program is generally regarded as a successful program, providing full counts of births and deaths at the local, state, and federal geographic levels. Except for the important issue of timeliness, the reports emanating from the vital statistics program have done an excellent job of meeting the demands of users. The availability of data electronically has helped to improve the timeliness of vital-statistics data, thereby enhancing the usefulness of the data.

PUBLIC HEALTH SURVEILLANCE

Public health surveillance is defined as the “ongoing systematic collection, analysis, and interpretation of data on specific health events affecting a population, closely integrated with the timely dissemination of these data to those responsible for prevention and control” (Thacker et al. 1996, p. 633). A feature of surveillance is the ability to identify individuals and groups of individuals for further action on prevention and treatment. The CDC and other federal agencies are involved in the collection of surveillance data, including, but not limited to, the following:

- The CDC operates the National Notifiable Disease Surveillance System. Physicians, laboratory personnel, and other health care providers are required by state law to report weekly all cases of health conditions, mainly infectious in origin, that are specified as being notifiable. The Council of State and Territorial Epidemiologists determines which notifiable conditions should be reported from state health departments to the CDC.
- The National Institute of Occupational Safety and Health has maintained the National Traumatic Occupational Fatalities Surveillance System, a sentinel health event verification system for occupational risk. It is based on information taken from death certificates.
- The Food and Drug Administration conducts post-marketing surveillance of adverse reactions to drugs.
- The National Cancer Institute conducts the Surveillance, Epidemiology, and End-Results (SEER) Program that includes eleven population-based registries in the United States. It provides data on all residents diagnosed with cancer during the year, as well as follow-up information on all previously diagnosed patients.
- The CDC conducts the Behavioral Risk Factor Surveillance System (BRFSS), a telephone survey conducted in each of the fifty states that provides data on health behaviors. Questions can be added to the survey by individual states.
- The CDC has developed the Pregnancy Assessment Monitoring System (PRAMS) to collect information on maternal behaviors that occur before, during, and shortly after pregnancy.
- The Consumer Product Safety Commission conducts surveillance on product-related injuries.

Surveillance data vary in their quality, are often incomplete and unrepresentative, and they may vary in sensitivity and specificity. Although

the current programs provide essential data to monitor the incidence of communicable diseases and some chronic diseases, the system also relies on voluntary physician reporting, which has been demonstrated to be variable and inconsistent. States differ in their authority to require physician reporting. Development of greater standardization in reporting from state to state and obtaining improved physician cooperation are both areas that need further exploration.

Population-based registries and national sample surveys have also been used for surveillance purposes. Registries are established to identify cases through several sources (schools, hospitals, laboratories). Registries require extensive confirmation of cases, which leads to longer lag times between a health event and the reporting of the event. NCI's SEER program covers about 10 percent of the U.S. population and provides data that are used to monitor long-term trends of cancer incidence and mortality. Currently, approximately thirty states have population-based registries, but they may be limited by both under-registration and selection bias.

HEALTH STATUS, HEALTH CARE UTILIZATION, AND COSTS

Statistics abound on health status and the use of medical care services at the federal, state, and local levels. The National Health Interview Survey (NHIS) and the National Health and Nutrition Examination Survey (NHANES) are the major national surveys for assessment of health status in the United States. Both are sponsored by the NCHS. The NHIS is a primary source of information on the health of the civilian, noninstitutionalized population of the United States. Conducted continuously since 1957, it provides national data on the annual incidence of acute illness and accidental injuries, the prevalence of chronic conditions and impairments, the extent of disability, the utilization of health care services, and other health-related topics. To provide data on special topic areas in addition to the basic NHIS data, extensive supplements have been conducted annually. Topics of coverage in the supplements vary from year to year. For example, in 1995 the supplements included questions on the following topics: immunization, disability,

followback of persons with disabilities interviewed in the prior year, family resources (access to care, health care coverage, income, and assets), year 2000 objectives, tobacco use, nutrition, clinical preventive services, physical activity and fitness, and AIDS (acquired immunodeficiency syndrome) knowledge and attitudes. The NHIS sample design includes about 40,000 households interviewed, resulting in a sample of about 102,000 individuals, with oversampling of black and Hispanic persons.

The National Health and Nutrition Examination Survey (NHANES) was established in 1971 to collect the kind of health data best obtained by direct physical examinations and physiological and biochemical measurements. The NHANES is the cornerstone of the National Monitoring and Related Research Program, providing data needed for nutrition monitoring, food fortification policy, establishing dietary guidelines, and assessing government programs and initiatives such as the *Healthy People 2000* objectives of the USDHHS. In the past, researchers sometimes had to wait as long as ten years after data collection before gaining access to data based on the entire six-year sample. The NHANES is now a continuing, annual survey, linked to the NHIS, and data are being collected from a representative sample of the U.S. population every year.

The NHIS and the NHANES are only two of the many national federal surveys that collect data on health status, medical care utilization, and insurance coverage. Other important surveys that collect similar data, as well as data on medical care expenditures, include the following:

- The National Immunization Survey (NIS) is a continuing nationwide telephone sample survey that gathers data on children 19 to 35 months of age. In 1997, data were obtained for 32,742 children to provide estimates of vaccine-specific coverage for areas considered to be high risk for under-vaccination.
- The Medical Expenditure Panel Survey (MEPS) conducted by the Agency for Healthcare Research and Quality (AHRQ) is a study of approximately 9,000 households. MEPS is a subsample of NHIS participants, providing health status and other data to enhance analytical capacity. Use of NHIS data, in concert with the data collected in the MEPS, provides the capacity for longitudinal analysis. Each sample panel is interviewed a total of five times over thirty months to yield annual use and expenditure data for two calendar years. The MEPS household component reflects an oversampling of households with Hispanics and blacks. MEPS also has an institutional component.
- The National Household Survey on Drug Abuse (NHSDA), conducted by SAMSHA, focuses on the incidence, prevalence, consequences, and patterns of substance use and abuse. In 1997 the NHSDA was expanded from 18,000 respondents to about 25,000 respondents to generate estimates for the nation and for two states (California and Arizona). In 1999 the NHSDA was further expanded to 70,000 respondents to generate estimates for all fifty states.
- The Survey of Mental Health Organizations, conducted by SAMSHA, is a biennial inventory of mental health organizations and general hospital mental health services.
- The Medicare Current Beneficiary Survey (MCBS), conducted by the Health Care Financing Administration (HCFA), is an ongoing rotating panel survey of approximately 12,000 aged and disabled Medicare beneficiaries, consisting of four overlapping panels of Medicare beneficiaries surveyed each year. Each panel contains a national representative panel of beneficiaries who are interviewed twelve times to collect three complete years of utilization data. The survey provides comprehensive data on health and functional status, use of medical services, covered and noncovered health care expenditures, and health insurance for Medicare beneficiaries.
- The National Health Care Survey (NHCS) is a family of NCHS provider-based

surveys that measure the utilization of health services. Included are hospitals (National Hospital Discharge Survey), physicians (National Ambulatory Medical Care Survey), emergency and outpatient departments (National Hospital Ambulatory Medical Care Survey), ambulatory care centers (National Survey of Ambulatory Surgery), nursing homes (National Nursing Home Survey), and health agencies providing home health care services and hospice care (National Home and Hospice Care Survey).

- The National Survey of Family Growth (NSFG) is a periodic survey of women 15 to 44 years of age. The purpose of the survey is to provide national data on factors affecting birth and pregnancy rates, adoption, and maternal and infant health. In 1995, for the first time, the sample was obtained from households that had been interviewed in the NHIS. A total of 10,847 women were interviewed, and Hispanic and black women were oversampled. Cycle six of the NSFG will include a sample of men for the first time.
- The Healthcare Cost and Utilization Project (HCUP), conducted by the AHRQ, consists of the State Inpatient Databases (SID) and the Nationwide Inpatient Sample (NIS). The SID contains all hospitals and all discharges from twenty-two participating states. The AHCPR receives the data from each statewide data organization, processes the data into a uniform format, and then returns the uniform SID files to the statewide data organization. The NIS database contains a sample of hospitals selected from SID. The NIS can be used to produce national estimates, regional estimates, and state estimates for participating states.
- The Current Population Survey (CPS) is a monthly sample survey of about 50,000 households conducted by the U.S. Bureau of the Census for the Bureau of Labor Statistics. The CPS is the primary source of information on labor force

characteristics of the U.S. population. Monthly estimates from the CPS include employment, unemployment, earnings, hours of work, and other indicators. The annual March supplement produces national and state estimates on health insurance coverage, including private health insurance, Medicare, Medicaid, CHAMPUS, and military health care.

PRIVATE SECTOR DATA COLLECTION SYSTEMS

In addition to the federal health statistics surveys and the programs briefly discussed above, the fifty states and the private sector maintain data systems and conduct many surveys of hospitals, health professionals, and health care organizations. The private health sector includes organizations of health-service providers, health professionals, health-insurance payers, consumers, industry, and private philanthropy. The following private organizations maintain health-data systems relating to their specific areas of interest: The Alan Guttmacher Institute conducts an annual survey of abortion providers; the American Association of Colleges of Osteopathic Medicine compiles data on various aspects of osteopathic medical education; the American Association of Colleges of Pharmacy compiles data on student enrollment and types of degrees conferred; the American Association of Colleges of Podiatric Medicine compiles data on schools and enrollment; the American Dental Association conducts annual surveys of predoctoral dental educational institutions, including information on student characteristics, financial management, and curricula; the Association of American Medical Colleges collects information on student enrollment in medical schools; the Association of Schools and Colleges of Optometry compiles data on the various aspects of optometric education; the Association of Schools of Public Health compiles data on the twenty-eight schools of public health in the United States; and the National League for Nursing conducts an annual survey of schools of nursing.

The American Hospital Association conducts an annual survey of all hospitals and compiles

information on characteristics of the facilities and services provided, admissions, and expenses and revenues. The American Medical Association maintains a physician masterfile on almost every physician in the United States. InterStudy compiles data on health maintenance organizations. Many national and state data collection activities are conducted by these private organizations, but their scope and quality varies.

HEALTHY PEOPLE 2000

A relatively recent and important development in monitoring the health of the nation has been the identification of broad goals and detailed objectives, described in *Healthy People 2000: National Health Promotion and Disease Prevention Objectives*, published by the U.S. Department of Health and Human Services in 1991, and in subsequent reports. The targets contained in *Healthy People 2000* were developed between 1987 and 1990 through an extensive consultative and hearings process conducted and managed by the U.S. Public Health Service in partnership with the Institute of Medicine of the National Academy of Sciences. To provide guidance to the effort, a national consortium was formed that included the principal health officials in the fifty states and representatives of more than three hundred professional and voluntary national membership organizations.

Three broad goals were identified for the program: (1) increase the span of healthy life for Americans, (2) reduce health disparities among Americans, and (3) achieve access to preventive services for Americans. To foster accomplishment of these goals, *Healthy People 2000* also set forth three hundred measurable objectives to be accomplished by the year 2000 in twenty-two priority areas of health promotion, health protection, and clinical preventive services. In addition, objectives were established for improving surveillance and data systems at national, state, and local levels to target interventions to areas of greatest need. The range of topics covered by the objectives is extensive, and includes the following: (1) personal behavior and risk factors such as physical fitness and activity, nutrition, tobacco, and alcohol and other drugs; (2) psychosocial factors such as mental health and violent and abusive behavior; (3) the physical environment, including unintentional injuries, occupational safety and health, environmental health,

and food and safety; (4) infectious diseases, including HIV (human immunodeficiency virus) infection and sexually transmitted diseases; (5) reproductive and infant health, including family planning and maternal and infant health; (6) chronic diseases such as heart disease and stroke, cancer, diabetes, oral health problems, and chronic disabling conditions; and (7) services and protection, including educational and community-based programs, as well clinical preventive services.

Based on 319 unduplicated objectives, 15 percent of the objectives reached or surpassed the year 2000 targets by the end of 1999. At this point, progress toward the targets had been made for another 44 percent of the objectives, 18 percent showed movement away from the target, 6 percent showed mixed results, and 3 percent showed no change from the baseline. The remaining objectives had no data with which to evaluate progress.

The national objectives in *Healthy People 2000* have provided motivation for the continued development of public health assessment and monitoring of the nation's health efforts at the national, state, and local levels. This effort has led to the development of *Healthy People 2010*, the nation's prevention agenda for the first decade of the twenty-first century. It contains two broad goals—to increase the years and quality of healthy life and to eliminate health disparities among Americans, especially minorities. The two goals are supported by 467 objectives, grouped into 28 focus areas with specific numerical targets. Data for the baselines and to monitor progress in reaching these targets come from the National Vital Statistics Program, the National Health Interview Study, the National Health and Nutrition Examination Survey, and the Behavioral Risk Factor Surveillance System, and others data systems.

CONCLUSIONS

A variety of health data and information systems are now available in the United States to monitor the health of the nation. This information base must continue to be available to allow the monitoring of trends and the detection of changes or aberrations in the economic, social, or health characteristics of the nation. The appropriate federal role is to produce national data useful for these purposes, as well as to provide norms to which state and local data can be compared. The data

must be of high quality, produced in a timely manner, and relevant to issues of the day.

As the nation moves closer to the objective of a national, systematic approach to meeting the information needs for monitoring the health of the nation, an effort must also be made to coordinate data-collection activities, both within the federal establishment and between the government and the private sector. This will avoid unnecessary and costly duplication and encourage comparability of information collected by different systems. These health information systems are essential to meet the multiple needs of many programs and organizations in the twenty-first century.

DOROTHY P. RICE

(SEE ALSO: *Biostatistics; Certification of Causes of Deaths; Community Health Report Cards; Epidemiology; Field Survey; Healthy People 2010; Information Technology; Mortality Rates; National Center for Health Statistics; National Death Index; National Health Surveys; Notifiable Diseases; Registries; Reporting, Mandatory; Sampling; SEER Program; Statistics for Public Health; Surveillance; Surveys*)

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INFORMATION TECHNOLOGY

Many areas of public health, including vital statistics, investigation and research, surveillance, epidemiology, surveys, laboratories technology, maternal and child health, and environmental health, use information technology (IT) to achieve their goals and objectives. IT includes the use of computers and communications, and the transformation of data into information and knowledge.

In the 1960s, "number crunching" was one of the first applications for which computers were used in the hospital environment. A decade later, in the early 1970s, IT applications were being used

Table 1

Text, Graphics, Multimedia Common Sound, Still-Video, and Motion-Video Formats on the Web		
Text & Graphics		
Extension	Formats	Explanation
TXT, DOC	MS Word	Word processing application
WPD	WordPerfect	Word processing application
RTF	Rich Text Format	Method of encoding text formatting and document structure using ASCII character set.
PPT	Microsoft PowerPoint	Presentation Graphics application
PRS	Harvard Graphics	Presentation Graphics application
XLS	MS Excel	Spreadsheet application
HTM	MS FrontPage	Editor: application for creating and editing Web pages. Explorer: application for maintaining, testing, and publishing webs.
Extension Sound Formats		
Extension	Formats	Explanation
RA	RealAudio	Used with RealAudio Web Server and RealAudio Player add-on for browsers
SBI	Sound Blaster Instrument	Used for a single instrument with Sound Blaster cards
WAV	MS Waveform	Sound format used in Windows for event notification
Still-Video/ Graphics		
Extension Formats (SVF) (Raster or bitmap images)		
GIF	Graphics Interchange Format	Compressed graphics format commonly used on CompuServe
BMP	Windows bitmap	Bitmap images
PCC, PCX	PC Paintbrush	Bitmap images
JPEG, JPG	Joint Photographic Experts Group	Highly compressed format for still images, widely used for multi-platform graphics
TIFF	Tagged Image File Format	High-resolution, tag-based graphics format used for the universal interchange of digital graphics
PCD	Photo CD	A graphics file format developed by Eastman Kodak Company
PDF	Portable Document Format	Adobe's format for multi-platform document access through its Acrobat software
PS	PostScript	Adobe's type description language, used to deliver complex documents over the Internet

in admissions, patient care, clinical laboratories, and intensive care units. In the 1990s, the fusion of computers and all forms of communication have become commonplace in all aspects of life. The Internet and the World Wide Web (WWW) are now tools that both professionals and laypeople use for all type of businesses. An evolution has occurred in the ways people use computers, in the power, capacity, and speeds of computers, and in

Table 1, continued

Text, Graphics, Multimedia Common Sound, Still-Video, and Motion-Video Formats on the Web [CONTINUED]		
Still-Video/ Graphics		
Extension	Formats (SVF)	Vector Images
AI	Adobe Illustrator	
CGM	Computer Graphics Metafile	
DRW	Micrografx Drawing	
PCT	Macintosh PICT	
WMF	Windows Metafile	Used mostly for word-processing clip art
WPG	WordPerfect Graphics	Word-processing clip art
Extension Motion-Video Formats (MVF)		
DVI	Digital Video Interactive	MVFs found in CD-ROMs
FLI	Flick	Autodesk Animator MVF
MPEG, MPG	Motion Picture Experts Group	Full-motion video standard using frame format similar to JPEG with variable compression capabilities
MOV	Quick Time	Apple's motion video and audio format (originally for Macintosh, available for Windows)
SOURCE: Courtesy of author.		

the way systems are put together and integrated (see Table 1).

