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Chapter 1

A History of Public Health

Learning Objectives

Upon completion of this chapter, the student should be able to:

1. Identify major historical trends and concepts of public health, and their relationship to the individual and the community;
2. Address health issues within a historical perspective;
3. Apply experience from the past to address present and new health problems.

INTRODUCTION

The history of public health is derived from many historical ideas, trial and error, the development of basic sciences, technology, and epidemiology. In the modern era, James Lind's clinical trial of various dietary treatments of British sailors with scurvy in 1756 and Edward Jenner's 1796 discovery that cowpox vaccination prevents smallpox have modern-day applications as the science and practices of nutrition and immunization are crucial influences on health among the populations of developing and developed countries.

History provides a perspective to develop an understanding of health problems of communities and how to cope with them. We visualize through the eyes of the past how societies conceptualized and dealt with disease. All societies must face the realities of disease and death, and develop concepts and methods to manage them. These strategies evolved from scientific knowledge and trial and error, but are associated with cultural and societal conditions, beliefs and practices that are important in determining health status and curative and preventive interventions to improve health.

The history of public health is a story of the search for effective means of securing health and preventing disease in the population. Epidemic and endemic infectious disease stimulated thought and innovation in disease prevention on a pragmatic basis, often before the causation was established scientifically. The prevention of disease in populations revolves around defining diseases, measuring their occurrence, and seeking effective interventions.

Public health evolved through trial and error and with expanding scientific medical knowledge, at times controversial, often stimulated by war and natural disasters. The need for organized health protection grew as part of the development of community life, and in particular, urbanization and social reforms. Religious and societal beliefs influenced approaches to explaining and attempting to control communicable disease by sanitation, town planning, and provision of medical care. Religions and social systems have also viewed scientific investigation and the spread of knowledge as threatening, resulting in inhibition of developments in public health, with modern examples of opposition to birth control, immunization, and food fortification.

Scientific controversies, such as the contagionist and anticontagionist disputations during the nineteenth century and opposition to social reform movements, were ferocious and resulted in long delays in adoption of the available scientific knowledge. Such debates continued into the twentieth and still continue into the twenty-first century with a melding of methodologies proven to be interactive incorporating the social sciences, health promotion, and translational sciences bringing the best available evidence of science and practice together for greater effectiveness in policy development for individual and population health practices.

Modern society in high, medium and low income countries still faces the ancient scourges of communicable diseases, but also the modern pandemics of cardiovascular disease, cancers, mental illness, and trauma. The emergence of acquired immunodeficiency syndrome (AIDS), severe acute respiratory syndrome (SARS), avian influenza, and drug-resistant microorganisms forces us to seek new ways of preventing their potentially serious consequences to society. Threats to health in a world facing severe climate and ecological change pose harsh and potentially devastating consequences for society.

The evolution of public health is a continuing process; pathogens change, as do the environment and the host. In order to face the challenges ahead, it is important to have an understanding of the past. Although there is much in this age that is new, many of the current debates and arguments in public health are echoes of the past. Experience from the

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past is a vital tool in the formulation of health policy. An understanding of the evolution and context of those challenges and innovative ideas can help us to navigate the public health world of today and the future.

PREHISTORIC SOCIETIES

The Paleolithic Age is the earliest stage of human development where organized societal structures are known to have existed. These social structures consisted of people living in bands which survived by hunting and gathering food. There is evidence of the use of fire going back some 230,000 years, and increasing sophistication of stone tools, jewelry, cave paintings, and religious symbols during this period. Modern humans evolved from *Homo sapiens*, probably originating in Africa and the Middle East about 90,000 years ago, and appearing in Europe during the Ice Age period (40,000–35,000 BCE). During this time, humanity spread over all major land masses following the retreating glaciers of the last Ice Age at 11,000–8000 BCE.

A Mesolithic Age or transitional phase of evolution from hunter–gatherer societies into the Neolithic Age of food-raising societies occurred during different periods in various parts of the world, first in the Middle East from 9000 to 8000 BCE onward, reaching Europe about 3000 BCE. The change from hunting, fishing, and gathering modes of survival to agriculture was first evidenced by domestication of animals and then the growing of grain and root crops, and vegetables. Associated skills, including food storage and cooking, pottery, basket weaving, ovens, smelting, and trade, led to improved survival techniques and population growth gradually spread throughout the world.

