Chapter 1

Definitions of Health

Health is described in the Preamble to the Constitution of the World Health Organization (1948) as, “A state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.”2 This statement has been much criticized because of its vagueness, absence of measureable indicators, and the fact that it is almost entirely subjective.

Fortunately there are several acceptable alternative definitions, mostly varying with context. Discussions under the aegis of WHO and the Canadian Public Health Association in 1984 led to this one: “The extent to which an individual or a group is able to realize aspirations and satisfy needs, and to change or cope with the environ- ment; 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.”3 This implies some control over many determinants of health by individuals, families, and social groups and connects well with a simplified yet salient definition of public health as “society’s response to threats to the collective health of its citizens.”4

A definition that accords with the status of humans as one among myriads of inter- dependent life forms is: “A sustainable state of equilibrium or harmony between humans and their physical, biological and social environments that enables them to coexist indefinitely.”5 This does not necessarily imply that the environment or life-supporting ecosystems must remain unchanged; however, it implies that the environmental capacity to adapt or adjust to change is not adversely affected by human activities and changes in aspects of the environment and the life-supporting ecosystem do not adversely affect human health. In the Preface we discussed the global context of this book. Simply defined, “global health” may be considered as the health of all people globally within sustainable and healthy living (local and global) conditions.6

A Brief History of Public Health

To understand where we are and what we have yet to do to improve the human condition requires that we review and learn from the past successes—and mis- takes—that have punctuated human history. The history of public health is reflected in scientific advances that can be described through the accomplishments of indi- viduals, but these accomplishments took place within the social context of the time and reflected more than individual successes. Further, some of the methods used to achieve this scientific knowledge would today be considered unethical, for example using children as subjects in experiments without parental consent or the children’s assent. Such choices made in earlier times reflected a view of children as property, just as were women considered in many of the societies discussed in this chapter; orphans were given even less social recognition. Nonetheless, at various times in history there was considerable concern by some people about the role of social

deprivation in contributing to early death. Therefore we need to consider the histor- ical context in which physicians, nurses, and public health practitioners operate, as well as the social conditions that produce health and disease within the framework of the political and economic conditions of the day. The conditions of a given era, whether the present or the future (whatever it may bring), will always impact health and disease.

One way to consider the history of public health is as a series of paradigm shifts that accompany epochal insights and discoveries about ways to improve health or prevent debilitating and life-shortening disease. This approach works most of the time but lets us down when we recall that some of the most important discoveries occurred historically in haphazard sequence, only tenuously related, if related at all, to what was already known, and to prevailing beliefs and theories about what caused many of the most terrible diseases, as well as annoying but not lethal afflictions, of humankind. So for the most part, this account focuses on the great insights and discoveries, sometimes identified with names of those who made the discoveries, and illustrates the intermittent and accelerating pace of progress toward good health for all.

About a million years ago our hominid precursors discovered how to use fire to cook the meat they had hunted. They found that cooked meat tasted better, it didn’t go bad so quickly, and eating it was less likely to make them ill. Our understanding of nutrition (an important public health science), food hygiene, and the art of cooking has been improving ever since. In those prehistoric times, judging from archeologi- cal evidence, there is little doubt that humans evolved as spiritual beings in search of meaning for their lives and relationships with their environment. This trait lies at the core of the gradual development of belief systems about health and disease.

As long as 9000 to 10,000 years ago, people discovered how to grow crops and tame animals. With the advent of agriculture came permanent settlements, and at about the same time people discovered that grain could be used to make flour and then high-density carbohydrate foods. The settlements led to efforts to control the flow of water for agricultural needs (irrigation) and were evident in Mesopotamia and Egypt during the Neolithic period (5700–2800 bce).7 Sophisticated urban water systems date from a later period, in the Bronze Age (2800–1100 bce). Mohenjo-Daro, a major urban center of the Indus Civilization, developed one such system for water supply and sewage.8 Water came from over 700 wells and supplied domestic needs, a system of private baths, and a Great Bath for public use. Rainwater collection in cisterns was practiced in an area north of Jordan around the same time, and groundwater collection systems were developed in Persia.9 The system in Persia consisted of subterranean tunnels of connecting wells, using vertical shafts designed to collect and transport water from highland areas to low-lying farmland. This system is important because the technology was applied over extensive periods and the systems were so durable that some are still in use. About the same time advanced urban water technologies were developed in Greece and on the island of Crete. These included construction and use of aqueducts, cisterns, wells, fountains, bathrooms, and other sanitary facilities, which suggested lifestyle standards close to those of today. The Romans developed engineering skills and expanded these technologies for use on large-scale projects. But with the fall of the Roman Empire, water supply systems, sanitation, and public health declined in Europe. Europe reacquired high standards of water supply and sanitation only in the 19th century, largely as a result of efforts to improve human health and reduce the burden of disease resulting from unsanitary conditions and polluted drinking water.7

A secure food supply led to the first great population surge. Little settlements became villages, villages became towns, and towns grew into cities. Before long, civilizations with religions, laws, history, customs, traditions, and sciences arose in favorable settings: on lake shores, river estuaries, and fertile plains beside the great rivers in Egypt, the Middle East, India, and China. Our ancestors had begun their progress on the road to health, toward our present situation.

But it has been a long road, because as the human population increased, so did the variety and number of their diseases. Permanent human settlements transformed ecosystems, and the probability of respiratory and fecal-oral transmission of infec- tion rose as population density increased.

Ecological and evolutionary changes in microorganisms and vectors account for the origins of measles, influenza, malaria, smallpox, plague, and many other diseases. Microorganisms evolve rapidly because of their brief generation time and prolific reproduction rates. Many microbes that previously had lived in symbiosis with ani- mals began to invade humans, in which some of them became pathogenic. Some evolved complex life cycles that require more than one host species: humans and other mammals, humans and insects, humans and freshwater snails.