Most people tend to think about computers in terms of the systems that they use at home or at work. Most of the time these are "stand-alone" models, such as desktops, laptops, or notebooks, and sometimes they are wireless devices, such as palm pilots, personal organizers, and third-generation cellular phones that allow access to e-mail and the Internet. Although public health has not yet taken full advantage of these technologies, it is important to understand the basics of these technologies in order to visualize their potential uses in the near and long-term future.

COMPUTERS

Initially, the computer was conceived as a device to manipulate numbers and solve arithmetical problems. During its development, it was recognized that a machine capable of manipulating numbers could also be used to manipulate any "symbol" represented in numeric form. An electronic data processing system (EDPS) involves at least three basic elements: the input entering the system, or

source data; the orderly processing that takes place within the system; and the output, or end result. The EDPS has four functional units: the input devices; the central processing unit (CPU); the storage, or memory; and the output devices.

The central processing unit (CPU) is the control center of the EDPS, and it has two parts: the "arithmetic/logic unit" (ALU) and the "control unit." The ALU performs operations such as addition, subtraction, multiplication, and division; as well as moving, shifting, and comparing data. The control section of the CPU directs and coordinates all the operations of the computer according to the conditions set forth by the stored program. It selects instructions from the stored program and interprets them. It then generates signals and commands that cause other system units to perform certain operations at appropriate times. It controls the input/output units, the arithmetic-logic operations of the CPU, and the transfer of data to and from storage. It acts as a central nervous system, but performs no actual processing operations on data.

Storage Devices. The main storage of a computer—the memory, or internal storage unit—is basically an electronic filing cabinet where each location is capable of holding data and instructions. The storage unit contains four elements: (1) all data being held for processing, (2) the data being processed, (3) the final result of processing until it is released as output, and (4) all the program instructions while processing is being carried out. Each location in main storage is identified by a particular address. Using this address, the control section can readily locate data and instructions as needed. The size or capacity of main storage determines the amount of data and instructions that can be held within the system at any one time. In summary, the internal memory is a temporary storage and is called "random access memory" (RAM). There is also a second type of memory, called "read-only memory" (ROM). This memory is fixed; meaning it can be read but cannot be written to, changed, or deleted. There are also secondary memory devices or auxiliary storage, sometimes called "sequential access memory," such as diskettes, hard drives, and magnetic tape. Depending on how often the data will be used these auxiliary devices will be chosen. For example, mass storage devices or certain types of tapes may be used for archival purposes of medical

records or bank accounts, where certain legal aspects of the data may be required.

Input/Output (I/O) Devices. These are devices that are linked to the computer and can introduce data into the system, and devices that can accept data after it has been processed. Some examples are: disk storage drives, printers, magnetic tape units, display stations, data transmission units, and the old punched card or paper tape. Input devices perform the function of converting the data from a form that is intelligible to the user to a form that is intelligible to the computer. Output, on the other hand, is data that has been processed, (e.g., shown on a display device). In some cases, a printer can readily display the data in an understandable form. In other instances, such as with a magnetic tape drive, the data is carried as input for further processing by another device. In this case, the computer retains the data until further processing takes place. In summary, a digital computer identifies an electronic device capable of manipulating bits of information under the control-sequenced instructions stored within the memory of the device. Some common forms of storing data today include: floppy disks (used mainly for temporary storage); magnetic disks (fixed or removable); and optical disks that can store very large amounts of data. *CD-ROM* (compact disk—read only memory) devices store the information by means of a finely focused laser beam that detects reflections from the disc. This technology is sometimes referred by the term "write once, read many times" (WORM).

Computer System. The computer elements described thus far are known as "hardware." A computer system has three parts: the hardware, the software, and the people who make it work. The computer software can broadly be divided in two categories: systems software and application software or programs. These systems software can be further divided into: operating systems and programming languages. A computer program is a set of commands (in the form of numeric codes) that is put into the computer's memory to direct its operation. Testing, or debugging, is done to check if a program works properly. The ongoing process of correcting errors and modifying working programs is called software maintenance. The science of software engineering has provided formal methods for writing and testing programs.

DATA PROCESSING, DATA REPRESENTATION

When people communicate by writing in any language, the symbols used (the letters of the alphabet, numerals, and punctuation marks) convey information. The symbols themselves are not information, but representations of information. Data in an EDPS must be expressed symbolically so that the machines can interpret the information presented by humans. In general, the symbols that are read and interpreted by a machine differ from those used by people. The designer of a computer system determines the nature and meaning of a particular set of symbols that can be read and interpreted by the system. The actual data that is used by these systems is (or was in the past) presented as holes on punched cards or paper tape, as spots on magnetic tape, as bits (binary digit) or bytes of information in a disk, diskette, CD-ROM, or optical disk; as magnetic-ink characters; as pixels in display-screen images; as points in plotted graphs; or as communication-network signals.

In many instances, communication occurs between machines. This communication can be a direct exchange of data in electronic form over cables, wires, radio waves, infrared, satellites or even wireless devices such as cellular phones, pagers, and hand-held personal organizers and/or notebooks. It can also be an exchange where the recorded or stored output of one device or system becomes the input of another machine or system.

In the computer, data is recorded electronically. The presence or absence of a signal in specific circuitry represents data in the computer the same way that the absence or presence of a punched hole represented data in a punched card. If we think of an ordinary lightbulb being either on or off, we could define its operation as a binary mode. That means that at any given time the lightbulb can be in only one of two possible conditions. This is known as a "binary state." In a computer, transistors are conducting or nonconducting; magnetic materials are magnetized in one direction or in the opposite direction; a switch or relay is either on or off, a specific voltage is either present or absent. These are all binary states. Representing data within the computer is accomplished by assigning a specific value to each binary indication or group of binary indications.

Binary signals can be used to represent both instructions and data; consequently the basic language of the computer is based primarily on the "binary number system."

A binary method of notation is usually used to illustrate binary indications. This method uses only two symbols: 0 and 1, where 0 and 1 represent the absence and presence of an assigned value, respectively. These symbols, or binary digits, are called "bits." A group of eight bits is known as a "byte," and a group of 32 bits (4 bytes) is known as a "word." The bit positions within a byte or a word have place values related to the binary number system. In the binary number system the values of these symbols are determined by their positions in a multidigit numeral. The position values are based on the right to left progression of powers having a base of 2 (2^0 , 2^1 , 2^2 , 2^3), commonly employed within digital computers. For example, if there are four light bulbs next to each other numbered 4, 3, 2, and 1 and 1 and 3 are "on" and 2 and 4 are "off," the binary notation is 0101.

The system of expressing decimal digits as an equivalent binary value is known as Binary Coded Decimal (BCD). In this code, all characters (64 characters can be coded), including alphabetic, numeric, and special signs, are represented using six positions of binary notation (plus a parity bit position). The Extended Binary Coded Decimal Interchange Code (EBCDIC) uses eight binary positions for each character format plus a position for parity checking (256 characters can be coded). The American Standard Code for Information Interchange (ASCII) is a seven-bit code that offers 128 possible characters. ASCII was developed by users of communications and data processing equipment as an attempt to standardize machine-to-machine and system-to-system communication.

Computer Number Systems and Conversions.

Representing a decimal number in binary numbers may require very long strings of ones and zeros. The hexadecimal system is used as a shorthand method to represent them. The base of this system is 16, and the symbols used are: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E and F. In other words, F is 15 in decimal notation and 1 1 1 1 in binary.

Programming Languages Techniques. Assembler languages are closer to machine instructions than to human language, and having to express

logical procedures, arithmetical calculations, and textual manipulations in these languages affects a programmer's productivity because they are so cumbersome. There are many higher-level programming languages, such as ALGOL, BASIC, COBOL, FORTRAN, and Pascal, that are much closer to human means of expression.

A programmer writes a source program in a human-readable programming language. A compiler translates these English-like statements into instructions that the computer can execute—such instructions are called an “object program.” Through added library routines the computer does further processing of the object program, executes it, and an “output” is produced. There are some “optimizing compilers” that automatically correct obvious inefficiencies in source programming. Sometimes, with the use of “interpreters,” debugging can be done to a program as it executes the user program piece by piece. MUMPS, LISP, and APL are interpreters used for this purpose in the health care environment, artificial intelligence, and mathematics fields, respectively. Because of the time and costs associated with development, it is generally not cost effective in today's environment to develop an application package, but rather buy it (if available) from a vendor. The costs are thus spread among thousands of users. Typical applications packages used for public health purposes are SAS and SPSS (for biostatistics) and ArcView/GIS (for Geographical Information Systems). In addition there are some data manipulation languages (e.g., Oracle and dBASE) that were written with this purpose. A database manipulation language (DML) is a special sublanguage used for handling data storage and retrieval in a database system. Using a data definition language (DDL), programmers can organize and structure data on secondary storage devices.

Data Acquisition. Capturing and entering data into a computer is expensive. Direct acquisition of data avoids the need for people to read values and measure, encode, and/or enter the data. Automated data acquisition can help eliminate errors and speed up the procedure. Sensors connected to a patient convert biological signals into electrical signals that are transmitted into a computer. Many times these signals (e.g., ECG, blood pressure, heart rate) are analog signals, and in order to be stored into a digital signal a conversion needs to

occur. This process is called analog to digital conversion (ADC).

DATABASES AND DATABASE MANAGEMENT SYSTEMS

A database (DB) system is a computer-based record keeping system used to record and maintain certain types of information that have a significant value to some organization. A DB is a repository of stored data, which in general is both integrated and shared. Between the physical database and the users of the system is a layer of software, usually called the database management system (DBMS). All requests from the users to access the DB are handled by the DBMS.

When trying to organize the data and information within an organization, the DB helps the user in entering, storing, and retrieving it, and when trying to integrate all or part of the information of the enterprise the DB becomes a key player. Normally, within the DB, information is organized into data elements, fields, records, and files. In a system such as a hospital information system (HIS), a patient name is a data element or a field; a record could be related to that patient's visit on a particular date (e.g., date, diagnoses, treatments, charges, medications, tests) at a particular time; and a file would contain all the information from all the visits for that patient. An HIS DB will include not only patient files, but it could also have accounting information related to charges, inventory, payroll, and personnel records. With DB systems, different people can have access to different parts of the system, so, for example, not all personnel employees will have access to laboratory results.

The DBMS organization and definition of the contents of the individual data elements, fields, records, and files are provided via a machine-readable definition called “schema.” This creates an independence of physical location from logical location of the content of a DB. The DBMS not only “manages the DB” but also allows for entering, editing, and retrieving results. The DBMS helps with the integration of data coming from multiple sources. The user can also access and retrieve specific types of information via queries.

A DB provides an organization with centralized control of its operational data. Some of the

advantages of having centralized (versus distributed) control of the data are:

- Redundancies can be reduced.
- Inconsistencies can be avoided.
- Data can be shared.
- Standards can be enforced.
- Privacy, confidentiality, authenticity, and security restrictions can be applied.
- Integrity can be maintained.
- Conflicting requirements (among users) can be balanced (for the enterprise).
- Data is easier to support (the single repository, the application, and the end-users).

Due to technological advancements, databases today are much more complex than a few decades ago. They contain “multimedia” information, such as text, graphics, scanned images from documents, clinical images from all modalities (X-rays, ultrasound, MRI, CT scan), still and dynamic studies, and sound. When doing population studies, the creation of data “warehouses” is necessary, and data “mining” techniques are used to extrapolate results. In public health, the data needed for a study can reside in a small computer, in a local area network (LAN), or in a wide area network (WAN). In order to use information that is geographically distributed (and/or with distributed users) it is important to learn techniques for data integration and data communications. Because of the continuing fusion of computers and communications, this is the fastest changing area within information technology.

INTERNET AND THE WORLD WIDE WEB

There is little historical precedent for the swift and dramatic growth of the Internet, which was originally a limited scientific communication network developed by the U.S. government to facilitate cooperation among federal researchers and the university research community. With its rapid adoption by the private sector, the Internet has remained an important research tool, and it is also becoming a vital ingredient in maintaining and

increasing the scientific and commercial leadership of the United States. In the twenty-first century, the Internet will provide a powerful and versatile environment for business, education, culture, entertainment, health care and public health. Sight, sound, and even touch will be integrated through powerful computers, displays, and networks. People will use this environment to work, study, bank, shop, entertain, visit with each other, and communicate with their health care providers. Whether at the office, at home, or traveling, the environment and its interface will be largely the same, and security, reliability, and privacy will be built in. Benefits of this dramatically different environment will include a more agile economy, improved health care (particularly in rural areas), less stress on ecosystems, easy access to lifelong and distance learning, a greater choice of places to live and work, and more opportunities to participate in the community, the nation, and the world.

Internet and WWW Acronyms. People that communicate with each other electronically may not have the same “platform.” “Cross-platform” means that people do not have to use the same kind of operating system to access files on a remote system. In order to access the Web there are two basic mechanisms: (1) using the telephone system to link to another computer or network that is connected to the Internet, and (2) connecting to a network; and from there into the Internet. An Internet service provider (ISP) may be required to access the Internet. An important factor regarding Internet access is bandwidth, which determines how much data a connection can accommodate and the speed at which data can be accessed.

Information on the Web is generally written in Hypertext Markup Language (HTML), which is a text-based markup language that describes the structure of a Web document’s content and some of its properties. It can also be viewed as a way of representing text and linking it to other resources, such as multimedia files, graphic files, still or dynamic images files, and sound files. HTML contains the information or text to be displayed and the control needed for its display or playback.

Navigation Tools. Prior to the use of Web browsers, there were several Internet navigation tools that required more user expertise than the modern browser, including:

- *File Transfer Protocol (FTP)*, a cross-platform protocol for transferring files to and from computers anywhere on the Internet.
- *Gopher*, a tool for browsing files on the Internet.
- *Usenet*, a worldwide messaging system through which anyone can read and post articles to a group of individuals who share the same interests.
- *Wide Area Information Server (WAIS)*, one of a handful of Internet search tools that can be spread across the network to scour multiple archives and handle multiple data formats.
- *Hyperlink* (also called link), a pointer—from text, from a picture or a graphic, or from an image map—to a page or file on the World Wide Web; hyperlinks are the primary way to navigate between Web pages and among Web sites.

Today, a Web browser is the main piece of software required by the end user to find information through Internet. Some of the most popular browsers are: Lynx, Mosaic, Netscape Navigator/Communicator, and Internet Explorer. Lynx is a text-only Web browser; it cannot display graphical or multimedia elements. Mosaic, a graphical Web browser, was the first “full-featured” graphical browser for the Web. It was developed by a team of programmers at the National Center for Supercomputing Applications (NCSA). One of these programmers, Marc Andreessen, later formed Netscape. Netscape Navigator/Communicator is one of the most popular Web browsers. Internet Explorer is Microsoft’s Web browser.

Web Resources. A Uniform Resource Locator (URL) is a Web resource that describes the protocols needed to access a particular resource or site on the Web, and then point to the resource’s Internet location. URLs are, in short, used to locate information on the Web.

Normally the URL is composed of six parts:

1. The protocol or data source (i.e., ftp://, gopher://, news://, telnet://, WAIS://, http://)

2. The domain name (for the Web server where the desired information resides)
3. The port address
4. The directory path (location of the Web page in the Web server’s file system)
5. The object name
6. The spot (precise location within the file)

Protocols are the rules and formats that govern the methods by which computers communicate over a network. Protocols link clients and servers together and handle requests and responses, including making a connection, making a request, and the closing of the connection. Transmission Control Protocol/Internet Protocol (TCP/IP) is the full set of standard protocols used on the Internet. Hypertext Transfer Protocol (HTTP) is an Internet protocol specifically for the World Wide Web. It provides a way for Web clients and servers to communicate primarily through the exchange of messages.

Multipurpose Internet Mail Extension (MIME) is a technique designed to insert attachments within individual e-mail files. MIME allows a Web server to deliver multiple forms of data to the user in a single transfer. Also, when creating a Web page, it could include text files as well as nontext files, such as sound, graphics, still images, and videos.

Intersection and Information Technology and Public Health. The applications of IT in public health are numerous and varied. One particularly important example, however, is the use of Geographical Information Systems (GIS). Using GIS, public health officials can create very effective procedures to do their tasks using information technology. Doing a feedback loop they can: measure, plan, act, and measure again. In this manner, officials can identify a problem (e.g., cancer) by measuring data from a registry. Further, from the health care providers community, they can select a target population (e.g., breast cancer) and develop an implementation strategy for an intervention plan with the health care providers. Finally, by measuring again, GIS allows public health officials to evaluate the impact of the implementation plan on that data registry.