Communal habitation became essential to adaptation to changing environmental conditions and hazards, allowing population growth and geographic expansion. At each stage of human biological, technological, and social evolution, humans coexisted with diseases associated with the environment and living patterns, seeking herbal and mystical treatments for the maladies. People called on the supernatural and magic to appease these forces and prevent plagues, famines, and disasters. Shamans or witch doctors attempted to remove harm by magical or religious practices along with herbal treatments acquired through trial and error. Life expectancy in prehistoric times was 25–30 years, with men living longer than women, probably due to malnutrition and maternity-related causes.

As human society evolved, technologically, culturally, and biologically, nutrition and exposure to communicable and non-infectious disease changed. Social organization led to innovations in tools and skills for hunting, clothing, shelter, fire for warmth and cooking, food for use and storage, burial of the dead, and removal of waste products from living areas. Adaptation of human society to the environment has been and remains a central issue in population health. This is a recurrent theme in the development of public health, with resilience in facing daunting new challenges of adaptation and balance with the environment.

THE ANCIENT WORLD

The development of agriculture served growing populations unable to survive solely on hunting, gathering, crafts and trading, stimulating the organization of more complex societies able to share production and irrigation systems, in response to disease, malnutrition, and stunted growth. Division of labor, trade, commerce, and government was associated with the development of urban societies. Population growth and communal living led to improved standards of living but also created new health hazards, including the spread of diseases. As in our time, these challenges required community action to prevent disease and promote survival.

In the first civilizations, mystical beliefs, divination, and shamanism coexisted with practical knowledge of herbal medicines, midwifery, management of wounds or broken bones, and trepanation to remove “evil spirits”. All were part of communal life with variations in historical and cultural development. The advent of writing led to medical documentation. Requirements of medical conduct were spelled out as part of the general legal code of Hammurabi in Mesopotamia (*c.* 1700 BCE). This code included regulation of physician fees, with punishment for treatment failure, which set a legal basis for the subsequent secular practice of medicine. Many of the main traditions of medicine were based on magic or derived from religion. Medical practice was often based on belief in the supernatural, and healers were believed to have a religious calling. Training of medical practitioners, regulation of their practice, and ethical standards evolved in a number of ancient societies. In general, physicians were regulated by specific schools that acted as trade guilds, often with many competing schools based on differing gods, methods, and mystical beliefs.

Some cultures equated cleanliness with godliness and associated hygiene with religious beliefs and practices. Chinese, Egyptian, Hebrew, Indian, and Incan societies all provided sanitary amenities as part of the religious belief system and took measures to provide water, sewerage, and drainage systems. These measures allowed for successful urban settlement and reinforced the beliefs upon which such practices were based. Technical achievements in providing hygiene at the community level slowly coevolved with urban society.

Chinese practice in the twenty-first to eleventh centuries BCE included digging wells for drinking water; from the eleventh to the seventh centuries this included the use of protective measures for drinking water and destruction of rats and rabid animals. In the second century BCE, Chinese communities were using sewers and latrines. The basic concept of health was that of countervailing forces between the principles of yin (female) and yang (male), with an emphasis on a balanced lifestyle. Medical care emphasized diet, herbal medicine, hygiene, massage, and acupuncture.

Ancient cities in India were planned with building codes, street paving, and covered sewer drains built of bricks and mortar. Indian medicine originated in herbalism associated with gods. Between 800 and 200 BCE, Ayurvedic medicine developed, and with it, medical schools and "public hospitals". The ancient Indian way of medical practice, Ayurveda, is the Sanskrit translation of "knowledge of life". Primarily originating in the Indus Valley, the golden age of ancient Indian medicine began approximately 800 BCE. Personal hygiene, sanitation, and water supply engineering were emphasized in the laws of Manu. Pioneering physicians, supported by Buddhist kings, developed the use of drugs and surgery, and established schools of medicine and public hospitals as part of state medicine. Indian medicine played a leading role throughout Asia between 800 BCE and 400 CE, when major texts on medicine and surgery were written. Among the most valued pieces of ancient Indian writings are those created by Sushruta, a surgeon, and Charaka, a physician, both prominent teachers who ran prestigious schools of medicine. These writings contribute to validating ancient India's medical history. According to some historians, the teachings of Sushruta and Charaka were passed along to the Romans and Greeks. Despite these advanced medical teachings, with the Mogul invasion of 600 CE, state support declined, and with it, Indian medicine.