These evolutionary changes in host-parasite relationships occurred several millen- nia before we had written histories. Our oldest written records that have a bearing on health date back about 4000 years. The Code of Hammurabi (c. 2000 bce) contains ideas that indicate insights into the effects on health of diet and behavior.10 It also sug- gests rewards and punishments for physicians who did their jobs well or poorly.

Understanding that theories of disease have changed over time allows us to put into proper perspective historical approaches to disease prevention. Some cultures attribute diseases to malevolent supernatural forces, curses from enemies or sorcer- ers, or the anger of gods.8 The Classical Greeks conceived a theory of imbalance among four “humors,” loosely associated with personality types—choleric, phleg- matic, melancholic, and sanguine—and in the absence of contrary evidence, this

theory persisted for centuries.8 It led to empirical treatment regimens including poultices, blood-letting, and steam inhalations.8 These same personality types are described in psychology today as descriptors of types of people, and research contin- ues in relation to their contributions to mental and behavioral disorders.11 Another theory held that diseases were caused by miasma, emanations of malign vapors or fumes from rotting vegetation in swamps and marshes.8 This theory provided an explanation for some vector-borne diseases such as malaria and yellow fever but not other lethal epidemics, including typhus and plague.

Defining the Magnitude of the Problem

A census (discussed in chapter 5) is the single most important tool for the construc- tion of a population profile, whether for health or other application (e.g., educa- tion, economic development). The earliest census was probably carried out about 1500 bce in ancient Egypt. Censuses were used by the Romans to identify potential military recruits and eligibility for taxation, and they are conducted today at 10-year intervals in most countries for a much wider range of applications. Information pro- vided by a census allows public health professionals to compute rates of diseases in order to assess the relative magnitude of risk for populations and to determine what types of health care services may be needed in a community.

Information about the impact of diseases, especially of epidemics, from those ancient times has come down to us in myths and religious accounts of pestilences and plagues, although we can’t reliably identify the nature of any epidemics that afflicted ancient populations. The Greek historian Thucydides provided a meticu- lous description of the epidemic that struck the Athenians in the second year of the Peloponnesian War in 426 bce, from which the Athenians never fully recovered; but modern epidemiologists cannot identify the disease. The causal organisms of other ancient epidemics is similarly a mystery: almost 1000 years ago “sweating sick- ness” recurred in epidemics many times in mediaeval Europe then vanished, never to be seen again; we have no idea what caused this lethal disease. Even the exact nature of the Black Death, the terrible pandemic that devastated Asia Minor and all of Europe in 1347–1350 is debated. It was almost certainly bubonic and pneumonic plague but some scholars argue that it may have been anthrax or fulminating strep- tococcal infection, or a combination of all these.

A systematic approach to defining disease problems emerged in the more recent past. The earliest attempt to systematically classify diseases was attributed to French physician and botanist Francois Bossier de Lacroix (1706–1777), better known as Sauvages.12 Carl Linnaeus (1707–1778), the Swedish botanical taxonomist and a colleague of Sauvages, also wrote a treatise on disease classification: Generus Morborum.13 At the beginning of the 19th century, the classification of disease in most general use was one by William Cullen (1710–-1790) of Edinburgh, which was published under the title Synopsis Nosologie Methodicae.

The statistical study of diseases, however, began with John Graunt and his pub- lished work in Natural and Political Observations...upon the Bills of Mortality (London, 1662),14 which was the foundation for the science of vital statistics. John Graunt demonstrated the importance of gathering facts in a systematic manner to identify, characterize, count, and classify health conditions of public health impor- tance. The diagnostic categories in the Bills of Mortality tell us what was understood 400 years ago about the variety of human ailments and their causes. Progress in the use of medical statistics, as well as improved classifications and international unifor- mity, was made with the establishment of the General Registrar Office of England and Wales in 1837, under the direction of William Farr (1807–1883).12

The utility of a uniform classification of causes of death was recognized by the International Statistical Congress, and at the first meeting in Brussels in 1883, William Farr and Marc d’Espine of Geneva were asked to prepare an internation- ally applicable and uniform classification of causes of death. The resulting schemes were based on different principles. d’Espine classified diseases based on their nature (e.g., gouty, herpetic), whereas Farr classified diseases under five groups: epidemic, constitutional, local arranged according to anatomic site, developmental, and those resulting from violence.12 The general arrangement proposed by Farr was used as the basis for the International List of Causes of Death. In 1891 at the International Statistical Institute meeting in Vienna, Jacques Bertillon (1851–1922) was asked to prepare a classification of causes of death, which he presented at the International Statistical Institute meeting held in Chicago in 1893.12

The Bertillon Classification of Causes of Death was adopted by several countries and first used in North America by Jesus Monjaras in San Luis Potosi, Mexico.12, 15 In Ottawa, Canada in 1898, the American Public Health Association recommended adoption of the Bertillon Classification of Causes of Death by registrars in Canada, Mexico, and the United States and that the classification be revised every 10 years. The International List of Causes of Death, as Bertillon’s Classification of Causes of Death came to be called, was revised in 1900, 1910, and 1920 under the direction of Bertillon. The Fourth and Fifth revisions of the International List of Causes of Death were carried out as a coordinated effort with the Health Organization of the League of Nations and the International Statistical Institute.

At the Fifth International Conference for the Revision of the International List of Causes of Death in Paris in 1938, the group recognized the need to have a cor- responding list of diseases for morbidity statistics. The group recommended that

Table 1-1

ICD revisions and years covered

Revision Years Covered Revision

1st 1900–09 6th

2nd 1910–20 7th

3rd 1921–29 8th

4th 1930–38 9th 5th 1939–48 10th

the United States government continue to study the classification of causes of death when two or more causes were mentioned on the death certificate and to work with other countries to investigate this issue over the next ten years. In 1948 in Paris, the International Conference for the Sixth Revision of the International Lists of Diseases and Causes of Death adopted the classification system prepared by an expert com- mittee appointed by the World Health Organization in 1946.12 Table 1-1 illustrates the history of revisions, showing the years for which they were applied.