GIS is thus an information technology which can help improve health care and public health in

many areas such as disease tracking, outbreak investigations, geostatistical analysis, and routing of health workers. As a means of tracking, residential zip codes of patients who appear at different clinics can be plotted with signs and symptoms of a selected diagnosis (e.g., upper respiratory infections [URI]). URIs are a marker for some toxic biological agents. Furthermore, community outbreaks of infectious diseases such as measles can be quickly analyzed then using GIS tools. Color shading can indicate areas with certain levels of morbidity probability or likeliness of getting sick. Areas that require immediate interventions such as immunizations can be depicted by a different shade. Geostatistical analysis is one of the most powerful tools available to a public health department. With a relatively small number of sampling points, predictive maps can be quickly produced to provide the likely extent of threats to public health. This mode of forecasting allows for the effective and efficient allocation of health care resources in a community.

GIS can also help create disease focused databases representing patients from a specific user-defined geographic area. In this fashion, the impact of a toxic release or exposure against a target population can be measured. GIS is a powerful tool for supplying immediate visualization of the likely geographic exposures, allows an analyst to examine the various variables that might effect the "fallout" of sprays and to estimate its extent. Through the use of Computer Aided Design tools and GIS, medical centers as well as clinics are increasingly monitoring their patient care environments to assist managers evaluate risk for highly contagious diseases and implement control and isolation programs.

GIS helps health organizations visualizing diagnostic and geographic information simultaneously and dynamically. Over 14,000 ICD 9 and 10 codes describe medical diagnosis, treatment, and medical events worldwide. Public health clinics, hospitals, managed care, and health insurers use this application to conduct data mining on very large clinical and administrative data warehouses.

In public health education, GIS can be an analytical tool of choice for health promotions staff when deciding where to target the public health messages and warnings. GIS is also used to

create interactive maps for health organizations required to publish information to the public. Health organizations require interactive maps depicting geographical areas and regions where infectious diseases and threats to the public's health are imminent.

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(SEE ALSO: *Communication for Health; Communication Theory; Data Sources and Collection Methods; Information Systems; Internet*)

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INFORMED CONSENT

The concept of informed consent originated with the recognition of individuals' rights to freedom and human dignity. People reduced to conditions of slavery were subjected without their consent to interferences with their freedom. Children and other dependent persons may also be treated in ways to which they do not consent, but those responsible for their care, such as parents or other

legal guardians, are bound by ethical and legal limits in the procedures they can authorize.

ETHICAL ORIGIN

The ethical principle of respect for autonomy requires that people capable of responsible independence should not be subjected to others' interventions with their bodily freedom or comfort unless they have consented in advance. Similarly, autonomous people who consent to a procedure that affects them should not be liable to another person's veto or prohibition because the other person considers the procedure to be not in their best interests.

Consent has particular significance concerning health care, because medical or other health care interventions can affect persons' bodies, comfort, and lives in very invasive and irreversible or long-lasting ways. public health initiatives designed to protect or promote the health of individuals as members of population groups or residents of communities can also be intrusive and long-lasting, but consent is often given to these through political or democratic means, such as by legislation permitting inspection of health records to find the incidence and prevalence of preventable diseases. However, some public health strategies, such as vaccination programs, affect individuals so personally that their own consent, or that of their legal guardians, is required before procedures can be undertaken on them.

CONSENT IN LAW

In law, the physical touching of a person's body without authorization or consent is an offense, often called assault in criminal law and battery in civil law directed toward compensation. The person's consent to the touching neutralizes or removes the offense. Consent is an important concept in medical and related health care. Health care personnel act unethically, unprofessionally, and illegally if they directly interfere with a person's body without consent by undertaking unauthorized procedures on the person, exceeding consent the person has given, or performing procedures different from those the person has approved. Consent is often spoken in deliberate language, and for more invasive procedures such as surgery and for research procedures may have

to be given or confirmed in writing. For minor procedures, however, consent may be implied by a person's behavior, for example, by consciously permitting an intervention such as vaccination or blood-drawing to occur. Further, because in law "peril invites rescue," emergency interventions when life or enduring health are endangered are considered to have implied consent if they are reasonable under the circumstances.

INFORMED CONSENT

Law and ethics sometimes require more than compliance alone to render an intervention acceptable. The consent must be adequately informed for it to satisfy legal and ethical standards. In medical care law, consent continues to remove liability for assault and battery, but the physician or other care provider has a legal duty to ensure that the person whose consent is required receives information that is material to the choice whether or not to consent. Reasonable efforts must also be made to ensure that the person understands the information to his or her satisfaction. Failure to provide adequate information to a person deciding whether to consent to a proposed intervention or to refuse it constitutes legal negligence when injury results, often called malpractice. This is so even when no assault and battery occurs because the person refuses treatment. "Informed consent" includes informed dissent and is better understood as informed choice or informed decision-making.

ELEMENTS OF INFORMED CONSENT

Whether or not to consent to proposed medical treatment is not itself a medical decision. It is a personal decision that someone makes when adequately informed of medical and nonmedical options and their relevant implications. Health care providers do not have to explain all the physiological, biological, pharmaceutical, and other processes that constitute the procedures among which the person may choose. But they must distill the elements the person will want to understand in order to exercise judgment about what will best serve his or her interests and preserve or promote personal values and goals. For instance, the effect of prospective treatments on capacity to work is often important. A person intending to have a child must understand the impact of treatment

options on future fertility and child-rearing. A person who devoutly feels that life must be preserved to the last possible moment must be informed whether a treatment will lead to or risk earlier loss, and a person fearful of pain should be informed whether and how future comfort can be provided.

Accordingly, information must focus on the sort of individual the decision-maker is. This cannot usually be known in intimate detail and must initially be based on a representative reasonable or prudent person in the decision-maker's circumstances. Information may be amplified in light of the person's response, particularly the questions the person asks on initial receipt of information. Informing is often best regarded not as a single event but rather as a continuing process that begins with the provider asking the decision-maker questions about lifestyle, preferences, and intentions in order to direct information toward his or her needs, give information and explanation to serve such needs, answer uncertainties and questions the decision-maker has, and supply material information throughout the course of treatment.

Items to be addressed usually include:

1. Implications of going without treatment and of treatment being postponed for different periods
2. The range of accessible diagnostic or treatment options
3. The extent of public or private insurance coverage for each option and costs patients would personally incur
4. The benefits each option offers
5. The possibilities of diagnostic false results or treatment failures
6. The risks and discomforts of diagnostic or treatment options even when successful
7. Short-term injuries that diagnostic or treatment failures may cause
8. Long-term effects of diagnostic or treatment options, favorable and unfavorable, separating probabilities from possibilities

The more invasive or risk-laden a procedure, the more information should be provided. For the

low-risk procedure of blood-sampling, for instance, disclosure of liability to sudden pain, bruising, and easily treated infection is usually adequate in itself, with greater information given about why sampling is proposed and what it may show.

COLLECTIVE OR GROUP CONSENT

Consent is usually requested from individuals proposed to be physically affected by health care procedures, but some decisions justify collective or group consent, such as fluoridation of a municipal drinking water supply. Information is made available, for instance, to democratically elected representatives authorized to make decisions on behalf of local residents. Community hospitals' decisions on what services to offer and what types of equipment to purchase are made by hospitals' boards of governors or trustees. Governors or trustees may be appointed by governments, but are often elected from among residents of areas the hospitals serve who choose to become members of the hospital associations. The decisions affect the water local residents consume and the health services they may receive, but individual consent is replaced by democratic or otherwise political consent. In some communities, hereditary or traditional leaders who make decisions with the permission of those they govern can consent to public health measures. Hereditary or traditional authority to make decisions affecting such groups is legitimate when groups' members identify themselves with each other and acknowledge an internal group structure and hierarchy that appoints chiefs or leaders. However, consent from such leaders to public health programs does not compel individuals to give their consent to personally invasive procedures such as vaccination. When group members do not possess a sense of community with each other but simply meet criteria of a particular study, such as on the effects of giving different dietary combinations to hospitalized single or widowed women aged 65 to 75, there is no representative group member with authority to make decisions on behalf of others.

REFUSAL OF INFORMATION

Competent persons have the autonomous right to consent without information. They have the right,

not the duty, to receive information. They must state their preferences for overall care, but they may forgo detailed information that health-service providers prepare to offer. Providers incur no liability for risks that patients freely assume by refusal of offered information.

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(SEE ALSO: *Autonomy; Beneficence; Codes of Conduct and Ethics Guidelines; Ethics of Public Health; Nonmaleficence; Paternalism; Public Health and the Law*)

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INHALABLE PARTICLES (SULFATES)

Airborne particles in the air that can be aspirated into the nose or mouth during normal breathing are known as "inhalable particles." Inhalability decreases gradually with increasing particle diameter, reaching a level of about 50 percent at 100 microns (μm). "Subfractions" of the inhalable fraction are the particles that can penetrate through the upper respiratory tract (head airways) and enter the thoracic airways (lower respiratory tract). The aerodynamic particle diameter for 50 percent penetration into the thorax is 10 μM , and air samplers that mimic this penetration are used to determine PM10 (particulate matter of 10 micrometers [microns] or less in diameter), or thoracic particulate matter standards. There is a smaller

cut-size for 50 percent penetration through the conductive airways of the tracheobronchial tree that distributes the inhaled air to the gas-exchange airways in the lungs. By internationally agreed-upon convention among occupational health professionals, this fraction is known as “respirable particulate matter,” and the cut-size is 4 μm . Size-selective sampler inlets for inhalable, thoracic, and respirable dust prevent the oversized particles from reaching the sampling filters used to determine the mass concentrations of the overall sample or specific chemical constituents within the sample.

For particulate matter in community air in the United States, the thoracic particulate matter (PM₁₀) is, by regulatory specification, divided into fine particulate matter (that fraction penetrating through an inlet with a 50 percent cut-size at 2.5 μm [PM_{2.5}], and the PM₁₀ coarse fraction [PM_{10-2.5}]). This particular size discrimination was a recognition that fine and coarse particles generally have distinct sources and formation mechanisms. Primary fine particles are formed from condensation of high-temperature vapors during combustion. Secondary fine particles are usually formed from gases in three ways: (1) nucleation (e.g., gas molecules coming together to form a new particle); (2) condensation of gases onto existing particles; and (3) by reaction of absorbed gases in liquid droplets. Particles formed from nucleation also coagulate to form relatively larger aggregate particles or droplets with diameters between 0.1 and 1.0 μm , and such particles normally do not grow into the coarse mode.

Particles also form as a result of the chemical reaction of gases in the atmosphere. Some examples include: (1) the conversion of sulfur dioxide (SO₂) to sulfuric acid droplets (H₂SO₄); (2) reactions of H₂SO₄ with ammonia (NH₃) to form ammonium bisulfate (NH₄HSO₄) and ammonium sulfate [(NH₄)₂SO₄]; and (3) conversion of nitrogen dioxide (NO₂) to nitric acid vapor (HNO₃), which reacts further with NH₃ to form particulate ammonium nitrate (NH₄NO₃).

By contrast, most of the coarse fraction particles are emitted directly as particles and result from mechanical disruption such as crushing, grinding, evaporation of sprays, or suspensions of dust from construction and agricultural operations. Basically, most coarse particles are formed by breaking

up bigger masses into smaller ones. Energy considerations normally limit coarse particle sizes to greater than 1.0 μm in diameter. Some combustion-generated mineral particles, such as fly ash, are also found in the coarse fraction. Biological material such as bacteria, pollen, and spores may also be found in the coarse mode. As a result of the fundamentally different chemical compositions and sources of fine and coarse fraction particles, the chemical composition of the sum of these two fractions, PM₁₀, is more heterogeneous than either mode alone.

Fine accumulation-mode particles typically have longer atmospheric lifetimes (e.g., days to weeks) than coarse particles, and they tend to be more uniformly dispersed across an urban area or large geographic region, especially in the eastern United States. Larger particles generally deposit more rapidly than small particles, and as a result, total coarse-particle mass will be less uniform in concentration across a region than are fine particles.

In the United States, the Environmental Protection Agency (EPA) administrator promulgated revised PM NAAQS in July 1997 in recognition of the inadequate public health protection provided by enforcement of the 1987 NAAQS for PM₁₀. For PM₁₀, the annual average was retained without change, and the twenty-four-hour PM₁₀ was effectively relaxed by permitting more exceedences each year. These PM₁₀ standards were supplemented by the creation of new PM_{2.5} standards. Implementation of the new PM_{2.5} NAAQS will advance the degree of public health protection for ambient air particulate matter, especially in the eastern United States and in some large cities in the West where fine particles make up a major percentage of PM₁₀.

MORTON LIPPMANN

(SEE ALSO: *Airborne Particles; Ambient Air Quality [Air Pollution]; Clean Air Act; Environmental Protection Agency; Hazardous Air Pollutants; Smog [Air Pollution]; Sulfur-Containing Air Pollutants [Particulates]; Total Suspended Particles [TSP]*)

INITIATOR

The term “initiator,” when used in the field of carcinogenesis, refers to a chemical or physical

agent or a condition, that is capable of beginning the process that leads to cancer. Early work in chemical and radiation carcinogenesis recognized that it was a multistep process. These steps were usually called initiation, promotion, and progression. Studies in mouse skin, as well as other organs and species, demonstrated that a single application of certain chemical carcinogens was capable of causing a skin tumor much later in the lifespan of the animal. These initiating chemicals had the common characteristics of being genotoxic and mutagenic.

Further, there were other chemicals, known as promoters, that if subsequently applied to the same area of the skin could lessen the time needed for the tumor to appear or decrease the dose of the initiator that was needed. Modern molecular biology has expanded the knowledge of carcinogenesis into recognition of the multiple steps that underlie most human cancers, including mutations in the systems that control cell growth—so-called oncogenes and repressor genes. However, the basic concept remains that certain chemicals are capable of initiating the cancer-causing process.

BERNARD D. GOLDSTEIN

(SEE ALSO: *Cancer; Carcinogen; Carcinogen Assessment Groups; Carcinogenesis; One-Hit Model*)

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INJECTION DRUG USE AND HIV INFECTION

Injection drug use (IDU) contributes to considerable illness burden in both developed and developing countries. Transmission of blood-borne pathogens (e.g., HIV, hepatitis B and C virus, Human T-Cell Lymphotropic viruses I and II, and malaria) occurs primarily through direct sharing of needles or multi-person use of syringes.

More recent studies suggest potential additional risks posed by shared use of injection paraphernalia (e.g., cookers, cotton, water), which is especially a concern with respect to transmission of hepatitis B and C viruses.

Human immunodeficiency virus/acquired immunodeficiency syndrome (HIV/AIDS) and injection drug use can be considered as two intertwining epidemics. Socioeconomic, legal, and cultural factors and migration contribute to the emergence of drug injection. Injection drug use has been reported in 144 countries worldwide, among which 128 have detected HIV among injection drug users (IDUs). Although IDUs presently account for 5 to 10 percent of cumulative adult HIV infections worldwide, injection drug use is the predominant mode of HIV transmission in most of Western and Eastern Europe, North Africa, the Middle East, and increasingly in parts of Asia. Taking into account direct transmission among IDUs through sharing of contaminated injection equipment, and indirect transmission to sexual partners and offspring, injection drug use accounts for 44 percent of reported AIDS cases in Europe and nearly one-third of cases in the United States and the Southern Cone of South America. In the United States, approximately half of all new HIV infections are among IDUs. In Canada, the proportion of AIDS cases attributable to injection drug use is steadily increasing.

IDU-associated HIV epidemics are characterized by a high degree of regional and local heterogeneity. Explosive epidemics have occurred in both developing and developed countries or regions, with documented HIV incidence rates reaching as high as 20 to 30 percent per year. Early examples of HIV epidemics among IDUs were documented in Manipur, India; Milan, Italy; Bangkok, Thailand, and New York City, suggesting that once HIV prevalence reaches a threshold of approximately 10 percent, it can surpass 40 to 50 percent within one to four years. More recently, Vancouver, Canada, witnessed an HIV outbreak with incidence reaching 18.6 per 100 person-years, despite an extended period of low stable HIV prevalence and a high-volume needle exchange program. In the Ukraine, over 100,000 HIV infections occurred in a single year, mostly due to sharing of injection equipment. These examples

serve to illustrate the extent to which IDU-associated HIV epidemics can occur with startling speed. In such cases, subsequent spread to heterosexual non-IDU populations is almost imminent, which underscores the need for swift prevention measures.

In contrast, Australia and the United Kingdom have essentially averted widespread transmission of HIV among drug users. These prevention successes did not occur by chance. The early introduction of interventions such as widespread legal access to sterile injection equipment and expansion of methadone maintenance treatment programs likely spared these regions from the tragedies described above. Preventive strategies to curtail HIV transmission among IDUs are discussed in more detail below.

PREVENTIVE STRATEGIES TO DECREASE TRANSMISSION OF BLOOD-BORNE DISEASE

Several interventions have been developed to reduce the spread of blood-borne disease among IDUs. These include programs that promote sterile syringe acquisition, drug abuse treatment, network-oriented interventions, and community outreach. These programs are briefly summarized.