In addition to the ancient Indian medical texts, there is evidence of several ancient Egyptian texts, dating from the years around 1900 BCE. The Kahoun Papyrus, from 1950 BCE, the most ancient scroll, includes three parts: human medicine, veterinary science, and mathematics.

Ancient Egyptian intensive agriculture and irrigation practices were associated with widespread parasitic disease. The cities had stone masonry gutters for drainage, and personal hygiene was highly emphasized. Egyptian medicine developed surgical skills and organization of medical care, including specialization and training that greatly influenced the development of Greek medicine. The Ebers Papyrus, written 3400 years ago, gives an extensive description of Egyptian medical science, including the isolation of infected surgical patients. It is recognized as the most extensive and significant of all the known papyri, given the physiological knowledge uncovered. While the first section of the Ebers Papyrus revolves around divine origin and the strength of magic, the latter portions discuss the treatment of medical conditions including digestive diseases, eye diseases, and skin problems. Fractures and painful limbs are also described. The papyrus includes a treatise on the heart and vessels, standing out as only one of many covering anatomy and physiology. The last portion of this important papyrus focuses on surgery, in particular, tumors and abscesses.

The Hebrew Mosaic law of the five Books of Moses (*c.* 1000 BCE) stressed prevention of disease through regulation of personal and community hygiene, reproductive and maternal health, isolation of lepers and other "unclean conditions", and family and personal sexual conduct as part of religious practice. It also laid a basis for medical and public health jurisprudence. Personal and community responsibility for health included a mandatory day of rest, limits on slavery and guarantees of the rights of slaves and workers, protection of water supplies, sanitation of communities and camps, waste disposal, and food protection, all codified in detailed religious obligations. Food regulation prevented use of diseased or unclean animals, and prescribed methods of slaughter improved the possibility of preservation of the meat. While there was an element of viewing illness as a punishment for sin, there was also an ethical and social stress on the value of human life with an obligation to seek and provide care. The Talmudic interpretation of biblical law is the concept of sanctity of human life (*Pikuah Nefesh*); the saving of a single human life was considered "as if one saved the whole world", which has been given overriding religious and social roles in community life. A second principle from this source is improving the quality of life on Earth (*Tikkun Olam*). In this tradition, there is an ethical imperative to achieve a better earthly life for all. The Mosaic Law, which forms the basis for Judaism, Christianity, and Islam, codified health behaviors for the individual and for society. These found secular versions in Humanism over recent centuries, which have continued into the modern era as basic concepts in societal values and in practical application in environmental and social hygiene.

In Cretan and Minoan societies, climate and environment were recognized as playing a role in disease causation. Malaria was related to swampy and lowland areas, and prevention involved planning the location of settlements. Ancient Greece placed high emphasis on healthful living habits in terms of personal hygiene, nutrition, physical fitness, and community sanitation. Hippocrates articulated the clinical methods of observation and documentation and a code of ethics of medical practice. He articulated the relationship between disease patterns and the natural environment (air, water, and places), which dominated epidemiological thinking until the nineteenth century. Preservation of health was seen as a balance of forces: exercise and rest, nutrition and excretion, and recognizing the importance of age and sex variables in health needs. Disease was seen as having inevitable natural causation, and medical care was valued, with the city-states providing free medical services for the poor and for slaves. City officials were appointed to look after public drains and water supply, providing organized sanitary and public health services. Hippocrates gave medicine a rudimentary, scientific, and ethical spirit which lasts to the present time.

Ancient Rome adopted much of the Greek philosophy and experience concerning health matters, with high levels of achievement and new innovations in the development of public health. The Romans were extremely skilled in engineering of water supply, sewerage and drainage systems, public baths and latrines, town planning, sanitation of military encampments, and medical care. Roman law also regulated businesses and medical practice. The influence of the Roman Empire resulted in the transfer of these ideas throughout much of Europe and the Middle East. Rome itself had access to clean water via 10 aqueducts supplying ample water for the citizens. Rome also built public drains. By the early first century BCE, the aqueducts made available 600–900 liters per person per day of household water from mountains. Marshlands were drained to reduce endemic malaria. Public baths were built to serve the poor, and fountains were built in private homes for the wealthy. Streets were paved, and organized garbage disposal served the cities.