The 9th Revision of the International Classification of Diseases (ICD, launched 1979) developed supplementary classifications of Impairments and Handicaps and of Procedures in Medicine, amended coding rules for mortality and introduced rules for selection of a single cause for counting morbidity, changed definitions and rec- ommendations for statistics in the field of perinatal mortality, and encouraged coun- tries to work on multiple-condition coding.12 Between the 9th and 10th Revision of the ICD, it became clear that the established ten-year interval between revisions was too short, resulting in delayed implementation of the 10th Revision (endorsed by the World Health Assembly in 1990) in 1994. The 11th revision is underway and this process will continue until 2015.

The 10th Revision of the ICD is currently in use. The ICD has been the interna- tional standard diagnostic classification for general epidemiological studies, health planning and management, and clinical use. These include the analysis of the general health situation of population groups and monitoring of the incidence and preva- lence of diseases and other health problems in relation to other variables such as the characteristics and circumstances of the individuals affected, reimbursement, resource allocation, and quality and treatment guidelines.

Determining the Causes, Risks, Protective Factors, and Population Affected

Understanding the causes, risks, and protective factors for many diseases, and describ- ing the populations at risk of them, has been accomplished throughout history by the astute observations of many people. There is no clear separation between under- standing the causes of disease and implementing approaches to control or prevent them, since some of our understanding of causes comes from attempts to control disease, as does some of our understanding of health and what keeps people healthy. Therefore the next section deals with foundational work in understanding why disease occurs in specific locations among particular individuals.

Safe Environments

The role of the environment in health has been recognized since ancient times and in many cultures, as stated by the Greek physician Hippocrates (circa 400 bce) in his treatise on Airs, Waters, Places. The Egyptian Ibn Ridwan wrote at the turn of the first millennium on the adverse effects of the urban environment in the city of Cairo.16 European scholars followed, such as Agricola (1494–1555), whose treatise De Re Metallica documented the health hazards of mining and smelting,17 and his contemporary Paracelsus (1493–1541), who became recognized as founder of the modern science of toxicology. His dictum, “everything is toxic, depending on the dose,” is an important principle that underlies the concept of the now frequently used exposure-response curve.18

Of these contributions, we learned perhaps most from Paracelsus (his full name was Theophrastus Bombastus von Hohenheim), as we accept today that an associa- tion between an exposure and a biological outcome may be evidence for a causal rela- tionship and for defining exposure levels that may be cause for concern. Although many pollutants of concern today also occur freely in nature (e.g., nitrogen and sul- fur compounds, carbon monoxide and particulate matter), as their concentrations increase they become increasingly incompatible with physiological function and health (e.g., even oxygen is toxic at high concentrations). The study of such relation- ships (in animals and in humans) helps us prevent or alleviate such exposures and effects through the design of effective interventions.

Occupation and Disease

In Ancient Greece, a focus on aristocratic hygiene reflected, as well, the lack of concern about the health of workers (whether paid or slave) with little mention of occupational issues in historical medical literature. One reference to an illness of a miner can be found in Hippocratic writings.8 In Roman writings there is evidence of recognition of hazards associated with work from Pliny mentioning diseases prevalent among slaves, references to dangers of certain occupations in poetry, and diseases specific to sulfur workers, blacksmiths, and gold miners. Galen mentions that copper sulfate miners worked in a suffocating environment where the miners were naked during work because the fumes destroyed their clothing.8 Accounts of diseases among workers continued to focus on miners and expanded in the 16th century to include the health of sailors, with concerns about scurvy and typhus fever as the sea routes expanded to the Far East and the New World.8 Bernardino Ramazzini (1633–1714) was an Italian physician who published the first comprehen- sive treatise on occupation and diseases. He provided a foundation for occupational medicine when he reported his observations about the diseases for which workers in each occupation were vulnerable in De morbis artificum diatribe (Discourse on the Diseases of Workers, 1713).19 But not until the middle of the 18th century were further significant contributions to occupational welfare made. A few are described next.

Theories about Cause

For over a thousand years after Hippocrates, people were afflicted with ever-present respiratory and gastrointestinal infections that cut deeply into the lives of everyone, especially children, who often died before adolescence, carried off by measles, scar- let fever, diphtheria, bronchitis, croup, pneumonia, or gastroenteritis. From time to time this steady drain on long life and good health was punctuated by terrifying epidemics—smallpox, typhus, influenza, and, most terrible, the plague—the black death. The causes of these periodic devastations, the reasons they happened, were a mystery. Many believed they were God’s punishment for sin or the work of evil spir- its. Ideas about contagion were rudimentary, even though it had been dimly under- stood since antiquity that leprosy, perhaps the least contagious of all the infectious diseases, was associated with overcrowding and uncleanliness.

Understanding the number of means by which diseases are spread has allowed for the development of public health approaches to control transmission of diseases. The Italian priest-physician, Girolamo Fracastoro (1478–1553) concluded that disease could pass by intimate direct contact from one person to others because he observed the dramatic epidemic of syphilis that was manifestly spread by sexual intercourse.8 Fracastoro’s other concepts, droplet spread and spread by way of contaminated articles such as clothing and kitchen utensils, were published in De Contagione, in 1546 and provided a systematic view of the role of contagion in the rise and fall of communicable diseases; as such it serves as a landmark in the evolution of scientific theory of communicable diseases.20

The nature of diseases caused by creatures not visible to the naked eye was a mys- tery that began to clarify when Antoni van Leeuwenhoek (1632–1723), a Dutch linen draper and amateur lens grinder, perfected the first functioning microscopes. He gazed at and drew pictures of what he saw in drops of water, vaginal secretions,

feces, his own semen, and the structures of plants and insects. He lacked formal scholarly training but in a series of 165 letters to the Royal Society of London, he described accurately and in detail the microscopic creatures that he saw. He did not suggest that these tiny creatures were capable of causing diseases, but he is celebrated as the first of the “microbe hunters” who sought and identified pathogenic microor- ganisms responsible for many diseases.