Since sterile syringes are not accessible, affordable, or legal in the majority of countries that report injection drug use, the fundamental mechanism for reducing parenteral HIV transmission among IDUs is to provide unrestricted access to sterile syringes and to promote their one-time use. Examples are syringe exchange programs (SEPs), syringe vending machines, and enabling IDUs' access to syringes through pharmacies. These interventions are consistent with the concept of harm reduction, which aims to reduce the negative consequences associated with injection drug use among persons who cannot or will not cease injecting, and their surrounding community. At SEPs, IDUs exchange sterile syringes for potentially contaminated ones. A large body of international literature suggests that SEPs can be effective in reducing the incidence of HIV, Hepatitis B, and Hepatitis C, as well as needle sharing. No evidence exists to suggest that SEPs increase drug use or crime. At many SEPs, IDUs can receive condoms, referrals to HIV testing and drug treatment programs, and screening for STDs and tuberculosis.

Unfortunately, in many U.S. states where SEPs operate illegally due to syringe paraphernalia laws, these critical ancillary services are less likely to be offered. In many developing countries, even when SEPs have been successfully introduced, severe fiscal restraints limit their ability to consistently offer services to a large number of IDUs.

Drug abuse treatment, and methadone maintenance in particular, has been associated with reduced injection frequency as well as declines in needle sharing, sexual risk behaviors, and HIV seroconversion. These studies support the notion that drug abuse treatment can be effective as primary HIV/AIDS prevention. Other opiate agonist therapies that are undergoing evaluation include substitution with buprenorphine, naltrexone and levo-alpha acetylmethadol (LAAM). Clinical trials have also evaluated the prescription of heroin under continuous medical surveillance, for example, in Switzerland. However, in cities where cocaine and methamphetamine are the main drugs of abuse, little is available in terms of drug abuse treatment. In North America, less than 25 percent of IDUs are receiving drug treatment at any given time, which signals an urgent need for expanded drug treatment services, including but not restricted to methadone maintenance. Other treatment-oriented initiatives that require expansion and evaluation include programs to prevent relapse from abstinence, interim treatment of drug users on waiting lists, interventions to refer SEP attenders into treatment, and development of substitution therapies for drug users addicted to stimulants.

Network and community-level strategies that modify social norms surrounding needle sharing constitute also valuable prevention tools. Network-based strategies of HIV prevention are based upon the personal networks of IDUs. Personal networks include people an IDU may have a social relationship with: an injecting partner, a sex partner, a family member, and so on. Studies have shown that personal network-based interventions can decrease needle sharing, decrease use of shooting galleries, and increase bleach disinfection.

Community-based outreach is characterized by utilization of former IDUs and/or peers to create a liaison between the drug using community and HIV education/treatment. In the United States, outreach has been shown to impact HIV

risk by decreasing the frequency of drug use and reuse of needles and increasing use of bleach for purposes of disinfection. M. S. Kumar and colleagues have shown that community-based outreach may also be effective in an international setting. They demonstrated significant decreases in needle use frequency and needle sharing among IDUs involved in outreach efforts as compared to IDUs not involved in outreach efforts in Madras, India. D. C. Des Jarlais has shown that community outreach is a crucial component held in common by five cities that have consistently maintained low stable HIV prevalence rates among IDU populations.

PROSPECTS FOR THE FUTURE

In several cities that experienced early HIV epidemics among IDUs (e.g., Milan, Italy; Geneva, Switzerland; Amsterdam, the Netherlands; and New York City), HIV prevalence has declined. This has been attributed to AIDS-related mortality, pre-AIDS mortality, improvements in HIV treatments, migration, diminishing size of some IDU populations (e.g., Amsterdam), and reduced HIV incidence as a probable consequence of combinations of the above interventions. However, in the presence of high background HIV prevalence, even low levels of needle sharing can give rise to a relatively high number of new infections. In Amsterdam, large declines in injection risk (i.e., syringe borrowing, lending, and reusing) occurred from 1986 to 1991, and annual HIV incidence declined from 8 percent to 4 percent. However, van Ameijden and colleagues reported no further reductions occurred thereafter, suggesting that a minimum level of injecting risk may persist that is difficult to prevent. Since risk reduction rather than risk elimination appears to be a realistic goal, studies are needed to determine minimum levels of acceptable injection risk for specific regions, based on a thorough understanding of local risk behaviors, HIV prevalence and incidence, mixing patterns of susceptibles, and the estimated impact of interventions. This will require collaboration across the disciplines of epidemiology, behavioral science, and biostatistics.

Apart from the aforementioned strategies of HIV prevention among IDUs, a core prevention

strategy that has yet to receive adequate attention is interventions that discourage transition from noninjection to injection drug use. The rationale for this approach is that the prevalence of hepatitis B and C surpasses 50 percent among new initiates to injection drug use within one year after initiation.

There is also evidence to suggest that risk factors for HIV seroconversion among IDUs may differ significantly by gender. For example, among male IDUs, injection-related risks and homosexual/bisexual activity appear to play a predominant role, whereas among females, sexual risks are paramount. These findings suggest that prevention programs should be gender-specific as well as being ethnoculturally and locally sensitive. Future studies should pay special attention to patterns of sexual behaviors of drug users in an effort to develop practical interventions.

In summary, the characteristics of IDU-associated HIV epidemics and interventions that have been effective in reducing IDUs' risk behaviors include access to sterile injecting equipment, methadone maintenance treatment, community-based outreach, and peer network interventions. Unfortunately, in many settings the implementation of these proven interventions is often delayed due to lack of political will or inadequate resources. The delicate balance between an epidemic that is averted and one that is merely delayed argues against complacency in the realm of prevention. These obstacles will need to be overcome if HIV epidemics among drug user populations are to be controlled or prevented.

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(SEE ALSO: *Addiction and Habituation; Cocaine and Crack Cocaine; HIV/AIDS; Lifestyle*)

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INSTITUTE OF MEDICINE

The Institute of Medicine was chartered by the National Academy of Sciences in 1970 "to improve the health of the American people and peoples of the world" by advancing health science and providing analysis of important issues in health and health policy for government, the professions, the

private sector, and the public. The institute carries out its work largely through committees of pro bono experts who employ an evidence-based deliberative process to produce nonpartisan reports, symposia, workshops, and roundtables. Studies originate in several ways. The U.S. Congress may mandate a government agency to contract with the institute; there may be a direct request from government agencies, or from foundations or other private organizations; or, for those projects of high importance and sensitivity that might not be requested by outside organizations, studies may be initiated by the institute.

The institute's portfolio is extensive, ranging from issues of scientific integrity to the future of particular areas of health-science research. A landmark 1988 institute report, *The Future of Public Health*, identified many of the critical challenges to public health education, practice, and applications. That report is about to be updated. In 1998, the institute developed the prototype leading indicators for *Healthy People 2010*, the nation's blueprint for health prevention. The importance of community organization and partnerships in furthering public health has been underscored by a number of reports on healthy communities and community organization, and a series of studies on health and behavior and on the role of the social and behavioral sciences in health have important implications for public health as well as other aspects of medicine. A 1992 report, *Emerging Infections: Microbial Threats to Health in the United States*, was among the earliest warnings with regard to these issues, including the development of antibiotic-resistant organisms. It has been followed by a number of efforts in both public and private sectors to respond to these threats.

The Institute of Medicine is responsible for the recommended dietary allowances of vitamins and other nutrients in the American diet, and it has provided guidelines for nutrition, to diminish chronic illnesses. As an independent nongovernmental entity, the institute has initiated studies with a profound impact on public health. The 1986 report, *Confronting AIDS: Direction for Public Health, Healthcare, and Research*, addressed what had been to that time a largely ignored epidemic. Subsequent reports have addressed needle exchange and perinatal AIDS (acquired immunodeficiency syndrome), and a 2000 report provided a

new vision for HIV (human immunodeficiency virus) prevention in the United States. In addition to providing the research community with priorities for a new AIDS vaccine, this report also provided analysis and advice with regard to the complications of vaccines, barriers to immunization, and appropriate uses of vaccines.

Several studies have focused on environmental issues, including environmental justice, environmental and occupational instruction in medicine and nursing, and environmental roles in a number of illnesses, including asthma. Among the reports issued on tobacco, the 1994 report, *Growing Up Tobacco Free: Preventing Nicotine Addiction in Children and Youths*, was particularly influential in establishing national policy. The institute also conducts a program in international health, including efforts to control hepatitis and diarrheal diseases in the Middle East, conducted by a collaboration of American, Israeli, Egyptian, and Palestinian scientists. More recently, scientists from Jordan have participated in programs addressing problems of water conservation and micronutrients in the region.

The institute also has an honorific function. It elects sixty regular members, five senior members, and five foreign associates each year. Elected members include many leaders in public health, nutrition, environmental science, and social and community medicine. Members also include leading ethicists, economists, and social and behavioral scientists.

All of the publications of the Institute of Medicine are published on the web site of its publisher, the National Academy Press, at www.nap.edu. Information on the institute and its current activities can be found at www.iom.edu.

KENNETH I. SHINE

(SEE ALSO: *National Academy of Sciences; Prevention Research*)

INTEGRATIVE MEDICINE

See Alternative, Complementary, and Integrative Medicine

INTERNATIONAL CLASSIFICATION OF DISEASES

The International Classification of Diseases (ICD) is the descendant of a series of events dating back to the early seventeenth century and the work of John Graunt.

The annual London Bills of Mortality had been established early in the sixteenth century, initially listing only the numbers of burials “as a sort of an early warning system against the onset of bubonic plague.” This was not trivial information; the earliest London epidemic of the disease recorded in the “Bills” occurred in 1563 and killed between 20 and 25 percent of the population. By early in the seventeenth century, much additional information had been added, including causes of death. Sometime near the middle of the seventeenth century, John Graunt (1620–1674), a merchant, felt that the Bills contained a wealth of information that was not being used. He tabulated and studied the thirty-two years of data from the annual Bills from 1629 through 1660, and in 1662 he published *Natural and Political Observations Made upon the Bills of Mortality*. The volume used the Mortality Bills’ list of eighty-one causes of death, and is considered the forerunner of today’s international mortality classifications.

The next noteworthy step in the history of the classification occurred with the establishment of the General Register Office of England and Wales in 1837 and the appointment of William Farr (1807–1883) as its first statistician. Farr lobbied for an improved classification, and the first International Statistical Congress (ISC), Brussels, 1853, asked Farr and Dr. Marc d’Espine of Geneva to prepare the necessary list of categories. Farr brought back a list based in general on anatomical site, while d’Espine brought a list based on the nature of the disease. Farr’s scheme prevailed.

The International Statistical Institute succeeded ISC and in 1891 charged a committee headed by Dr. Jacques Bertillon (1851–1922) to prepare a classification of causes of death. The committee’s list was accepted in 1893 at the institute’s meeting in Chicago. In 1898, the American Public Health Association recommended the adoption of Bertillon’s list in the United States.

In 1900, the French government convened the first International Conference for the Revision of the *Bertillon or International Classification of Causes of Death*. Delegates from twenty-six countries attended. The list that was adopted had 179 groups of causes of death and an abridged classification of thirty-five groups. This was the first of the *ICDs* (“*International Classification of Diseases*”), the initialism that has been applied to the series since 1955 despite slightly modified titles and expanding scope of content. In 1946, the United Nations gave responsibility for ICD to the World Health Organization (WHO), which issued the sixth and succeeding revisions. *ICD-6* (1948) included a comprehensive list for morbidity as well as mortality statistics, and saw the establishment of national committees on health and vital statistics throughout the world and increasing worldwide coordination of health statistical activities. The current revision is the *International Statistical Classification of Diseases and Related Health Problems, 10th Revision (ICD-10)*.

Over the years, the number of categories in *ICD* has grown to about thirteen thousand, in response to the increasing variety of uses to which it has been put—mortality, followed by morbidity, hospital indexing and statistics, reimbursement, public policy, and others. It has become a multi-purpose classification. Yet, by attempting to accommodate each succeeding user it has become less satisfactory for any. Actually, *ICD*’s fundamental purpose of international exchange of mortality and morbidity statistics is for most purposes still answered by the use of “short lists” of one to two hundred broad categories, into which the greater detail for the categories of interest is collapsed. The views of health are thus clearer. Further, many developing nations cannot collect data in much greater detail. The short lists are given at the back of *ICD* as “Special Tabulation Lists” for mortality and morbidity.

ICD-10 states that “. . . in the interests of international comparability, no changes should be made in the content (as indicated by the titles) of the three-character categories and the four-character sub-categories of the Tenth Revision . . . except as authorized by WHO. . . . WHO should be promptly notified about the intention to produce translations and adaptations or other *ICD*-related classifications.” In an effort to enforce this position,

ICD-10 was the first of the *ICD* revisions to be copyrighted.

In the United States in the mid-1950s, *ICD-6* (1948) and *ICD-7* (1958), with minor subdivisions and modifications, began to be used in hospitals for clinical purposes, initially the indexing of medical records and compilation of hospital statistics. Later, the categories were used for reimbursement and a variety of other demands for information on diagnosed and their treatment. The early modifications were published in 1959 by the U.S. Public Health Service (Publication 719) as *International Classification of Diseases Adapted for Hospital Records and Operation Classification*, the “Disease Index,” which was revised in 1962.

In 1967, WHO published *ICD-8*. This was followed by competing clinical modifications in the United States, the *Hospital Adaptation of ICDA (H-ICDA)*, published by the Commission on Professional and Hospital Activities (CPHA), a non-profit corporation, and the U.S. government’s *Eighth Revision, International Classification of Diseases, Adapted for Use in the United States (ICDA-8)*. Each of these volumes was used in about half of the country’s hospitals.

When *ICD-9* was published by WHO in 1977, it again failed to meet the United States’ widening clinical needs, and another clinical modification was created jointly by the U.S. National Center for Health Statistics and the Council on Clinical Classifications (a consortium of physician organizations and CPHA): *International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM)*. While *ICD-9* had about seven thousand categories, *ICD-9-CM* has about twelve thousand, the increase being the result of the clinical demand for greater specificity, a demand accommodated primarily by subdivisions that permitted collapsing the detail into the seven thousand of *ICD-9*’s categories when necessary for international statistical purposes.

WHO in 1989 prepared the *International Statistical Classification of Diseases and Related Health Problems, 10th revision (ICD-10)*, which was published in 1992. *ICD-10* was put into use for the classification of death certificate information in the United States in 1999, but as of 2000, *ICD-9-CM* was still being used for all other disease classification purposes.

Although *ICD-10* included most of the clinical modifications from the United States' *ICD-9-CM*, the United States again prepared a modification, *ICD-10-CM* with about sixty thousand categories. *ICD-10-CM* has not, at this writing (2000), been put into use. In view of the WHO copyright of *ICD-10*, the United States had to obtain special permission to create *ICD-10-CM*.

Neither *ICD* itself nor its clinical versions is a nomenclature (a list of approved terms) for diseases, although it is sometimes mistakenly referred to as such. All of the versions are classifications—sets of categories into which to place “all” diseases, about one hundred thousand of which are given in the alphabetic index to *ICD-9-CM*. Detailed description of the organizing principles behind the groupings in *ICD* is beyond the scope of this essay. It can be noted, however, that in some sections of *ICD*, grouping is by cause (etiology) as with “Certain Infectious and Parasitic Diseases.” The chapter entitled “External Causes of Morbidity and Mortality” does not classify diseases at all. Elsewhere, the results of the external causes can be classified under “Injury, Poisoning, and Certain Other Consequences of External Causes.” In some sections, grouping is by physiological systems, such as respiratory and circulatory. Obstetrical conditions form a group. In *ICD-10*, the classificatory territory has expanded to include a chapter entitled “Symptoms, Signs and Abnormal Clinical and Laboratory Findings, Not Elsewhere Classified” and one entitled “Factors Influencing Health Status and Contact with Health Services.” The latter two are not within the usual definition of diseases.

ICD is not truly a classification of diseases (even in those chapters that deal with diagnoses). It is actually a way to group individuals who exhibit the diagnoses—or other “objects” in its universe, such as “need for immunization,” rather than just the diagnoses themselves. For this purpose, other attributes of the individual often must be taken into account. For example, “pneumonitis” is, by itself, a diagnosis, but to be classified in *ICD*, the classifier must put it into one of three different categories, depending on whether it is due to inhalation of food, oil, or some other solid. In some generations of the *ICD* series, acute myocardial infarction was put in one group if the patient had hypertension and in a different group if not.

This distinction was based on an obsolete data management process called “combination coding” (combination coding has been used liberally in *ICD-10-CM* and is largely responsible for the great increase in categories in that volume). A diagnosis, without further information about the patient, often cannot be properly classified in *ICD*.

ICD, like all classifications, has its categories arranged in a sequence logical to its author. The categories are often divided into subcategories and even sub-subcategories. For convenience in arranging these categories, they are numbered sequentially, with decimal subdivisions indicating subcategories. It is quite natural to substitute the sorting number of a category for its label—to use the sorting number as a code for the category. If *ICD* were never modified to reflect changes in knowledge and appearance of new diseases, this “category coding” would present no problems. But consider genetic disorders, which were given 32 categories in the sixth revision, a number which had grown to 709 in the tenth revision (written in 1989, before the human genome developments of the 1990s).