Roman military medicine included well-designed sanitation systems, food supplies, and surgical services. Roman medicine, based on mystical beliefs and religious rites, with slaves as physicians, developed partly from Greek physicians who brought their skills and knowledge to Rome after the destruction of Corinth in 146 BCE. Training as apprentices, Roman physicians achieved a highly respected role in society. Hospitals and municipal doctors were employed by Roman cities to provide free care to the poor and the slaves, but physicians also engaged in private practice, mostly on retainers to families. Occupational health was described with measures to reduce known risks such as lead exposure, particularly in mining. Commercial weights and measures were standardized and supervised. Rome made important contributions to the public health tradition of sanitation, urban planning, and organized medical care. Galen, Rome's leading physician, perpetuated the fame of Hippocrates through his medical writings, basing medical assessment on the four humors (sanguine, phlegmatic, choleric, and melancholic). These ideas dominated European medical thought for nearly 1500 years until the advent of modern science.

THE EARLY MEDIEVAL PERIOD (FIFTH TO TENTH CENTURIES CE)

The Roman Empire disappeared as an organized entity following the sacking of Rome in the fifth century CE. The eastern empire survived in Constantinople, with a highly centralized government. Later conquered by the Muslims, it provided continuity for Greek and Roman teachings in health. The western empire integrated Christian and pagan cultures, which viewed disease as punishment for sin. Possession by the devil and witchcraft were accepted as causes of disease. Prayer, penitence, and exorcising witches were accepted means of dealing with health problems. The ensuing period of history was dominated in health, as in all other spheres of human life, by the Christian doctrine institutionalized by the Church. The secular political structure was dominated by feudalism and serfdom, associated with a strong military landowning class in Europe.

Church interpretation of disease was related to original or acquired sin. Humanity's destiny was to suffer on Earth and hope for a better life in heaven. The appropriate intervention in this philosophy was to provide comfort and care through the charity of church institutions. The idea of prevention was seen as interfering with the will of God. Monasteries with well-developed sanitary facilities were located on major travel routes and provided hospices for travelers. The monasteries were the sole centers of learning and for medical care. They emphasized the tradition of care of the sick and the poor as a charitable duty of the righteous and initiated hospitals. These institutions provided care and support for the poor, and made efforts to cope with epidemic and endemic disease.

Most physicians were monks guided by Church doctrine and ethics. Medical scholarship was based primarily on the teachings of Galen (131 CE), sustained in Muslim centers of medical learning and later brought to Europe with the return of the Crusades, whose teachings provided the basis of medical teaching until the fifteenth century. Education and knowledge were under clerical dominance. Scholasticism, or the study of what was already written, stultified the development of descriptive or experimental science. The largely rural population of the European medieval world lived with poor nutrition, education, housing, sanitary, and hygienic conditions. Endemic and epidemic diseases resulted in high infant, child, and adult mortality. Commonly, 75 percent of newborns died before the age of five. Maternal mortality was high. Leprosy, malaria, measles, and smallpox were established endemic diseases, along with many other less well-documented infectious diseases.

Between the seventh and tenth centuries, outside the area of Church domination, Muslim medicine flourished under Islamic rule primarily in Persia, Central Asia and later Baghdad and Cairo. Famous physicians, including the Persian Rhazes (850–*c.* 932) and the outstanding Islamic Bukhara-born philosopher and physician Ibn Sinna (Avicenna, 980–1037), translated and adapted ancient Greek and Mosaic teachings, adding clinical skills developed in medical academies and hospitals. Piped water supplies were documented in Cairo in the ninth century. Great medical academies were established, including one in Muslim-conquered Spain at Cordova. The Cordova Medical Academy was a principal center for medical knowledge and scholarship prior to the expulsion of Muslims and Jews from Spain in 1492, and the Inquisition. The Academy helped to stimulate European medical thinking and the beginnings of western medical science in anatomy, physiology, and descriptive clinical medicine.

THE LATE MEDIEVAL PERIOD (ELEVENTH TO FIFTEENTH CENTURIES)

In the later feudal period, ancient Hebraic and Greco-Roman concepts of health were preserved and flourished in the Muslim Empire. The twelfth-century Jewish rabbi–philosopher–physician Moses Maimonides (Rambam), who trained in Cordova and was expelled to Cairo, helped to synthesize Roman, Greek, and Arabic medicine with Mosaic concepts of communicable disease isolation and sanitation.