Recognition that insects can transmit diseases to humans was another major shift in identifying means to control diseases. In an attempt to reduce mortality among cattle from Texas cattle fever in 1889, Fred Kilbourne, Cooper Curtice, both veterinarians, and bacteriologist Theobold Smith discovered the role of ticks as vectors in the disease.22 The discovery was the first time that insect vectors had been established in the transmission of disease and also established that adult ticks could infect nymphs. Understanding the life cycle of the tick provided a path to control by dipping the cattle to kill the ticks. Further, this discovery presaged the discoveries that led to understanding the role of insect transmission of trypano- somiasis of cattle by David Bruce (1895), malaria by Ronald Ross (1897), yellow fever by Walter Reed and his colleagues (1900), and typhus by Charles Nicolle (1909).22

Malaria was described by Hippocrates in the 4th century bc and is probably one of the most ancient diseases of humans.23 Today (chapters 2, 5, and 6), at the dawn of the third millennium, it remains a public health priority. About 3.3 billion people (almost half the world’s population) are at risk; endemic in 106 countries, in 2009 there were an estimated 225 million cases and some 800,000 people died, the vast majority of them children in sub-Saharan Africa and Asia.22 The word itself comes from Latin roots (literally “bad air”), and in its prescientific history it was among a number of conditions known as “swamp fever.” In those days people knew that swamps were not healthy places for human habitats, which in itself played a role in the location and sustainability of human settlements, and in efforts to reclaim such areas so as to make them more conducive for human habitation. However, the development of agriculture that resulted in clearing forests and vegetation, turning soil, and irrigating land created new collections of water and encouraged breeding of the anophopline mosquitoes in close proximity to human populations.24 The extent of malaria in a community typically depended on the location of homes relative to the fields, housing conditions, the presence of livestock, and also the breeding and feeding habits of the mosquitoes.22, 23 Only at the beginning of the 20th century, slightly more than 100 years ago, did people begin to systematically control the dis- ease through attacking its insect propagators.22 Over time agricultural communi- ties experienced less malaria because of the development of resistance to the disease, improved approaches to agriculture that reduced habitat for mosquitoes, such as draining swamps, improved housing, including windows and screens, better nutri- tion and improved overall health, and moving of livestock away from homes.23

Economic and social forces, in addition to ecological conditions, also shape the distribution of malaria globally. In the United States, Europe, and Great Britain, declines in malaria coincided with increased political and economic power.23 The growth of industrial capitalism and the spread of colonial rule, which incorporated local tropical economies into global markets and the concentration of land owner- ship at the expense of peasant farmers, also contributed to the persistence of malaria in areas where some of the population lived in inadequate housing and subsisted on poor diets.22, 23 Social, economic, and political disruptions, including human conflicts that result in human migrations from malaria endemic regions, also have provided opportunities for malaria to return to areas where it had previously disappeared.23

The control of malaria at the end of the 19th century and in the early part of the 20th century focused on defending people against the disease by reducing expo- sure to mosquito populations. In 1900 Italian malariologist Angelo Celli published “Malaria According to the New Researches” describing the epidemiology and pre- vention of malaria based on the discovery of the malarial parasite and the role of anopheline mosquitoes.23 He discussed the biological relationship between the par- asites, the mosquitoes, and humans but added the influence of economic develop- ment, politics, and social conditions on the geographic distribution of the disease.23

Develop, Implement, and Evaluate Prevention Programs

One of the oldest techniques for control of disease is quarantine, which began dur- ing the 14th century to protect coastal cities from plague epidemics. Ships arriving in Venice were required to be anchored for 40 days before landing. The word quar- antine is derived from this practice and the Italian words quaranta giorni, meaning “40 days.”25 Quarantine is still used today in various forms (chapter 6). However, as understanding of the causes of diseases progressed, other techniques for controlling diseases developed. Notable shifts in disease control based on evolving understand- ing of transmission and causes of disease are described next.

Sanitation, Hygiene, and Health

As populations in cities grew there was increasing need to have systems to deal with the disposal of animal and human waste. The respect Romans had for public and per- sonal hygiene was evident in the water supply and sewage systems they left behind and was also evident in the baths.7 During the Middle Ages bathhouses served the dual purpose of hygiene and pleasure and were licensed by municipalities.8 Ritual bathing was a part of ancient Hebrew culture, but routine bathing for hygienic purposes was practiced as well.26 Washing was a major feature of Islamic countries through medieval and Renaissance periods, and frequent washing was a religious requirement. In Japan the tradition of public bathing dates back at least to 552 ad and was linked to Buddhism, which taught that such hygiene purified the body and brought good luck.27

During the 15th century, when syphilis became a public health problem, com- munal bathing fell into disfavor in Europe, much as it did in the United States at the height of the current AIDS epidemic. There was a resurgence of interest in public bathing in the mid-1800s when sanitary conditions were exceptionally bad.8 Epidemics of cholera had plagued Great Britain, and the need for improved cir- cumstances had been highlighted in 1842 by an Inquiry into the Sanitary Conditions of the Labouring Classes. In his report, Sir Edwin Chadwick (1800–1890) argued that disease was directly related to living conditions and that there was a need for public health reform. The Public Baths and Wash Houses Act of 1846 subsequently allowed local parishes in the United Kingdom to raise money to provide public baths and laundries.8 The rapidly increasing urban population, often living in unsanitary conditions, resulted in viewing bathhouses as essential public services. This example serves to represent a number of shifts in health perspectives, from viewing bathing as a personal hygiene issue to recognizing it as a public health issue. It also illustrated the use of data to provide support for legislative action in the interest of people who do not have the economic resources to improve their living conditions.