Since *ICD* itself and its clinical modifications will forever have to respond to these and other influences, the category codes keep changing their meanings, making it impossible to know if a given code means the same thing today as it did yesterday. As a result, longitudinal studies are often impossible, because they must be based on the codes—the exact diagnoses, the “diagnostic entities,” which once put into a given category cannot be retrieved. This problem, the inherent impossibility of decoding *ICD* codes, can only be solved by an information system that tags each code with an identifier as to its source, in the same fashion that the number “0-9615255-2-5” only has meaning if it “tagged” with “ISBN,” a tagging that identifies forever a specific book. *ICD* cannot solve this problem—only a properly designed information system can.

The authors of *ICD-9* had “realized that the *ICD* alone could not cover all the information required and that only a ‘family’ of disease and health-related classifications would meet the different requirements in public health.” They proposed that *ICD* should be “a ‘core classification’ . . . with a series of modules, some hierarchically

related and others of a supplementary nature.” The authors of *ICD-10* followed up on this idea, and *ICD-10* diagram of the concept is shown in Figure 1.

Assumptions about the relationships would seem to have been that the hierarchical classifications outside the core would be feeders to the core categories, basically a “parent-child” arrangement. One would then expect that the “specialty-based adaptations” would have greater detail but have the same organization and thus “fit into” the broader categories of the core, *ICD*. The major and oldest such classification is *ICD-O*, *International Classification of Diseases for Oncology*, which is in its second edition (1990). It was written after *ICD-10* had been created but before its publication. *ICD-O* states, however:

There are basic differences between the structure of ICD-O and ICD. Chapter II (Neoplasms) of ICD is basically a topography code that takes into account the behavior of the neoplasm, i.e., malignant, benign, in situ, or uncertain whether malignant or benign . . . ICD-O has one set of four characters for topography based on [emphasis added] the malignant neoplasm section of ICD-10, and the behavior code, incorporated in the morphology field identifies whether the neoplasm is malignant, benign, etc. . . .

The inference that may be drawn from this is that *ICD-O* has simply used *ICD-10* topography categories as one “module” and has linked to each category a morphology module of its own, so that description of a tumor is a “topography-morphology pair” of codes. However, there are significant departures in the topography categories between the two volumes.

For example, Lymphocytic lymphoma of the stomach is coded C83.0 in ICD-10 but in ICD-O the topography would be coded Stomach C16.9 and the morphology M-9670/3.

In the case of the “supplementary” relationship, the separate classifications would be used to give added information related to core categories as appropriate. For example, when a patient’s occupation would be useful to know, that information could be given by an occupation code accompanying the disease code. Many supplementary

classifications have been developed by others, some but not all of them other arms of WHO. For example, WHO published a procedure code only once, on a trial basis in 1978: *International Classification of Procedures in Medicine*. The U.S. Health Care Financing Administration (HCFA) in the mid-1990s commissioned the creation of a procedure coding system which, although entitled *ICD-10 Procedure Coding System (ICD-10-PCS)*, is not a classification and is in no way related to *ICD-10*.

One of the “family” shown in the diagram that could be considered supplementary is the *International Nomenclature of Diseases (IND)* series. This built on work begun by the Council for International Organizations of Medical Sciences (CIOMS) in 1970, and joined by WHO in 1975. The stated intention of IND was to provide a single “recommended” name for each “morbid entity.” The names were to be, “as much as possible, specific (apply to only one disease), unambiguous, self-descriptive, simple, and based on cause.” Each name carried with it a brief definition and list of synonyms, if any. Ten volumes were published in the series, which was suspended in 1992 for lack of funds. Subsequently, WHO has published five volumes described as having “diagnostic definitions.”

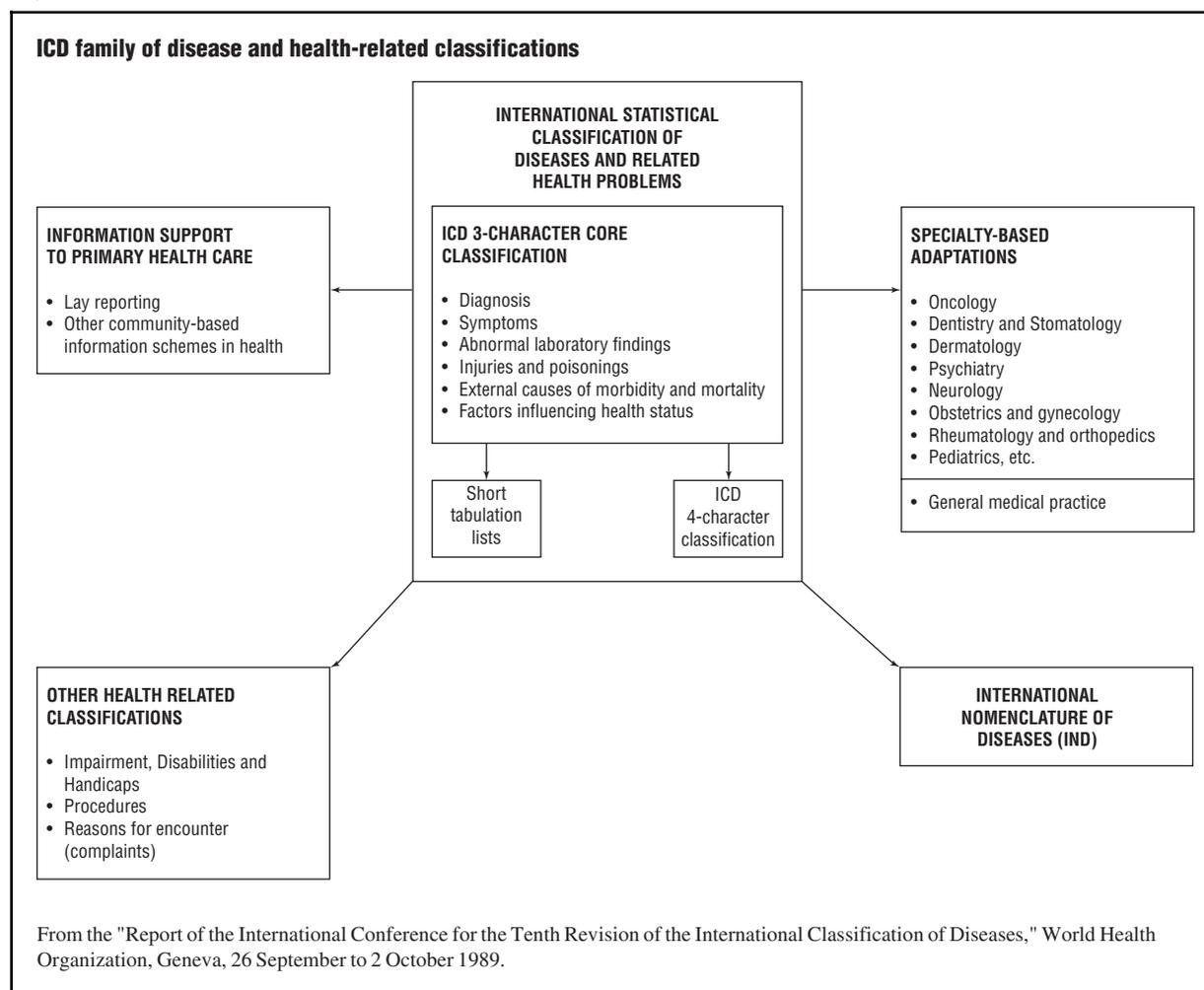
VERGIL SLEE

(SEE ALSO: *Classification of Disease; Graunt, John; Notifiable Diseases; World Health Organization*)

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Figure 1



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INTERNATIONAL DEVELOPMENT OF PUBLIC HEALTH

While most public health associations were organized during the closing decades of the twentieth century, some were formed over a century earlier. The older ones were established in Europe—Germany and the United Kingdom have a long-standing tradition of public health practice rooted in public health education and training—and in the United States. The American Public Health Association, the oldest and largest association in the world, was founded in 1872.

Public health associations generally differ from other professional health or medical-related associations in one aspect: They are multidisciplinary in membership. Therefore, they include in their ranks professionals from across the full spectrum of public health practice—sanitarians, health educators, nurses, physicians, health administrators, and so on—not just doctors, nurses, or dentists, who usually have their own separate professional societies in a given country.

Public health associations vary greatly in their degree of development. As such they can be located along a continuum that ranges from relatively small and undeveloped associations at one end to highly developed, sophisticated, multifunctional, organizations at the other. The smaller associations are often grouped around a few professionals, such as a social network of family or friends, and they undertake relatively few functions, such as hosting periodic meetings or issuing a newsletter. In contrast, the most developed associations are active in a variety of areas, including policy development, which may include advocacy

and legislative support; communications, including media and publications; and programs in scientific and professional affairs.

A wide range of activities currently characterize public health associations in the United Kingdom (U.K.), Canada, and the United States. In the United Kingdom, for instance, the Royal Society for the Promotion of Health is an accreditation body for two accreditation schemes and an awarding body for a number of qualifications. The accreditation schemes are designed to ensure safe practices in health and hygiene in the packaging of food products such as sugar and beverages. The Society has also been active in providing its expertise to plans to establish a food standards agency in the United Kingdom. While it has agreed in principle to the agency's establishment, it has expressed reservations about its proposed financing, structure, and role. The United Kingdom Public Health Association is active in injury prevention and control, an issue of increasing importance, and in developing health information and monitoring systems in Europe. It participates in European task forces on cause-of-death statistics, statistics on health care, and health and health-related survey data.

In Canada, the Canadian Public Health Association has six strategic program areas: administration of health services, disease surveillance and control, equity and social justice, health promotion, human and ecosystem health, and international health. The association's principal roles are in policy advocacy and liaison; national programs, including a national AIDS (acquired immunodeficiency syndrome) clearinghouse and national literacy and health programs; international programs, including ones involved in strengthening public health associations and international immunizations; national health resources; and conferences and workshops.

In the United States, public health associations such as the American Public Health Association (APHA) place a high priority on policy development. The APHA has recently seen the need to broaden its public advocacy efforts, developing relationships with partners in the political arena as well as with a number of government agencies at the federal, state, and local levels. By using current technologies such as e-mail messaging, e-mail listserves and broadcast faxes, APHA is able to rapidly inform members about pending policy measures,

including legislation and regulations, and to marshal support for its positions.

A second important function involves continuing education. The APHA presently provides affordable, fully accredited continuing education in eight disciplines, and it plans to further improve the training of public health professionals by expanding the number of accredited programs offered and by broadening collaboration with training partners. The APHA also promotes the public education role of public health associations. These groups can provide an evaluation of health standards for the public and help document where service is poor or falls short of adequate standards. They can also evaluate private-sector programs from a perspective other than the government's.

Since 1967, public health associations from around the world have been grouped together or "federated" through the World Federation of Public Health Associations (WFPHA). The founder member associations were from India, Japan, New Zealand, Pakistan, the United Kingdom, the United States, and Venezuela. The federation's goals are: (1) to facilitate collaborative efforts for improving health and health services, (2) to provide a mechanism through which nongovernmental health organizations can work with national and international health agencies to improve community health, (3) to encourage the formation of national public health associations, (4) to strengthen existing associations in their work of supporting the public health professions, and (5) to exchange information among member associations.

In 1970 the World Health Organization (WHO) recognized the WFPHA and granted it official relations status. Subsequently, the federation established official relations with the United Nations Children's Fund (UNICEF) and other international organizations. In 1999 the federation comprised sixty-one member associations, with representation from each of the major regions of the world.

The largest and most developed public health associations are generally in the world's more developed, industrialized nations. These associations provide a model for associations in the less developed countries of the world. In Africa, where public health associations are relatively new, a number have developed through donor assistance from western countries. For instance, the Canadian Public Health Association has supported,

with government funds, the establishment and development of public health associations in various African countries. A number of such associations are now doing well on their own and are less dependent, if at all, on outside support. An example is the Tanzanian Public Health Association, which now independently organizes branch associations, holds meetings, and publishes proceedings. This association also took on a significant added burden by hosting the WFPHA Eighth International Congress in October 1997.

Like the WHO, the UN agency with which it has its closest ties, the WFPHA has organized itself along regional lines. Member associations are grouped regionally and have a regional liaison officer appointed by the federation.

The European region is the largest with 23 members. Next is Latin America (13 members), followed by Africa (9), Southeast Asia (6), the Western Pacific (5) and the Middle East (4). A look at a few of the member associations and their activities during 1998–1999 furnishes a sampling of the public health concerns faced by these associations, and as such provides some global measure of the status of public health.

The Costa Rican Public Health Association, for instance, has focused on global tobacco issues and has translated and disseminated a federation position paper on global tobacco control. The Ethiopian Public Health Association carried out workshops on "Networking Public Health Schools," and "HIV/AIDS and Development in Ethiopia." It has also published the abstracts from its annual scientific conference and begun publication of the *Ethiopian Journal of Health Development* and a newsletter, *Felege Tena*.

The Indian Public Health Association held its forty-third annual conference in March 1999, with the theme "Environment and Health: Challenges for the Twenty-first Century." The Japanese association continued its activities promoting public health, focusing recently on community health. The association plans, implements, and evaluates comprehensive programs in community health, medical services, and welfare services. It also offers training programs for community health staff, including physicians and planners.

Public health associations around the world are working to improve the health status of their

populations. They may differ in stages of development, and some are more active and have greater resources than others. Yet they all share the same goal of promoting better health through policy advocacy, information sharing, and a variety of program activities.

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(SEE ALSO: *American Public Health Association; International Health; UNICEF; World Health Organization*)

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INTERNATIONAL DEVELOPMENT RESEARCH CENTRE

Created in 1970 by the Canadian government to help communities in the developing world find solutions to social, economic, and environmental problems, the International Development Research Centre (IDRC) is a unique public corporation headed by an international board of governors. It tries to connect people, institutions, and ideas to ensure that the results of the research it supports, and the knowledge that research generates, are shared among its many partners. The aim of the IDRC is to generate and use knowledge in ways that alleviate poverty and improve people's lives.

IDRC believes that knowledge is the key to lasting and widespread improvements in human well-being, that research is the means to development, and that development takes place when people and communities develop the ability to identify and solve their own problems.

The centre has attracted a renowned group of scientists and researchers and has had an influence in many parts of the developing world. It is focused on six development themes: food security; equity in natural resource use; biodiversity conservation; sustainable employment; strategies and policies for healthy societies; and information and communication.

The IRDC supported work at the Honduran Foundation for Agricultural Research on banana and plantain improvement for over a decade, starting in 1983, after the banana industry worldwide was threatened with extinction by fungal diseases. Millions of people in Africa, Asia, and Latin America faced food shortages as a result of this disease. Research at the foundation has led to the development of Goldfinger, the world's first dessert banana (distinct from the plantain) specially bred to resist pests and diseases. The main beneficiaries of Goldfinger's development are the millions of small growers and consumers throughout the world for whom the new banana promises a reliable food source.

IDRC support has also helped residents of the village of Chungungo, which lies in the shadow of northern Chile's coastal mountains, one of the world's driest regions. Water for the village's 350 residents used to come from a town 50 kilometers away by tanker truck. It was expensive, sometimes contaminated, and the lack of a reliable water source contributed to ill health and low food production in the village.

Scientists knew that for centuries the leaves of trees in the deserts of Oman had trapped water droplets from coastal clouds, and that people collected this water in small tanks. With IDRC support, Canadian and Chilean scientists updated this ancient technology by using a system of seventy-five large nets to collect moisture from the mountain fog above Chungungo. A pipeline now carries this water to the village. The water is clean and the system is inexpensive, easy to install and maintain, and environmentally sound. This simple technology is now being considered for use in thirty countries on six continents.

The IDRC has also focused on malaria, one of history's most debilitating diseases, which is making a comeback in the developing world. About 300 to 500 million people suffer from the disease each year, and more than 1 million die from it.

Mosquitoes, which spread the disease, are becoming more resistant to chemical insecticides, which are also expensive and can pose a threat to human health and to the environment.

Researchers in Peru, with assistance from IDRC, have discovered a low-cost, eco-friendly, and surprising weapon in the fight against malaria: coconuts. Plentiful and free, coconuts are used to incubate bacteria used in mosquito control. This bacteria is injected into coconuts, where it feeds on the coconut milk. After several days, the milk is thrown into ponds, where mosquito larvae eat the bacteria and die.

In addition, researchers in Brazil have developed a computer software program that evaluates malaria in municipalities and produces information for prevention and control of the disease; researchers in Bangladesh, Benin, Sri Lanka, and Tanzania are evaluating the effectiveness of bednets treated with insecticides in preventing mosquito bites while people are sleeping; and in Guinea, researchers have studied strains of malaria that are resistant to chloroquine, a common antimalarial drug. All of these efforts are supported by the IRDC.

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(SEE ALSO: *International Development of Public Health*; *International Nongovernmental Organizations*)

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INTERNATIONAL HEALTH

In its broadest sense international health (sometimes referred to as “global health”) is a systematic consideration of all the factors that affect the health of human populations. Among these factors are the genetic, ethnic, and cultural makeup

of individuals and groups; the natural environment, including biologic, physical, and climatologic aspects; the political and economic environment; and special circumstances such as population migration, warfare, and violence. Also within the definition is a study of the structure, policies, and functions of the varied components of the health sector. In any one country, the health sector is made up of national and local governmental public agencies, commercial private enterprises, and the many nongovernmental organizations that contribute to improving health.