Monastery hospitals were established between the eighth and twelfth centuries to provide charity and care to ease the suffering of the sick and dying. Monasteries provided centers of literacy, medical care, and the ethic of caring for the sick patient as an act of charity. The monastery hospitals (described in eleventh-century Russia) were gradually supplanted by municipal, voluntary, and guild hospitals developed in the twelfth to sixteenth centuries. By the fifteenth century, Britain had 750 hospitals. Medical care insurance was provided by guilds to its members and their families. Hospitals employed doctors, and the wealthy had access to private doctors.

In the early Middle Ages, most physicians in Europe were monks, and the medical literature was compiled from ancient sources. In 1131 and 1215, Papal rulings increasingly restricted clerics from doing medical work, thus promoting secular medical practice. In 1224, Emperor Frederick II of Sicily published decrees regulating medical practice, establishing licensing requirements: medical training (3 years of philosophy, 5 years of medicine), 1 year of supervised practice, then examination followed by licensure. Similar ordinances were published in Spain in 1238 and in Germany in 1347.

The Crusades (1096–1270 CE) exposed Europe to Arabic medical concepts, as well as leprosy. The Hospitallers, a religious order of knights, developed hospitals in Rhodes, Malta, and London to serve returning pilgrims and crusaders. The Muslim world had hospitals, such as Al Mansour in Cairo, available to all as a service provided by the governate. Increasing contact between the Crusaders and the Muslims through war, conquest, cohabitation, and trade introduced Arabic culture and diseases, and revised ancient knowledge of medicine and hygiene.

Leprosy became a widespread disease in Europe, particularly among the poor, during the early Middle Ages, but the problem was severely accentuated during and following the Crusades, reaching a peak during the thirteenth to fourteenth centuries. Isolation in leprosaria was common in Europe. In France alone, there were 2000 leprosaria in the fourteenth century. This disease has caused massive suffering and although leprosy still exists in tropical countries it is gradually disappearing globally. The development of modern antimicrobials has cured millions of leprosy (Hansen's disease) cases; with early case finding and multidrug therapy, this disease and its disabling and deadly effects are now largely a matter of history.

As rural serfdom and feudalism declined in Western Europe, cities developed with crowded and unsanitary conditions. Towns and cities were allowed to develop in Europe with royal charters for self-government, primarily located at the sites of former Roman settlements and at river crossings related to trade routes. The Church provided stability in society, but repressed new ideas and imposed its authority particularly via the Inquisition. Established by Pope Gregory in 1231, the Inquisition was renewed and intensified, especially in Spain in 1478 by Pope Sixtus IV, to exterminate heretics, Jews, and anyone seen as a challenge to the accepted Papal dogmas.

Universities established under royal charters in Paris, Bologna, Padua, Naples, Oxford, Cambridge, and others provided a haven for scholarship outside the realm of the Church. In the twelfth and thirteenth centuries there was a burst of creativity in Europe, with inventions including the compass, the mechanical clock, and the loom, with a surge in use of the waterwheel and the windmill. Physical and intellectual exploration opened up with the travels of Marco Polo and the writings of Thomas Aquinas, Roger Bacon, and Dante. Trade, commerce, and travel flourished.

Medical education was widespread in institutions of higher education in many parts of Muslim and other societies. Medical schools in Europe evolved in Salerno, Italy, in the tenth century and in universities throughout Europe in the eleventh to fifteenth centuries: in Paris (1110), Bologna (1158), Oxford (1167), Montpellier (1181), Cambridge (1209), Padua (1222), Toulouse (1233), Seville (1254), Prague (1348), Krakow (1364), Vienna (1365), Heidelberg (1386), Glasgow (1451), Basel (1460), and Copenhagen (1478). By the end of the fifteenth century there were around 80 universities in Europe. Printed books opened a new potential for secular as well as religious education. Physicians, recruited from the new middle class, were trained in scholastic traditions based on translations of Arabic literature and the ancient Roman and Greek texts, mainly Aristotle, Hippocrates, and Galen, but with some more current texts, mainly written by Arab and Jewish physicians.