Johann Peter Frank (1745–1821) studied medicine in Heidelberg and Strasburg, was a professor of medicine at Göttingen and Pavia, and taught in many other cen- ters of learning, ending his career in Vienna where he was professor of medicine at the Allegemeines Krankenhaus, the Vienna General Hospital. Early in his career he began writing System einer vollständigen medicinischen Polizey, his great work on ways to improve population health. This appeared in a series of nine volumes from 1779 to 1827. His work dealt with every then-known way to protect and preserve good health, including communal hygiene, personal hygiene and cleanliness, and a suggested set of laws and regulations to govern the control of conditions in lodging houses and inns, medical inspection of prostitutes, brothels, communal kitchens, and bathhouses.8

John Snow (1813–1858) was a London physician and a founder of modern epi- demiology. Snow’s work on cholera demonstrated fundamental intellectual steps that must be part of every epidemiological investigation.28, 29 He began with a logical analysis of the available facts, which established that cholera could not be caused by a “miasma” (emanations from rotting organic matter) as proposed in a theory popular a at that time, but must be caused by a transmissible agent, most probably in drinking water. He confirmed this with two epidemiological investigations in the great chol- era epidemic of 1854. He studied a severe localized epidemic in Soho, using analysis of descriptive epidemiological data and spot maps to demonstrate that the cause was polluted water from a pump in Broad Street. His investigation of the more wide- spread epidemic in South London involved an inquiry into the source of drinking water used in over 700 households. He compared the water source in houses where cholera had occurred with that in others where it had not. His analysis of informa- tion about cases and their sources of drinking water showed that the cause was water supplied by the Southwark and Vauxhall water company, which drew water from the Thames downriver, where many effluent discharges polluted the water (Table 1-2). Very few cases occurred in households supplied by the Lambeth company, which collected water upstream from London, where there was little or no pollution. John Snow reasoned that the cholera therefore must be caused by an agent in contami- nated water. This was a remarkable feat, 30 years before Robert Koch identified the cholera bacillus. Snow’s demonstration that polluted water can cause disease was another paradigm shift in understanding the ways in which diseases may be trans- mitted—and prevented.

Enhanced Immunity

Smallpox has been recognized as a disease for over 2000 years and was evident in Indian and Chinese writings around the 4th century ad.30 The disease appears to have spread from Africa to India by way of early Arab merchants.30 In the 9th cen- tury the Persian physician Al-Razi published an article on the epidemiology and clinical features of smallpox. From the time of the Crusades smallpox moved into Europe and then with the great European migrations that occurred from the 15th century onward, the disease was carried to Central, South, and North America,

Table 1-2

Cholera Mortality—London 4 week period July 9–August 5, 1854.1

Water Company Houses Supplied Deaths Rate per 10,000 Houses

Southwark and Vauxhall 40,046 286 71.4

Lambeth 26,107 14 5.4

All Others 287,345 277 9.6

South Africa, Australia, and some of the larger islands in the Pacific Ocean. The case fatality rate for smallpox ranged from 50% in the younger and older age groups to about 10% among those 5–14 years of age, but survivors were some- times severely scarred and, if smallpox vesicles affected the eyes, blind. Recovery conferred lifelong immunity for most people with the secondary attack rate less than one in a thousand. Smallpox was not a highly infectious agent and usually spread only to close family contacts, but the virus was resistant to environmen- tal conditions and could be spread through fomites, such as through the shar- ing or distribution of contaminated blankets. The occurrence was seasonal and spread favored low humidity and was inhibited by high humidity. No animal res- ervoir of the virus is known. The observation that infected people did not become infected again with smallpox led to experiments in China probably before the 10th century ce. Liquid obtained from a pustule was used to inoculate uninfected persons, who were in generally good health. Infection among these people was milder than natural smallpox and the practice of inoculation became widespread in parts of Asia. Lady Mary Wortley Montague, wife of the British ambassador to Constantinople, described this practice in a letter to a friend in 1717, and imported the idea to England on her return, following which the practice of inoculation became widespread there. The case fatality rate of inoculation was 2% or lower when the operator was skilled and lesions were less extensive than in natural small- pox. However, there was always illness and sometimes death involved, and the inoculation smallpox could cause outbreaks of severe natural smallpox in unpro- tected people, especially if more susceptible (e.g., underlying nutritional deficien- cies and skin disorders). By the time Edward Jenner (1749–1823) was a child, this practice had become popular among educated English families as a way to provide some protection against smallpox.

Jenner knew the popular belief 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 transmissible, it might be possible similarly to transmit cowpox. A smallpox outbreak in 1792 gave him an opportunity to confirm this notion. In 1796 he began a courageous and unprecedented experiment—one that would now be unethical, but that has had incalculable benefit for humankind.30 He inoculated a 9-year old boy with secretions from a cowpox lesion. In the following months until summer 1798 he inoculated others, mostly children, to a total of 23. All survived unharmed and none got smallpox. Jenner published An Inquiry into the Causes and Effects of the Variolae Vaccinae (1798)31—perhaps the most influential public health treatise of all time. The importance of Jenner’s work was immediately recognized, and although there were skeptics and hostile opponents, vaccination pro- grams began at once. Jennerian vaccination was widely adopted all over Europe and in North America. By 1802 the vaccine had been successfully transported to India and by 1804 to Spanish colonies in South America, the Philippines, and China.

No account of smallpox history can be considered complete without noting that it is the first disease to be eradicated. The application of scientific principles, includ- ing (in addition to the vaccine) the critical roles of surveillance, operational leader- ship, and management, to the eradication of smallpox is an epic of modern public health history, presented in chapter 2.