Persons interested in international health may seek specific training and skills in health or behavioral sciences, economics, anthropology, communications, management, or a wide variety of other fields. International health specialists are employed in colleges and universities, schools of medicine and public health, international or government agencies, humanitarian or charitable organizations, or commercial companies. Some may be self-employed as individual consultants. They may work in fields as diverse as basic biomedical research, immunization policy, implementation of programs in remote communities, or studies of international agencies concerned with health. Some scholars may analyze and compare the medical care systems of the industrialized countries of North America, western Europe, Japan, Australia, or New Zealand. As a practical matter, however, most professionals in this field are concerned with issues such as the control of infectious and other diseases, interactions of health and economic development, education and training, or the financing and operation of medical care institutions in the poorer countries.

GLOBAL HEALTH PROBLEMS

The problems confronted by international health workers can be considered in two main groups: those related to the control of illnesses, injuries, and other threats to individual health; and those related to the provision of medical care services to individuals, and public health services to communities and nations. The major diseases include the widely distributed respiratory and intestinal infections, particularly in the very young; AIDS (acquired immunodeficiency syndrome) and other sexually transmitted diseases; as well as malaria, schistosomiasis, river blindness, and others caused

by parasites that are prevalent in tropical regions. Non-communicable and chronic conditions are also of global concern. These include endocrine and metabolic conditions such as diabetes; mental illnesses; disabilities resulting from occupational and environmental hazards; and diseases of the circulatory system, malignancies, dementias, and other conditions that are found mainly in the elderly. Many of these health problems have origins in underlying factors such as poverty, culture and behavior, and the aging of individuals and populations. Regions ravaged by war, civil disturbance, or economic downturn often have outbreaks of diseases such as typhus, diphtheria, or tuberculosis, as well as manifestations of psychological stresses.

In populations throughout the world, patterns of high fertility and high mortality rates have been or are being replaced by low fertility and low mortality rates, a situation known as the "demographic transition." In the typical pattern, economic development and medical interventions generally lead to a rapid reduction in deaths, particularly in infants and children, and a decline in births follows after some time. In the interim, the excess of births over deaths results in a rapid rise in population numbers, a situation now occurring in many developing countries. Improved health further increases fertility by reducing the stresses of pregnancy and by lengthening the reproductive span of both parents. Voluntary family planning programs have been introduced widely to help limit this population increase.

As economic conditions improve and people are living longer, the median age of populations increases and the global burden of ill health is shifting slowly from infectious to chronic diseases. This change in the proportional causes of illness and death is known as the "epidemiologic transition."

In all countries, medical and health care systems are being re-examined. The World Bank's influential World Development Report for 1993, titled "Investing in Health," identified four major problems of health and medical care systems in most countries: misallocation of funds to less cost effective interventions; inefficient use of funds; inequities in access to medical care; and the explosion of health care costs. In 1990 the world spent

about \$1.7 trillion on health. High-income countries spent about \$1,500 per person, or 90 percent of total spending. Low-income countries, with roughly three times the population, spent an average of \$41 per person, or 10 percent of the global total. Approximately 1.3 billion people live in absolute poverty, living on less than the equivalent of one U.S. dollar per day.

CLIMATE AND GEOGRAPHY

In addition to the direct effects of altitude, sun exposure, frostbite, drought, flood, and so on, climate and geography affect human health in many ways. Soils and waters may contain an excess or deficiency of iodine, iron, fluoride, arsenic, selenium, or other beneficial or harmful chemical elements. Natural radioactivity may liberate carcinogenic radon gas or may affect human health through foods grown in radioactive soils. In the semidesert areas of the Americas, the fungal spores of valley fever (coccidioidomycosis) present in the soil can be stirred up and inhaled after windstorms or human activities. In sub-Saharan Africa a "meningitis belt" stretches across the Sahel region from Mauritania to Somalia. Here, epidemics of meningitis with high mortality occur during the hot and dry season. The range of food crops and animals that can be grown and raised locally has a great influence on nutrition and well-being. In poor areas where people depend entirely on locally grown food, malnutrition and weight loss may occur on a seasonal basis. Temperature, humidity, and soil type have direct effects on many disease-causing organisms, such as the larvae of hookworms and the eggs of other parasites. Temperature and humidity are also critical for transmission of diseases carried by vectors such as insects, mites, or ticks. For example, malaria parasites develop best in mosquitoes when the temperature is between 20° and 30° centigrade and the relative humidity is above 60 percent. Oceanic currents and temperatures are related to blooms of plankton that may harbor and disseminate the causative agent of cholera, leading to outbreaks on adjacent shores.

ECONOMICS, CULTURE, AND POLITICS

The most important determinant of the level of health in any population is not the absence or existence of formal health services. It is the degree

of economic development, especially the proportion of people living in poverty. The primary cause of ill health is poverty, which produces immense suffering and injustice, frustrates individual potential, and denies the benefits of poverty-stricken individuals' contributions to everyone else. Poorer people everywhere are, on average, less healthy and do not live as long as wealthier people, and this applies to populations and nations as well as to individuals and families. Economic development permits advances in transportation and communication, water supply, electrification, refrigeration, and similar factors that have powerful effects on the level of well-being. Adequate economic and social conditions enable people to make choices about their profession, place of residence, and number of children. Education, particularly of girls and women, is of primary importance to understanding the principles of sanitation and nutrition and recognizing the role of preventive measures such as immunization.

As income rises, health status does not continue to improve indefinitely. There appears to be a level at which basic human needs are met and beyond which health status remains stable or may even decline. Health hazards associated with high incomes include obesity, diseases of the elderly, and those resulting from environmental pollution and degradation.

TROPICAL PUBLIC HEALTH

The concerns of international health workers are often centered on conditions more common in the warmer and economically disadvantaged regions sometimes known as the "third world." The branch of public health that focuses on these issues is often known as tropical public health. Most countries between the tropic of Cancer and the tropic of Capricorn are also poor, and it is the combination of environment and economics that permits infectious and parasitic diseases to thrive. Attention is given also to the provision of health services of acceptable quality and equitable access to such services by all segments of society.

Tropical countries typically have agriculturally based economies, relatively low employment and literacy rates, large numbers of children and youths, few elderly people, and lower life expectancies when compared to the industrialized countries. Because illnesses and deaths in these

regions are more commonly caused by viruses, bacteria, and parasites, much of tropical public health is concerned with the control of these infectious agents, with maternal and child health, and similar topics. Large numbers of illnesses and deaths are caused by viral and bacterial pneumonias, viral and bacterial diarrheas, tuberculosis, malaria and other parasitic diseases, and AIDS. Worldwide, major vitamin deficiency diseases such as pellagra, beri-beri, or scurvy are now relatively uncommon, but protein energy malnutrition and deficiencies in micronutrients such as iodine, iron, and vitamin A are frequent expressions of failures of access to adequate diets. Inadequate intake of these three nutrients may lead to goiter, anemia, and blindness, respectively.

Certain diseases characteristic of warm countries are generally known as "tropical" but this description is not always appropriate. Few disease agents or vectors actually require high temperatures to develop, and most can adapt to temperate climates. For example, the United States had repeated epidemics of yellow fever into the early twentieth century, and malaria was endemic in the American South until the 1940s. Rapid air service around the world makes it possible to transport disease agents to areas in which they were previously unknown. For example, in 1999 the mosquito-transmitted West Nile Virus was introduced into New York City from somewhere in Africa, West Asia, or the Middle East. That year, an outbreak of human infection resulted in seven known deaths and 62 serious illnesses, emphasizing the need for constant vigilance and international cooperation in infectious disease control.

HEALTH AND MEDICAL CARE SYSTEMS

The health sector in any country embraces two kinds of functions. First are the public health activities such as assuring safe water and food, vector control, reduction of environmental hazards, and collection of statistics. Second is the provision of preventive, curative, and rehabilitative medical services to individuals (i.e., medical care). Within the structure of every sovereign government there is some agency, usually a Ministry of Health (MoH), with responsibility for health-related activities within the country. The various levels of government (national, provincial, district, municipal) may each operate health facilities. In

some countries the MoH supervises and regulates the entire health sector, or it may provide medical care directly to some segments of the population. The private sector is often important. In many areas only a minority of the population may make use of government-run health services, preferring to consult pharmacists, healers, or fee-for-service private practitioners. There may be many alternative or competing kinds of providers offering similar services.

Health and medical services are often associated with other public welfare functions such as workers' compensation or retirement systems. Many countries have quasi-governmental organizations, such as social security systems, funded separately from the general tax revenue base.

Medical care systems have complex historical origins in hospitals operated by religious organizations, and voluntary mutual-help groups, whose members agreed to make regular contributions to a pooled fund that would provide cash benefits in the event of sickness, unemployment, or death. Present-day systems have evolved into a great variety of forms with differing levels of comprehensiveness and effectiveness. These can be described here only in the briefest outline.

The first official mandatory social insurance-based system was developed in Germany in the 1880s and has been adopted widely, with modifications, in many countries. In general, workers and employees contribute to pooled funds that negotiate with physicians' organizations to obtain specified services for predetermined fees. Each physician is paid for the amount of services that he or she provides. Governments regulate the process and may or may not add tax money to the system.

The British government has operated the National Health Service (NHS), with modifications, since 1946. The NHS provides comprehensive medical care to all, generally without charge at the point of service. General practice physicians in Britain work as independent contractors and are paid a set fixed fee by the NHS for each patient on that doctor's list regardless of the number of visits. Specialists generally work only in hospitals. The government regulates the NHS and finances its services through collection of taxes.

The former Soviet Union and its satellite states maintained complete government control of all

aspects of Soviet public health and medical care. All health care providers were employees of the state, which regulated and financed the entire system. Since the early 1990s this system has ended in Russia and the other countries of central and eastern Europe, and centrally planned economies of this type continue mainly in Cuba and North Korea.

The People's Republic of China has also changed its medical care system in line with political and economic changes. The medical care system was never centralized as in the Soviet model, but consisted of many different Cooperative Medical Schemes based on grassroots insurance plans operated by commune members. By the early 1990s only about 5 percent of rural residents were covered by these plans while the others simply paid for services out-of-pocket. At the end of the 1990s there were many different medical care arrangements based on insurance principles, marked by risk sharing and negotiation with providers and third party payers. In rural areas, funds are generated from households, collectives, and local governments, and used to reimburse certain defined health care expenses. In urban areas, civil servants, college students, and disabled military officers are served by a publicly funded Government Insurance System financed by general tax revenues. Workers in state-owned and collective enterprises are covered by the Labor Insurance System, financed by employer contributions. Others, mainly employees in the private sector, pay privately for their medical care or may belong to one or another employer-sponsored prepaid Health Maintenance Organization.

The island Republic of Singapore has adopted a unique system combining compulsory individual payments and government subsidies. The government maintains control over facilities, medical manpower, and the overall operation of the system. Each citizen must place a percentage of his or her monthly income, matched by employers, into a medical savings account. When that individual is ill or hospitalized, the medical savings account is drawn on to pay the bills. If costs are excessive the government pays the difference. Persons who choose to pay extra can obtain a higher level of service. Singapore also has a thriving private sector, encouraged by the government, for those who elect to use it.

REFORM OF THE HEALTH SECTOR

Dissatisfaction with the health sector is a common feature in all countries, whether wealthy or poor, centrally planned or free market. Common inadequacies of health care systems have already been mentioned. There is a widespread feeling that conventional health expenditures are not cost-effective, and alternative opinions about the public and private sectors are actively debated in many countries. Increasingly complex technology and greater prosperity have led to rising expectations for prevention and treatment of illnesses. Expanding and aging populations place greater demands on health establishments and may outstrip the capacity of local systems.

In the early 1990s, spurred in part by comparative studies supported by the World Bank, health sector reform became established as a specific global strategy. The main goals of health sector reform are to improve the health status and satisfaction of the people; to obtain greater value for money spent on health services by increasing their effectiveness and quality; and to expand equity by improving the access of disadvantaged groups to quality health care. As a general principle, governments are encouraged to focus resources on programs, such as public health-oriented activities, that benefit whole communities rather than particular individuals. The provision and financing of personal clinical services, including diagnosis, preventive and curative procedures, rehabilitation, and supply of pharmaceuticals, is often an area of controversy.

Within a growing awareness of the importance of nongovernment health care providers, health insurance programs of various kinds are promoted to relieve government budgets while protecting households from large financial losses. Governments are encouraged to redefine their role as public sector institutions, trimming down the direct provision of medical care services in favor of setting goals, controlling finances, and managing growth and change in the entire health sector. These goals may be accomplished through regulation, licensing, and monitoring, as well as imposing fees, taxes, subsidies, and incentives. Another widely promoted feature of health sector reform is the decentralization of existing bureaucratic authority for planning, budgeting, and providing government-sponsored health services. Many

reform strategies allow for contracting of certain services to enhance the role of private providers in national health systems.

Among the most contentious issues in health sector reform is the promotion of market incentives to augment resources at the local level. User fees for clients of government health facilities have been proposed in situations where public financing is inadequate. Proponents argue that charges for drugs and curative care are the only way to pay for services in impoverished areas. Allowing revenues to be collected and retained as close as possible to the point of service delivery will help both the collection of fees and the efficiency of the service. Opponents say that user fees are regressive, discriminate against the poor, and promote inequity.

HEALTH AND INTERNATIONAL DEVELOPMENT

Development involves a series of directed changes in many aspects of individual, community, and national life. This term refers not only to increasing financial and material resources, but also to aspects of modernization. These include the expansion of technologies that make everyday life more comfortable and productive, and the attitudes that are associated with them. Incorporating these changes into everyday life generally leads to increased receptivity to further change. On a national scale, development includes investment in extractive and agricultural industries, factories, and infrastructure such as roads, dams, water supplies, and electric generation and communications systems. Investment in human potential through adequate educational opportunities, housing, employment, and health care is also important.

DEVELOPMENT AID PROJECTS

Development projects are often targeted toward the health sector in the poorer countries. Such projects are often aimed at strengthening the capacity of health providers to plan, budget, manage, supervise, and evaluate services. Many projects support primary health care systems and infrastructure at community, regional, or national levels. Other projects involve training of health workers of various kinds, providing maternal and child health services including immunization and

family planning, the supply of essential drugs, prevention and control of major diseases, and health education. Projects outside the conventional health sector also have a profound impact on health. Construction of infrastructure projects as mentioned, as well as agricultural diversification and expanded opportunities for employment, may improve the health of individuals and communities even more than nominal health projects.

INTERNATIONAL AGENCIES

Early official international health activities began in Venice in 1348, when quarantine, a forty-day detention period for entering vessels, was introduced in an attempt to stop the introduction of plague. Other major European ports also adopted this system. With the growth of international commerce such blockades were increasingly viewed as obstacles to trade. An International Sanitary Conference was held in Paris in 1851, mainly to try to control the frequent epidemics of cholera in Europe. The first international nongovernmental agency, the International Red Cross, was founded in Switzerland in 1864 primarily to promote neutral humanitarian assistance to wounded combatants, has come to be known as the original Geneva Convention. Many conferences and congresses on health and other topics were held in the latter nineteenth century. In 1902 the First Pan American Sanitary Conference in Washington established the International Sanitary Bureau (later named the Pan American Sanitary Bureau) among the nations of the western hemisphere. In 1909 a formal international public health organization, L'Office Internationale d'Hygiène Publique (OIHP) was established, called by English speakers the "Paris Office." The purpose of this office was to collect and disseminate information about public health with an emphasis on infectious diseases such as cholera, plague, and yellow fever. Outbreaks of diseases such as typhus during World War I and the great influenza epidemic of 1918 stimulated the formation of the Health Office of the League of Nations (LNHO), which was never joined by the United States.

Several large international agencies established during and after World War II are important in international health. Discussed here are some components of the United Nations system, primarily the World Health Organization and the World

Bank group. The charter of the United Nations (UN) was signed in San Francisco in 1945. The UN family includes many organizations that promote development and health. These include the UN Development Program, the UN Children's Fund (UNICEF), the UN Environment Program, the UN High Commission for Refugees, the World Food Program, the UN Centre for Human Settlements (Habitat), the International Labor Organization, the Food and Agriculture Organization, and the UN Educational, Scientific, and Cultural Organization (UNESCO). By far the most important UN agency for international health is the World Health Organization (WHO).

THE WORLD HEALTH ORGANIZATION

The UN charter contained provision for a specialized health agency with wide powers. In 1946 the Constitution of the World Health Organization was written, and ratified by member states on April 7, 1948. Procedures were set up to take over the remaining duties of the old OIHP, the LNHO, and other existing agencies. The old Pan American Sanitary Bureau remained independent but spun off the Pan American Health Organization (PAHO) as the WHO unit for the Region of the Americas.

The global headquarters of WHO are in Geneva, Switzerland, and there are six subordinate regional headquarters. These are: Copenhagen (Europe); Alexandria (Eastern Mediterranean); New Delhi (Southeast Asia); Harare (Africa); Manila (Western Pacific), and Washington (the Americas). The region of the Americas is divided further into six zones with regional headquarters in Mexico City, Guatemala City, Caracas, Lima, and Rio de Janeiro, as well as the headquarters in Washington. Dr. Gro Harlem Brundtland, former Prime Minister of Norway, was elected Director-General of the WHO in 1998 and quickly organized WHO operations into nine clusters. These clusters are: Sustainable Development and Healthy Environments; Family and Health Services; Social Change and Mental Health; Communicable Diseases; Non-Communicable diseases; Evidence and Information for Policy; Health Technology and Drugs; External Relations and Governing Bodies; and General Management. In 1997 the WHO had 193 members including the countries of the former Soviet Union and some smaller nations such as

Andorra. The budget of the WHO is made up of dues from members plus voluntary contributions for special programs such as research on human reproduction; community water supply; tropical diseases; and other purposes. Many projects are paid for jointly by the WHO regular budget, by the country concerned, and by funds from other UN agencies listed above, including the World Bank.

The mission of the WHO as stated in article 1 of its constitution is “the attainment by all peoples of the highest possible level of health,” a goal for which some two dozen specific functions are listed in article 2. The work of the WHO is divided into two major categories. The first is central technical services such as information about the occurrence of diseases; international standardization of vaccines and pharmaceuticals; and the dissemination of knowledge through meetings and publications. The second is services to governments, at the request of member countries, usually in the form of specific projects for training, primary care, or specific disease control programs.

THE WORLD BANK GROUP

The great world depression of the 1930s followed by World War II caused many people to believe that increased international organization and regulation would be helpful in preventing monetary and military crises. In 1944 the U.S. government organized the United Nations Monetary and Financial Conference in Bretton Woods, New Hampshire, attended by representatives from 43 countries. That conference established the International Bank for Reconstruction and Development (IBRD), more commonly called the World Bank, the International Monetary Fund (IMF), and the World Trade Organization, which was not formally constituted until 1995. While not primarily health organizations, these agencies, particularly the World Bank, have had a profound influence on international health.

The World Bank (IBRD) lends money to poorer countries for specific types of development projects. During its first decades of operation the bank concentrated its development lending on transportation, public utilities, and certain other infrastructure projects. It was not until the 1980s that the bank provided major support to more

human welfare-oriented sectors such as education or health, nutrition and population, which now constitute a substantial proportion of all lending. World Bank project loans are made at prevailing market interest rates. A separate member of the World Bank group, the International Development Association (IDA), was founded in 1960 because the poorer countries were unable to repay standard World Bank (IBRD) loans. Eligible countries with a sufficiently low per capita income receive IDA assistance at much lower interest rates and far better terms. Countries eligible to receive IBRD funding have an annual per capita income below about US\$6,000 equivalent, and those that qualify for IDA credits have a per capita income of less than about US\$1,000. Many hundreds of specific projects in health, nutrition, population, education, and related fields are funded each year to a total of many billions of dollars.

The International Monetary Fund operates to stabilize monetary and fiscal policies and the liquidity and convertibility of currencies. Countries in financial difficulty may receive support from the IMF on the condition that they adopt certain policies to control inflation and assure international payments. Such conditionalities, called Structural Adjustment Programs, have often been criticized as harmful to the interests of the poor.

ROLES AND FUNCTIONS OF BILATERAL AGENCIES AND NONGOVERNMENTAL ORGANIZATIONS

Beyond their contributions to the large international “multilateral” organizations just described, each of the wealthier industrialized countries has an official agency that provides assistance or “foreign aid” to poorer nations. These bilateral donor agencies generally deal directly with recipient governments. Bilateral agencies commonly provide two broad kinds of assistance: 1) for general economic development, including health projects such as control of malaria, services for mothers and children; or strengthening of health services; and 2) for humanitarian relief during periods of natural disaster or civil disturbance. In the United States this role is met by the U.S. Agency for International Development (USAID).

Many development and humanitarian activities are also carried out by a very large number of

nongovernmental or private voluntary organizations based in the wealthier countries and supported by religious or private groups, or donations from the public. Such nonprofit organizations often interact directly with local counterparts in the developing world. Some companies in the private sector provide services such as consulting, planning, implementing, or evaluating projects in the field, often funded by contracts from governmental bilateral agencies.

Since the 1950s, multilateral, bilateral, and nongovernmental donors have conducted specific health-related projects in recipient countries. Such projects, negotiated individually with local government officials, consume valuable staff time and result in duplication or gaps in coverage. Some countries are adopting a sector-wide approach, in which multiple donors join in a consortium to deal together with the local government in support of its national strategy.

PAUL F. BASCH

(SEE ALSO: *Anthropology in Public Health; National Health Systems; Pan American Health Organization; UNICEF; United States Agency for International Development [USAID]; World Health Organization*)

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Figure 1

Major Nongovernmental Organizations				
Organization	Contact Information	Geographic Focus	Thematic Focus	Description
International Committee of the Red Cross (ICRC)	ICRC Public Information Centre 19 avenue de la Paix CH1202 Genève Tel: ++41 (22) 734 60 01 Fax: ++41 (22) 733 20 57 http://www.icrc.org webmaster.gva@icrc.org	International	Emergency services	Directs and coordinates international relief activities, provides victims of war with protection and assistance, promotes humanitarian law and principles
Médecins Sans Frontières (MSF)	Rue de la Tourelle, 39 - Brussels - Belgium-1040 Tel: +32-2-280-1881 Fax: +32-2-280-0173 http://www.msf.org	International	Emergency medical assistance	Works in collaboration with authorities to provide assistance such as rehabilitation of hospitals, vaccination programs, sanitation projects, and training of local personnel
World Vision International	800 West Chestnut Avenue Monrovia, CA 91016-3198 U.S.A. Tel: (626) 303-8811 Fax: (626) 301-7710 http://www.wvi.org	International	Seeks and promotes human transformation and justice	A Christian organization that is involved in emergency relief, promotion of justice, strategic initiatives, and public awareness
CARE International	151 Ellis Street NE Atlanta, GA 30303-2439 U.S.A. Tel: 1-800-521-CARE, ext. 999 http://www.care.org info@care.org	International	Emergency aid and relief	A private international relief and development organization that reaches out to people whose lives are devastated by humanitarian emergencies or to people in poor communities who struggle to survive and improve their lives; involved in over 60 countries in Asia, Africa, Europe, and Latin America
OXFAM International	2nd Floor, Prama House, 267 Banbury Road, Oxford, OX2 7HT U.K. Tel: (+44) 1865 31 39 39 Fax: (+44) 1865 31 39 35 http://www.oxfam.org information@oxfaminternational.org	International	Poverty and related injustice	Composed of 11 autonomous nongovernmental organizations that work in different ways but share the common purpose of addressing the structural causes of poverty and related injustice
Program for Appropriate Technology in Health (PATH)	4 Nickerson Street Seattle, WA 98109-1699 U.S.A. Tel: (206) 285-3500 Fax: (206) 285-6619 http://www.path.org info@path.org	International	Health of women and children	Goals of improving women's health, improving children's health, and preventing communicable diseases are accomplished through the exchange of knowledge, skills, and technologies with governments and nongovernmental organizations in developing countries and with other groups in need
HOPE Worldwide	353 West Lancaster Avenue, Suite 200 Wayne, PA 19087 U.S.A. Tel: (610) 254-8800 http://www.hopeww.org	International	Promotes hope and well-being	A faith-based charity founded by the International Churches of Christ, its programs serve disadvantaged children and the elderly, provide education, and deliver medical services to developing regions
Voluntary Service Overseas (VSO)	317 Putney Bridge Road, London SW15 2PN, U.K. Tel: (+44) 20 8780 7200 Fax: (+44) 20 8780 7300 http://www.vso.org.uk enquiry@vso.org.uk	International	Aid to developing countries in the form of volunteers	A charity that recruits volunteers from around the world to share their skills and knowledge and build the capabilities of those with whom they work
African Medical and Research Foundation (AMREF)	P.O. Box 30125 Nairobi, Kenya Tel: 254-2-501301/2/3 Fax: 254-2-609518 http://www.amref.org amref.inf@amref.org	Africa	Health care in sub-Saharan Africa	Activities are divided into five main areas that reflect the health priorities of the African communities that they work with: child and adolescent health and development, sexual reproductive health, clinical services and emergency response, health policy and systems reform, and environmental health

Figure 1, continued

Major Nongovernmental Organizations				
Organization	Contact Information	Geographic Focus	Thematic Focus	Description
Aga Khan Foundation (AKF)	P.O. Box 2369 CH-1211 Geneva, Switzerland http://www.akfc.ca	International (mainly Asia and Africa)	Health, education, rural development, enhancement of nongovernmental organizations	An international family of nonprofit development agencies that seek to promote social development
Save the Children	54 Wilton Road Westport, CT 06880 U.S.A. Tel: 1-800-243-5075 http://www.savethechildren.org	United States and International	Child health care and well-being	Works to create positive, lasting change for disadvantaged children in the areas of health and nutrition, education, economic opportunity, and emergencies; uses a self-help approach to relief, recovery, and ongoing development
American International Health Alliance	1212 New York Avenue, NW, Suite 750 Washington, D.C. 20005 U.S.A. Tel: (202) 789-1136 Fax: (202) 789-1277 http://www.aiha.com aiha@aiha.com	New Independent States (NIS), Central and Eastern Europe	Advancement of global health	Places an emphasis on economically viable, low-technology solutions that improve health care and productivity; uses the exchange of health-care professionals and community leaders as the primary mode of developing unique, self-sustained approaches for improved quality and delivery of health-care
World Federation of Public Health Associations	1015 15th Street NW, #300, Washington, D.C. 20005 U.S.A. Tel: (202) 789-5696 Fax: (202) 789-5661 http://www.apha.org/wfpha/ allen.jones@apha.org	International	Professional exchange and collaboration	Promotes public health throughout the world by facilitating partnerships among its member groups and providing a medium through which they can exchange information, experience, and research

SOURCE: Courtesy of author.

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INTERNATIONAL NONGOVERNMENTAL ORGANIZATIONS

Nongovernmental organizations (NGOs) involved in international health are as numerous as they are diverse (see Figure 1). They are governed by different types of institutions and have a variety of emphases, both geographically and in terms of a thematic focus. The International Committee of the Red Cross (ICRC) is a global organization that tends to focus mainly on disaster relief, both short-term and long-term. Médecins Sans Frontières (Doctors Without Borders) is concerned with providing medical care in conflict zones. Save the Children concentrates on children's health and well-being, as do a number of other NGOs. Many are faith-based organizations, including World Vision International and Project HOPE. Others, like the Canadian Public Health Association, are affiliated with national organizations.

These and other nongovernmental organizations in the international-health field raise awareness about health issues and concerns worldwide. They strive to maximize the impact and outcome of international-health advocacy through coordination and collaboration.

JANET HATCHER ROBERTS

(SEE ALSO: *International Health*; *Pan American Health Organization*; *UNICEF*; *World Health Organization*)

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INTERNATIONAL SANCTIONS, HEALTH IMPACT OF

To sanction a country is to interrupt communications, diplomacy, or economic relations. Sanctions have become especially common since the end of the Cold War. Sanctions appear to externalize all costs onto the sanctioned country. But a lot of those costs are borne by the civilian population.

War has become more destructive as weapons have become more powerful, more devastating, and more mobile. The 1977 Additional Protocols to the 1949 Geneva Convention prohibit any wartime measure that has the effect of depriving a civilian population of objects indispensable to survival. Article 70 of Protocol I mandates relief operations if civilian populations are not "adequately provided" with humanitarian goods. Article 18 of Protocol II calls for relief operations for a civilian population that suffers "undue hardship owing to a lack of supplies essential for its survival, such as foodstuffs and medical supplies." Article 14 of Protocol II guarantees the protection of goods indispensable to survival: "Starvation of civilians as a method of combat is prohibited. It is therefore prohibited to attack crops, livestock, drinking water installations and supplies and irrigation works." Ironically, most people would be

better off materially in occupied territory during or after a war than in a country under comprehensive economic sanctions. Under sanctions, no such protections are assured.

This does not mean that sanctions are deadlier than war, as some have argued. The likelihood of injury or death is still greater from bombs or bullets than from a shortage of medicines or food. But even in the most aggressive of wars, most people are not exposed to bullets and bombs most of the time. By contrast, virtually the entire population of a country may be exposed to risks from a shortage of essential goods permanently under embargoes. This small increase in risk, when distributed among a large population for a long time, can result in more death and destruction than war.

COUNTRY BACKGROUNDS

Cuba was sanctioned by the United States in 1964. During détente in the 1980s sanctions were relaxed, permitting Cuba to purchase goods from United States companies through other countries. In 1992 the United States embargo was made more stringent with the passage of the Cuban Democracy Act. All United States subsidiary trade, including trade in food and medicines, was prohibited. Ships from other countries were not allowed to dock at United States ports for six months after visiting Cuba, even if their cargoes were humanitarian goods (see Table 1).

Haiti has been the poorest country in the western hemisphere for most of its two centuries of post-colonial history. When Jean-Bertrand Aristide became the country's first elected president in February 1991, half of the labor force was unemployed, half of all adults were illiterate, and a third of the people lacked access to modern health services. A military coup ousted Aristide in September, and sanctions were initiated by the United States and the Organization of American States (OAS), a regional body of the United Nations, in October 1991.

Sanctions began on all items exported to Iraq except medicines in August 1990. Following the Gulf War of January and February 1991, sanctions were reaffirmed by the United Nations. Starting April 1991, Iraq was again permitted to import food in addition to medicine. In fact, little of either

Table 1

Comparative Indicators for Case-Study Countries						
	Cuba 1992	Cuba 1996	Iraq 1990	Iraq 1996	Haiti 1990	Haiti 1994
Average Calorie Availability	3,100	1,865	3,150	2,277	2,125	?
Calories Available via Ration	1,400	1,200	N/A	1,500	N/A	N/A
Gross Domestic Product per capita	2,000	1,300	3,508	540	370	250
% Mothers Breast-feeding	63	97	60	80	?	96
% Births Under 2500 gms.	7.3	8.7	4.5	22.1	16	15
% of Calories Imported Prior to Sanctions	50		70		less than 50%	
Malnutrition Among Under Five Year Olds:						
Stunting	>5	>5	>22	32	?	32
Underweight	>5	>5	>12	23	18	28
Wasting	>5	>5	>3	1.1	?	9
Value of National Currency/\$	1	35	1	1,500	7	15
Value of Sanctions-Related Lost Production in Billions		\$2		\$120		\$850
Value of Humanitarian Assistance		>\$1 Billion		\$1 Billion		\$250 Million
Minimum Estimate of Excess Deaths per Year of Sanctions		7,500*		5,500**		27,000***
*Among adults over age 65						
**Among children age 1–4 years						
*** Among children age 0–4 years						

SOURCE: Data from E. Gibbons, *Sanctions in Haiti, Human Rights and Democracy under Assault* (1999). Westport, CT: Praeger; R. Garfield and S. Santana "The Impact of Economic Crisis and US Embargo on Health in Cuba" *American Journal of Public Health* (1997); 87(1): 15–20. A. F. Kirkpatrick. "Role of the USA in Shortage of Food and Medicine in Cuba." *The Lancet* (1996); 38: 1489–1491.

commodity was imported. In 1995 the United Nations Security Council authorized sales of oil for the purchase of humanitarian goods. The government of Iraq approved the Oil for Food (OFF) plan only in 1996, and the first deliveries of humanitarian goods began in 1997.

Oil sales from the first five six-month rounds of the OFF program generated \$7.7 billion for humanitarian goods. Goods purchased with these funds amounted to a little over half of this total, representing \$394 per capita in the center and south of Iraq and \$480 per capita in the north. Even though far more goods were being imported to Iraq under OFF than at any time since initiation of the embargo, the \$3 to \$4 worth of food and medicines distributed per capita per month under OFF represented only a fraction of the estimated \$12 imported per capita per month during 1988–1989.

HEALTH EFFECTS

Total mortality per 1,000 inhabitants in Cuba rose from 6.4 in 1989 to 7.2 in 1994. The increase was almost entirely due to a 15 percent rise in mortality among those aged 65 years and older. From 1992

to 1993, the death rate for influenza and pneumonia, tuberculosis, diarrhea, suicide, unintentional injuries, asthma, and heart disease each rose by at least 10 percent among this older population, as some of those with chronic diseases requiring daily medication or laboratory support did not get needed goods. In all other age groups, mortality rates remained stable or declined.

Maternal mortality among Cubans rose sharply from formerly low levels in 1993–1994. Extraordinary efforts to provide extra food rations to pregnant women and revamp birthing procedures rapidly reversed the trend toward rising mortality. Infant mortality in Cuba, long among the lowest in Latin America, did not rise but failed to continue declining during those same years. Subsequent efforts to improve maternal nutrition and conditions for delivery led to continued declines in infant mortality starting in 1996.

In Haiti, the 1995 Demographic and Health Survey found that between 1987 and 1994 the mortality of children one through four years of age rose from 56 per thousand to 61 per thousand. This high a rate last occurred 17 years earlier. During the same period infant mortality declined

38 percent, from 101 to 74 per 1,000. Average life-expectancy for Haitians decreased by 2.4 years during the crisis and in 1994 stood at 54.4.