Nutrition

James Lind (1716–1794) was apprenticed to a surgeon when he was 15, and spent nine years as a naval surgeon, during which time he saw many cases of scurvy, a dis- ease that disabled and often killed sailors on long ocean voyages.8 Lind thought this disease might be caused by a diet lacking fresh fruit and vegetables. He conducted an experiment in which he gave different diets to each of several pairs of sailors. The sailors who received fresh oranges and lemons recovered rapidly from the scurvy, the others did not or got worse. Lind also initiated the first effective measures aimed at enhancing hygiene in the British navy, but he is best known for his work on scurvy, reported in A Treatise of the Scurvy (1753).32 Not only was this a very early clini- cal trial, it also documented the role of diet in health. However, understanding the biochemistry lagged far behind the findings of this trial.

The foundation for increased understanding of the physiology and pathology of nutrition was created in the 18th century.8 Justus von Liebig (1803–1873) formu- lated a unified concept of metabolic activity that influenced work on nutrition and nutrition chemistry. This was based on classifying nourishment requirements into proteins, carbohydrates, and fats according to the earlier work of Francois Magendie (1783–1855), who showed how proteins were used to build or repair and carbohy- drates and fats were used for fuel.8 Experimental evidence of the principle of conser- vation of energy for living organisms was provided by Max Rubner (1854–1932).8

In the United States, an American standard requirement of 3500 calories per man per day was set. Carroll D Wright (1840–1909) studied the protein, fat, carbohy- drate, and fuel value of a variety of foods.8 During the same period, William Atwater (1864–1907) observed that nutrition involved social and psychological consider- ations; in 1888 he called on social scientists to help explain why the poor considered foods with delicate appearance and of the highest price to be the most desirable. He and industrialist Edward Atkinson felt consumers should obtain dietary needs in the most economical manner; they advocated including food laboratories within the Agricultural Experiment Stations, which had been recently created by the US Congress. Appropriations were made to accomplish this in 1895.8 These laboratories were to investigate and report on the nutritional value used in the human food sup- ply and to suggest economical ways to obtain full, wholesome, and edible rations. Later in this chapter you will find a historical case study that illustrates the role of social and economic factors (Case Study—Joseph Goldberger and Pellagra).

Knowledge of history helps us appreciate how the adequacy of the science of the day, and misinterpretations of it, led to errors in thinking and decision making. This is a vital lesson for our own and future times. For example, the early scientific focus on fuel value of food and lack of understanding of vitamins and minerals resulted in condemning foods that are now considered essential. In particular, use of green vegetables, sweet corn, and canned tomatoes were considered poor food value due to small amounts of proteins, low energy value, or too expensive a source of protein. Oranges and green vegetables were viewed as appetizing but nonessential, ignoring the earlier work of Lind that established the fact that citrus fruits would prevent scurvy.8

While laboratory work supported the need for essential components in diet beyond proteins, fats, and carbohydrates, the work of naval surgeon T. K. Takaki (1858–1920) proved to be a breakthrough comparable to the earlier work of Lind. Takaki eradicated beriberi by adding fish, meat, and vegetables to the diet of the Japanese navy.33 Experimental studies that isolated essential ingredients to prevent deficiency diseases such as rickets and beriberi were not accepted as evidence for preventive approaches to reduce disease in humans until 1912.8

Casimir Funk (1884–1967) announced the isolation of a chemical substance he believed to be an amine and therefore named it “vitamine.”8 Subsequently the “e” was dropped when it became clear that the substances were not amines, and the search began to identify chemicals that are known now as vitamins. Work quickly progressed in isolating vitamins associated with specific diseases, leading to the convention of using letters of the alphabet to name the vitamins. But further work revealed that vitamins alone may not prevent specific diseases. William Huntley, a medical missionary in India, concluded that while diet may play a role in rickets, lack of exercise outside and lack of exposure to sunshine seemed to be main factors in the disease.8 T. A. Palm conducted a geographical survey of the distribution of rickets and found it was more prevalent where there was less sunshine.8 Cod liver oil was known to cure rickets, but the link that explained why sunshine and cod liver oil could be associated with onset and cure of rickets was not made until the discovery of vitamin D. Sunshine acts on fats in the body to produce vitamin D. Cod liver oil contains vitamin D.

The ancient Greeks and others used iodine-rich seaweed to combat goiter (thyroid gland enlargement associated with metabolic dysfunction). In 1811, Bernard Courtois (1777–1838) noted a violet vapor arising from burning seaweed ash, subsequently identified by Joseph Louis Gay-Lussac (1778–1850) as iodine, a new element. Swiss physician Jean-Francois Coindet (1774–1834), in 1813, hypothesized that traditional treatment of goiter with seaweed was effective because of its iodine content and suc- cessfully treated goitrous patients with iodine.34 Almost two decades later, in 1831, the French agricultural scientist Jean Baptiste Boussingault (1802–1887), then working in the Andes Mountains where goiter was endemic, was first to advocate prophylaxis with iodine-rich salt to prevent goiter and that iodine-rich salts could be used to treat it.35 Sixty-five years were to pass, however, before Eugen Baumann (1846–1896) in 1896 was to discover the presence of iodine in the thyroid gland, thus affording a scientific basis for the importance of this element in human physiology. In the years 1907–1909, David Marine, a young physician in Cleveland, Ohio, began using iodine-fortified salt to prevent goiter.36 His early effort to conduct a large-scale trial of iodized salt in Cleveland public schools was vetoed by another doctor who served as chairman of the school board. This delayed the determined Dr. Marine until 1916, when he teamed with O. P. Kimball to convince the Akron, Ohio school board to conduct the trial on elementary school girls (who had double the expected rate of goiter). The outcome was successful and the lead shifted to David Murray Cowie of the University of Michigan, who led a process resulting in collaboration with the salt producers association. By 1924 iodized salt was commonly available in the United States. Within a decade, over 90% of salt consumed in the US “goiter belt” was iodized. Goiter incidence plummeted (e.g., in Detroit from 9.7% to 1.4% within 6 years of using iodized salt).37 The rest of the iodine story is still a work in progress. Current efforts are focused on global elimination of brain damage caused by iodine deficiency (reviewed in chapter 6).