Much of the increased mortality among one-through-four-year-olds was due to a measles epidemic from June 1991 to November 1993. The Immunization Program Technical Committee had decided to delay a measles vaccination campaign until President Aristide returned.

In Iraq, a large-scale demographic survey carried out by UNICEF in the first half of 1999 showed that mortality levels after 1995 were double the rates in the late 1980s at about 131 per 1,000 live births and that mortality in the North was lower than the Center and South. The maternal mortality rate in all three countries rose during sanctions.

In Cuba, the number of laboratory exams provided in the country's 273 hospitals declined by 36 percent and the number of X-rays declined by 75 percent from 1990 to 1994. Most Cuban ambulances were in working order in the 1980s; fewer than half worked in June 1994. In Baghdad in 1996, since spare tires were not permitted due to their potential military use, only five of the 100 public ambulances were working; the parking lots looked like junk yards.

Almost all sanction legislation has provisions for exemptions for food and medicines. Nonetheless all sanctions led to limitations on the importation of foodstuffs and medicines due to disruption of commercial arrangements, complications in transportation, or lack of capital in the embargoed country with which to purchase the exempted goods.

METHODOLOGICAL CHALLENGES

The methodologic challenges to establishing a valid assessment of the impact of an embargo are daunting:

- Embargoes spread a small increase in risk of death, illness, or social stress among a large group of people. Small risks are difficult to measure with precision.
- This small change in risk may be obscured by concurrent events that independently

contribute to the negative outcomes which result from an embargo, such as war, mass migration, or economic crisis.

- The impact of an economic sanction on health and well-being is mediated by a country's economic and social systems. Major impacts occur through the effect of sanctions on the production, importation, and distribution of essential goods. There are thus multiple pathways and steps by which influence is exerted on the health and well-being outcomes.
- Each sanction on economic trade is a type of natural experiment, where the intervention is national in scope and control groups with which to make comparisons are lacking. Baseline information available in sanctioned countries is usually limited in coverage or quality and, with the exception of Cuba, the quality of information on health and well-being has declined under sanctions.
- Changes in the distribution of essential goods within the family and the mobilization of underutilized resources due to political or social organization modify the impact of resource changes brought on by economic sanctions. These modifying influences are difficult to isolate and often go unrecognized or unmeasured. Even a dramatic decline in key resources does not always or immediately lead to increases in morbidity or mortality due to the resilience of such health assets as public education, healthy behaviors, trained health workers, and infrastructure, which deteriorate only gradually.
- Much available information comes from statistics from health or social service provider institutions. These organizations have information on services provided or people served (a numerator) but seldom have information on the underlying populations (the denominator) from which service users come. Such available information usually cannot be used to establish valid rates or to identify changing levels of demand, need, or severity.

FUTURE HUMANITARIAN ASSESSMENTS

Future assessments should focus more on the "well-being" aspects of "health and well-being." More needs to be learned about the impact of social deterioration on those who do not die or lie in hospitals for want of medicines during embargoes. Among children, this includes research on changes in mental capacity, educational achievement, and access to learning materials among those in school; and on employment and survival strategies among those not in school. Changes in learning and employment opportunities in higher education and in-service training should similarly be explored. Changing types and levels of delinquency and familial and governmental responses should be studied. Changing patterns and levels of family formation, family functioning, and family-related social pathologies should be identified. The loss of knowledge of professionals, cut off from routine international exchange, should also be evaluated. More needs to be known about the nutritional status of older children and adults along with that of young children, and research is needed to identify the pathways by which those changes occurred. Changing patterns of resource generation and utilization should be identified, including both formal (money) and informal (unpaid labor) resources. These measures of well-being will assist in identifying effective coping strategies, existing strengths in a society, and opportunities for relief and reconstruction.

Research should combine quantitative indicators of health and well-being with qualitative information to understand better how available inputs lead to the specific outcomes found. Such a combination will assist in clarifying the chain of events leading to damage, as well as those factors strengthening resilience or mitigating damage. This requires insights and measures not only from clinical medicine but also from demographics, sociology, anthropology, and psychology. Nongovernmental organizations have an important role to play in such assessments.

It has been shown that infant mortality has declined in some embargoed countries even during periods of severe resource shortages. This has occurred when scarce resources were distributed more efficiently, and health and national leaders mobilized child-health actions. When social and

political emergency moves parents to special actions, much is possible. Cuba, for example, moved from about half to more than 90 percent breastfeeding of newborns during the first three months of the embargo, when leaders showed that breastfeeding would make up for lost formula imports. Similarly, a campaign to boil water before drinking gained support when it was broadcast that the embargo resulted in a lack of chlorine to treat water supplies. In other countries, campaigns promoting monitoring of child development and pregnant women; vaccinations; the use of herbal medicines; community participation in sanitation to reduce malaria and dengue transmission have been successful under the special conditions of externally imposed resources shortage caused by embargoes. In Iraq, the development of community-based child nutrition and community development programs were stimulated. All of these basic health measures would have been beneficial prior to the embargo but were precipitated by a collective sense of emergency and the recognition of an opportunity to respond.

Improved monitoring, expanded humanitarian action, and the modification of national policies to protect the most vulnerable with simple low-cost public health actions will be needed to reduce humanitarian damage and speed recovery in countries affected by sanctions or other crises.

RICHARD GARFIELD

(SEE ALSO: *Famine; Genocide; Refugee Communities; War*)

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INTERNET

The Internet allows multimedia documents to be moved between any two computers, using an "internetwork" of relaying computers. Multimedia documents can be found by those seeking information using a web browser to "pull" information off the "World Wide Web," or using an e-mail system to "push" information to those currently uninterested or unaware of an issue.

The Internet has been called an "engine of empowerment" that creates healthy "virtual communities." Others, however, say it increases may social and health-related problems, including individual isolation and risky sexual practices by fragmenting relationships and by increasing the anonymous distribution and viewing of pornographic material. These seemingly contradictory outcomes can be reconciled in understanding that the Internet, like any communications technology, amplifies the intentions of its users. It amplifies these intentions by primarily increasing the "reach" of both the sender and receiver, who often share a common interest. As a result, its use may only increase the sharing of information that reinforces and amplifies preexisting life patterns.

MIKE CHIASSON

(SEE ALSO: *Advertising of Unhealthy Products; Information System; Information Technology; Patient Education Media; Self-Help Groups; Social Health*)

IODINE

Iodine is a critically important component of thyroid hormones. There are four iodine atoms per molecule of l-thyroxine, and three per molecule of

l-triiodothyronine. The highest content of iodine in food is found in fish, with lesser amounts occurring in eggs, milk, and meat. Fruits and vegetables contain little iodine. Without iodine supplementation, people in most inland areas of the world, particularly mountainous regions, have iodine deficiency. This was the case in the United States before iodination of salt. When iodine deficiency prevails, goiter and hypothyroidism commonly occur, along with congenital cretinism—all preventable diseases. Iodine excess, usually a result of diagnostic medical procedures or medications, can produce either hypothyroidism or hyperthyroidism in patients with different types of underlying thyroid disease.

MARTIN I. SURKS

(SEE ALSO: *Goiter; Hyperthyroidism; Hypothyroidism; Thyroid Disorders*)

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IONIZING RADIATION

See Radiation, Ionizing

IRON

Iron is a vital component of heme, the component of hemoglobin that transports oxygen in the blood. Iron deficiency is the world's most common cause of anemia (blood with low hemoglobin and red blood cell components). While some plants have modest amounts of iron (e.g., spinach), meat (red or white) has many times more iron than plants. Meat iron is also absorbed much more efficiently than plant iron. In addition to oxygen transport, iron and heme are key to normal brain development. Iron deficiency during the first six months of life can irreversibly impair cognitive development.

KENNETH R. BRIDGES

(SEE ALSO: *Hematocrit; Hemoglobin*)

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ISCHEMIC HEART DISEASE

See Coronary Artery Disease

ISOLATION

In epidemiology isolation refers to a procedure used in communicable disease control. It consists of a separation of cases (persons or animals) for a disease's period of communicability. The cases are isolated in a specific location and under conditions that minimize the risk of direct or indirect transmission of the infectious agents to those who may be susceptible. The American Public Health Association's *Control of Communicable Diseases Manual*, 17th edition, recommends "universal precautions" to prevent the transmission of blood-borne agents and strict hygienic measures such as thorough hand washing after attending to infectious cases and disinfection of articles that have been in contact with infectious cases.

The Centers for Disease Control's *Guidelines for Isolation Precautions in Hospitals* identifies several categories of isolation that are appropriate according to the mode of transmission of the infectious agent. Strict isolation is used for highly

contagious or virulent infections in which the agent may be spread by direct contact or droplet. Procedures include segregation in a private room; use of gowns, masks, and gloves; and sometimes special ventilation. Contact isolation is used for less dangerous conditions spread by direct contact. Measures similar to strict isolation are employed, but more than one person may share a room and sometimes barrier nursing suffices. Respiratory isolation is used to prevent airborne transmission of infectious agents—it resembles contact isolation in that infectious patients may share a room. Tuberculosis isolation is used for patients known or suspected to be excreting tubercle bacilli in sputum. A private room with the door closed is required, as well as the same procedures used for contact and respiratory isolation and the use of respirator-type masks by all who enter the room. Gowns are used but gloves are unnecessary. Enteric precautions are used when the infectious agent is transmitted in feces. These precautions resemble contact isolation and include particular care in sanitary disposal of feces. Drainage/secretion precautions are used when patients are discharging purulent material, such as that from an abscess or other infected body site. A private room is not necessary, and gowns and gloves are indicated if attendants have to touch contaminated material.

JOHN M. LAST

(SEE ALSO: *Barrier Nursing; Communicable Disease Control; Nosocomial Infections; Quarantine; Universal Precautions*)

J

JENNER, EDWARD

Edward Jenner (1749–1823) was a British family doctor who practiced throughout his life in the village of Berkeley, Gloucestershire. He apprenticed for two years with John Hunter, then the preeminent medical teacher in Britain, but never took any examinations to obtain a medical degree. Instead, he purchased a medical degree from a Scottish university and later applied for and was granted an M.D. degree from Oxford University. He was keenly interested in all aspects of natural history, and he wrote a notebook describing the habits and habitats of birds in his district. A man with considerable intellectual and leadership qualities, he also founded a local medical society that survived for many generations.

At the time of Jenner's birth, smallpox was an ever present threat to life and health. When it did not kill outright, it often left a legacy of disfiguring facial pockmarks, and if it affected the eyes it caused blindness.

The practice of variolation—inoculation into the skin, or insufflation into the nose, of dried secretions from a smallpox bleb—was invented in China around 1000 c.e. and spread along the silk route, reaching Asia Minor some time in the seventeenth century. Lady Mary Wortley Montague, wife of the British ambassador to the Ottoman Empire, described the practice, also called ingrafting, in a letter to her friend Sarah Chiswell dated April 1, 1717, and imported the idea to England when she returned home. By the time Jenner was a child, ingrafting had become widespread among

educated English families as a way to provide some protection against smallpox. If virulent smallpox virus had happened to survive in the batch of secretions used, however, the procedure sometimes caused severe illness and even occasional fatalities. This was generally considered to be a risk worth taking, as it was substantially less than the risk of death or disfigurement posed by epidemic smallpox itself.

Jenner knew the popular belief in Gloucestershire that people who had been infected with cowpox, a mild disease acquired from cattle, did not get smallpox. He reasoned that since smallpox in mild form was transmitted by variolation, it might be possible to similarly transmit cowpox. He made many observations, starting in 1778, and a smallpox outbreak in 1792 provided him with the opportunity to confirm his belief that persons previously infected with cowpox did not get smallpox. In 1796 he began a courageous and unprecedented experiment—one that by modern standards would be considered unethical—that would have an incalculable benefit for humankind. He inoculated a boy, James Phipps, with secretions from a cowpox lesion. Over the following months he inoculated others, most of them children, inoculating twenty-three in all. They all survived unharmed, and none got smallpox. In 1798, Jenner published his results in *An Inquiry into the Causes and Effects of the Variolae Vaccinae*. His findings rank among the most important medical discoveries of all time.

The importance of Jenner's work was immediately recognized, and although there were skeptics

and vicious antagonists, vaccination programs soon began. At first, these programs were conducted more vigorously in some European nations than in Britain. In 1802, Jenner was rewarded by Parliament with a grant of £10,000, and in 1807 with a further £20,000, but he was not otherwise honored in his own country. In France and other European nations, however, his achievement was more suitably commemorated.

In due course, Jenner's discovery led to a successful campaign by the World Health Organization to eradicate smallpox. In 1980, the World Health Assembly proclaimed that smallpox, one of the most deadly scourges of mankind, had been eradicated. At the beginning of the new millennium, samples of the smallpox virus survive in secure biological laboratories in several countries, but thanks to Edward Jenner, this terrible disease need never again take a human life.

JOHN M. LAST

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JOURNAL OF PUBLIC HEALTH MANAGEMENT AND PRACTICE

The Journal of Public Health Management and Practice (JPHMP) offers timely and relevant information about population-based health, encouraging scientifically based innovation and reform. Contributors include practitioners in public health agencies, teaching institutions, and other settings. Effective public health management requires a combination of scientific knowledge with skills in community organization. A broad range of peer-reviewed articles elucidates how scientific investigations and population-based applications work together to improve community health. *JPHMP* is published six times a year; each issue includes a cluster of articles on one aspect of public health management, such as directly observed therapy in the treatment of tuberculosis, prevention of HIV (human immunodeficiency virus) infection and

sexually transmitted diseases, managed care, performance measures, academic-practice partnerships, and bioterrorism. By focusing on actual practice, *JPHMP* facilitates the sharing of new initiatives to improve community health and is a forceful advocate for the health of the public.

LLOYD F. NOVICK

(SEE ALSO: *American Journal of Public Health*)

JUST-SAY-NO CAMPAIGN

"Just Say No" is a widely promoted public health campaign initiated in the United States by former First Lady Nancy Reagan in the 1980s. It emerged from a National Institutes of Health-supported substance abuse prevention research program pioneered in the 1970s by University of Houston Social Psychology Professor Dr. Richard I. Evans and his research group. Evans's social inoculation model encompassed "inoculating" students with skills to resist peer pressure and other social influences. "Just Say No" was among the resistance skills recommended in response to low peer pressure, and Nancy Reagan's campaign proved to be a useful dissemination of this social inoculation strategy.

RICHARD I. EVANS

(SEE ALSO: *Alcohol Use and Abuse; Communication Theory; Mass Media and Tobacco Control; School Health; Substance Abuse, Definition of; Tobacco Control*)

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K

KAP SURVEYS

See Surveys

KOCH, ROBERT

Robert Koch (1843–1910) was one of the greatest bacteriologists who ever lived. He was born in Klausthal, in what is now Germany, and educated at Göttingen, where he studied medicine before going into practice. His first achievement was to isolate and identify the anthrax bacillus (1876). In 1882 he isolated and identified the tubercle bacillus (*Mycobacterium tuberculosis*), and in 1883, while leading an expedition to Egypt and India, he identified the bacterium that causes cholera (*Vibrio cholerae*). In 1885 Koch was appointed professor of hygiene and bacteriology at the University of Berlin, and in 1891 he became director of the Institute for Infectious Diseases in Berlin. He studied bacterial diseases not only in humans but also in animals, and identified, among others, the cause of rinderpest, the lethal and economically important cattle plague of Africa.

His work was facilitated by many of the techniques he and his associates developed to isolate bacteria and grow them on culture media in the laboratory. Koch published many papers and books and fostered the development of a whole generation of bacteriologists and medical scientists in other fields, not only in his native Germany but from many other nations as well. With Jakob Henle

he developed the Henle-Koch postulates, four basic criteria that are required for proof that a microorganism caused a disease: (1) the organism can be isolated in every case of the disease; (2) it can be cultivated in pure culture; (3) cultured organisms can induce the disease in experimental animals; and (4) the organism can be recovered from the infected experimental animals. Robert Koch was awarded the Nobel Prize in medicine in 1905, a fitting capstone to his distinguished career.

JOHN M. LAST

(SEE ALSO: *Anthrax; Cholera; Henle, Jacob; Tuberculosis*)

KREBS CYCLE

The Krebs cycle is a series of biochemical changes that occur during the metabolism of nutrients, facilitating the storage of energy for further use. It is named after Hans Adolph Krebs (1900–1981), the biochemist who identified it. The alternative, and more descriptive, name is the tricarboxylic, or citric acid, cycle. The fundamental process involves oxidizing acetate molecules to carbon dioxide (CO₂) and water with transfer of the metabolic energy to “high energy” bonds for later use by the body. In the process, acetate is attached biochemically to a dicarboxylic acid to produce citric acids—the tricarboxylic acid from which the cycle derives its name. The citric acid then goes through a number of biochemical steps to oxidize

the two carbons from acetate, and to regenerate the dicarboxylic acid to which the acetate was originally attached.

GEORGE A. BRAY

(SEE ALSO: *Energy; Nutrition*)

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