Prudent and Accessible Health Care Provision of improved obstetric care to reduce maternal mortality began with the establishment of wards for obstetrical patients in the 1700s in London. Mortality rates for mothers and infants declined after the establishment of the special wards until around 1810–1820, when they began to rise again. To address the high mater- nal mortality that was becoming more common, the Hungarian physician Ignaz Semmelweiss (1818–1865) tried to transform traditional but ineffective treatment methods, using logic and statistical analysis to demonstrate efficacy, or lack of it, when he compared treatment regimens. He believed in the germ theory of disease and was convinced that the terrible death rates from puerperal sepsis (childbed fever) must be caused by pathogens introduced into the raw uterine tissues by birth attendants who did not disinfect their hands. He carried out a meticulous mortality study, comparing his own wards, where he insisted that all birth attendants must cleanse their hands in a disinfectant solution of bleach, with other wards run by senior obstetricians where hand-washing was not routine. His belatedly published comparative statistical analyses of the death rates from puerperal sepsis in his own and other wards of the Allegemeines Krankenhaus are a model of how to conduct such investigations, but unfortunately no one in Vienna heeded him and young women continued to die of childbed fever for another generation. In Boston, Oliver Wendell Holmes (1809–1865) made similar observations in 1847 and published them, but he, too, was ignored. Their observations and recommendations were applied in modified form later when Joseph Lister (1827–1912) began using carbolic acid to kill pathogens in obstetrical labor and surgical operating rooms.8, 20

Medical science advanced rapidly in the second half of the 19th century, with the application of the exciting discoveries of bacteriology, which transformed public health. The great bacteriologists of the late 19th century identified many pathogenic bacteria, classified them, developed ways to cultivate them, and, most important, worked out ways to control their harmful effects by using sera, vaccines, and “magic bullets” such as the arsenical preparations that Paul Ehrlich (1854–1915) developed to treat syphilis. In the interest of brevity only the work of the great Louis Pasteur (1822–1895) is described here. This French chemist evolved into a bacteriologist, and he was a towering figure of 19th century bacteriology and preventive medicine. In 1854, having just been appointed professor of chemistry in Lille, he was invited to solve the problem of aberrant fermentation of beer that made it undrinkable. He showed that the problem was caused by bacteria that were killed by heat. In this way he invented the process for heat treatment to kill harmful bacteria, first applied to fermentation of beer, then to milk—the process known ever since as pasteurization, that has saved innumerable people, especially children, from an untimely death. He went on to study and solve many other bacteriological problems in industry and animal husbandry. He developed attenuated vaccines, first to prevent chicken chol- era, then in 1881 to control anthrax, which was a serious threat to livestock as well as an occasional human disease. Before this, in 1880, he began experiments on rabies, seeking a vaccine to control this disease, which without treatment is invariably fatal. Following the success of the anthrax vaccine he believed that an attenuated rabies vaccine could be made. This was almost 60 years before the virus was identified. He successfully tested his rabies vaccine in 1885 on a boy who had been bitten by a rabid dog. Pasteur became not just a national but an international celebrity.

Born in the same year as Louis Pasteur, the Austro-Hungarian monk Gregor Mendel (1822–1884) was another amateur scientist, a botanist. Experimenting with varieties of garden peas, he cross-pollinated them, observing and recording the results. Unfortunately he published his findings in an obscure journal, where they remained unnoticed for many years, but when they came to light 15 years after his death, Gregor Mendel was retroactively honored as the founder of the new science of genetics, which soon found many applications in clinical medicine with recognition of the fact that many inherited diseases were caused by genetic disorders. Almost 100 years after Mendel’s death, other discoveries with great public health relevance, includ- ing development of genetically modified sterile insect vectors of disease, genetically resistant strains of food crops, and applications of genetic engineering to limit and even prevent some recessive inherited disorders. Genetics and genomic sciences (see chapters 6 and 9) may well transform public health during the 21st century.

The Modern History of Public Health

It is common practice in writing histories to focus on what is already done, not what is still a work in progress. Hence, we have somewhat restricted the scope of the foregoing historical view to the work of early bacteriologists, nutritionists, patholo- gists, and public health interventionists. They represent an era that established the fact that microorganisms caused many diseases, that the germ theory was fact, not theory. But the same era ushered in awareness that it takes more than a “germ” to cause disease. For example, tuberculosis is caused by the tubercle bacillus acting in conjunction with poverty, ignorance, overcrowding, poor nutrition, adverse social and economic circumstances ,and other enabling and predisposing factors. Therefore prevention and control programs have to address much more than the direct agent involved in disease transmission to reduce the burden of disease (chapters 5 and 6).

Similarly, diarrheal diseases like cholera are caused by microorganisms, which get into the gut when ingested with contaminated water or food; in other words, they are more fundamentally caused by poor sanitary and hygienic practices. By late in the 19th century, many of these factors had been clarified. The stage was set for the health reforms of the “sanitary revolution,” the beginnings of a social safety net, pro- vision of immunizations, nutritional supplements for school children, prenatal care for pregnant women, and other essential public health functions that we address elsewhere in this book, some of which we may even take for granted.

Obviously more is needed than scientific discoveries. These must be applied, and this often requires changes in the established social and economic order. A different set of skills also is usually required to translate a scientific idea into an effective and efficient public health program. So other pioneers also appear on the road to health. They include journalists, creative writers, performing artists, cartoonists, adminis- trators, professional leaders, and politicians.

Indeed, this has always been so, as shown by the role of activists throughout his- tory, whether they be diarists such as John Evelyn (1620–1706), who alerted the English-speaking world with his 1661 submission to King Charles II and parliament: Fumifugium: the Inconvenience of the Aer and Smoake of London Dissipated, thereby bringing an important public issue to the attention of persons who set policy and wield power.41 Consider also enlightened administrators such as Edwin Chadwick (1800–1890), whose Inquiry into the Sanitary Conditions of the Labouring Classes ushered in major reforms (discussed earlier) to improve the health prospects of peo- ple living in urban slums.42 And do not put aside the likes of Florence Nightingale: best known for her work on sanitation and nursing conditions during the Crimean war, she was a pioneer in the graphical use of statistics to make a vivid case to author- ities that dire health situations required attention.43 A contemporary of William Farr, at the Fourth International Statistical Congress (London, 1860), she urged adoption of Farr’s classification of diseases for the tabulation of hospital morbidity in her paper Proposals for a uniform plan of hospital statistics.12

By now the reader will have observed that it is mostly men who are recognized in the history of public health, although this is rapidly changing as a result of positive shifts in the status of women, especially in western industrialized states during the 20th century. While it is beyond our scope to delve into the realm of women’s rights as such, as an exemplar of this trend, and also as a lens through which we can appreci- ate the historical gender imbalance, we focus now on Alice Hamilton (1869–1970), a founder of occupational medicine in the United States.

Hamilton was the first woman academician at Harvard Medical School and first woman to receive the Lasker Award in Public Health (1947). She was appointed direc- tor of the Occupational Disease Commission of Illinois in 1910 when it was created by the state governor. First of its kind in the world, the commission was responsible for several worker’s compensation laws in Illinois and introduced the novel notion that workers were entitled to compensation for health impairment and injuries sus- tained on the job. Hamilton was asked by the US Commissioner of Labor to repli- cate her research on a national level but was not offered a salary. She studied hazards posed by exposure to lead, arsenic, mercury, organic solvents, as well as radium (used in manufacturing watch dials). She remained in this unsalaried post from 1911 to 1921 when her program was cancelled after pro-business Republicans gained control of the White House. Hamilton was a supporter of peace and, along with Jane Addams and Emily Balch, traveled in Europe encouraging the end of World War I. The group became the Women’s International League for Peace and Freedom. In 1919, she was offered and accepted the post of assistant professor of Industrial Medicine at Harvard Medical School. There were three restrictions on her appointment: she was not allowed to use the Faculty Club, she had no access to football tickets, and she could not march in commencement processions. Harvard did not admit women students until World War II, therefore all her students were males. After 1925, she was also appointed to the faculty of the Harvard School of Public Health. She published Industrial Poisons in the United States (1925) and Industrial Toxicology (1934) and fol- lowing retirement in 1935, became a consultant to the Division of Labor Standards, US Labor Department. In 1943, she published an autobiography entitled Exploring the Dangerous Trades. Hamilton received many honorary degrees, distinctions, and awards, including a listing in Men of Science in 1944. It is noteworthy that her final academic rank was Assistant Professor Emeritus of Industrial Medicine, meaning despite her many accomplishments she was never promoted.44

This brings to a close our reconnaissance of public health history from prehis- toric to modern times as a window on its aims and methods. In so doing, we have

highlighted some of those who made observations and investigated them using the science of their times, and others who translated the resulting concepts of public health to the public at large and to enlightened politicians, who in turn are indis- pensable partners in a team that makes it possible for society to advance along the road to better health. The process continues in contemporary times with similarly dedicated individuals, whose work is now further enhanced by investigative journal- ism, TV documentaries, You-Tube videos, blogging, and other social media, all of which has a role.

Disciplines in Public Health

The field of public health comprises many disciplines. For example, for the purposes of accreditation of schools of public health in the United States five core knowl- edge categories are specified.45 Accreditation requirements vary across countries (reflecting their priorities), but for illustrative purposes it is useful to review these five disciplinary categories briefly here:

• Biostatistics—collection, storage, retrieval, analysis, and interpretation of health data; design and analysis of health-related surveys and experiments; and concepts and practice of statistical data analysis

• Epidemiology—distributions and determinants of disease, disabilities, and death in human populations; the characteristics and dynamics of human populations; and the natural history of disease and the biologic basis of health

• Environmental and occupational health sciences—environmental and occupational factors including biological, physical, and chemical factors that affect the health of a community and workers

• Health services administration—planning, organization, administration, management, evaluation, and policy analysis of health and public health programs

• Social and behavioral sciences—concepts and methods of social and behavioral sciences relevant to the identification and solution of public health problems

Biostatistics is the application of statistics to biological and medical problems and is considered a basic science of public health. Epidemiology is a basic science of pub- lic health and is the study of the distribution and determinants of health-related states or events in specific populations and the application of derived knowledge from studies to the control of health problems. Social and behavioral sciences include the application of health promotion and health education to protect the health of the population. Environmental health sciences are concerned with the whole range of environmental determinants of health (physical, chemical, biological, social, and behavioral) and with diseases of environmental and occupational origins. Health services administration encompasses the role of public health practitioners in moni- toring equitable distribution of services, ensuring policies are in place to support health and are working as intended, as well as evaluating costs related to public health programs and medical services.

For each of these disciplines there are a number of textbooks available. It is not our intention to replicate the detailed information already available in such texts, but rather to show the intersection of them in the context of general public health practice using an ecological perspective. Elsewhere in this book (chapters 2, 4, and 8) we explore the competencies required of public health practitioners and core public health functions at all levels from local to global.

Conclusion

Public health practice changes with new discoveries and the emergence of new dis- eases, as well as changes in social and economic circumstances and new ways of think- ing. Understanding the fundamental principles that are used in developing public health programs can be enhanced by reviewing the history of public health as we have briefly done in this chapter. For those who wish to explore this further, there are a number of sources (Box 1-1) that discuss in more detail these and other historical accomplishments in public health. The future of public health belongs to those who continue to build upon this proud history through their vision, insights, efforts, and actions to promote and improve the health of present and future generations.