Growth exacerbated public health problems in the newly walled commercial and industrial towns, leading to eventual emergencies which demanded solutions. Rapidly growing medieval towns lacked systems of sewers or water pipes. Garbage and human waste were thrown into the streets. Houses were made of wood, mud, and dung. Rats, lice, and fleas flourished in the rushes or straw used on the clay floors of people's houses.

Crowding, poor nutrition and sanitation, lack of adequate water sources and drainage, unpaved streets, keeping of animals in towns, and lack of organized waste disposal created conditions for widespread infectious diseases.

Municipalities developed protected water sites (cisterns, wells, and springs) and public fountains with municipal regulation and supervision. Piped community water supplies were developed in Dublin, Basel, and Bruges (Belgium) in the thirteenth century. Between the eleventh and fifteenth centuries, Novgorod in Russia used clay and wooden pipes for water supplies, and municipal bath houses were available.

Medical care was still largely oriented towards symptom relief, with few curative resources to draw upon. Traditional folk medicine survived especially in rural areas, but was suppressed by the Church as witchcraft. Physicians provided services for those able to pay, but medical knowledge was a mix of pragmatism and mysticism, and there was a sheer lack of scientific knowledge. Conditions were ripe for vast epidemics of smallpox, cholera, measles, and other epidemic diseases, fanned by the debased conditions of life and chronic banditry, warfare, and famines raging throughout Europe, such as during the English invasion of France during the Hundred Years War (1337–1453).

The Black Death, mainly pneumonic and bubonic plague due to *Yersinia pestis* infection transmitted by fleas on rodents, was brought from the steppes of Central Asia to Europe with the Mongol invasions, and then transmitted via extensive trade routes throughout Europe by sea and overland. The Black Death was also introduced to China with Mongol invasions, bringing tremendous mortality, halving the population of China between 1200 and 1400 CE. Between the eleventh and thirteenth centuries, during the Mongol–Tatar conquests, many widespread epidemics, including plague, were recorded in Rus (now Russia). The plagues traveled rapidly with armies and caravan traders, and later by ship as world trade expanded in the fourteenth to fifteenth centuries (Box 1.1). The plague ravaged most of Europe between 1346 and 1350, killing between 24 and 50 million people, approximately one-third of the population, and leaving vast areas of Europe sparsely populated. Despite local efforts to prevent disease by quarantine and isolation of the sick, the disease devastated whole communities.

Fear of a new and deadly disease, lack of knowledge, speculation, and rumor led to countermeasures which often exacerbated the spread of epidemics (as seen in the last decades of the twentieth century, and in the twenty-first century, with SARS and pandemic H1N1 influenza). In Western Europe, public and religious ceremonies and burials were promoted by religious and civil authorities, which increased contact with infected people. The misconception that cats were the cause of plague led to their slaughter; however, they could have helped to stem the tide of disease brought by rats and their fleas to humans. Hygienic practices limited the spread of plague in Jewish ghettos, leading to the Jews being blamed for the plague's spread, and widespread massacres, especially in Germany and Central Europe.

Seaport cities in the fourteenth century began to apply the biblical injunction to separate lepers by keeping ships coming from places with the plague waiting in remote parts of the harbor, initially for 30 days (*treutina*), then for 40 days (*quarantina*) (Ragusa in 1465, and Venice in 1485), establishing the public health act of quarantine as a government measure, which on a pragmatic basis was found to reduce the chance of entry of the plague. Towns along major overland trading routes in Russia took measures to restrict movement in homes, streets, and entire towns during epidemics. In sixteenth-century Russia, Novgorod banned public funerals during plague epidemics, and in the seventeenth century, Czar Boris Godunov banned trade, prohibited religious and other ceremonies, and instituted quarantine-type measures. All over Europe, municipal efforts to enforce isolation broke down as crowds gathered and were uncontrolled by inadequate police forces and public health. In 1630, all officers of the Board of Health of Florence, Italy, were excommunicated because of efforts to prevent spread of the contagion by isolation of cases, thereby interfering with religious ceremonies to assuage God's wrath through appeals to divine providence.

The plague continued to strike, with epidemics in London in 1665, Marseille in 1720, Moscow in 1771, and Russia, India, and the Middle East through the nineteenth

BOX 1.1 "This is the End of the World": The Black Death

"Rumors of a terrible plague supposedly arising in China and spreading through Tartary (Central Asia) to India and Persia, Mesopotamia, Syria, Egypt and all of Asia Minor had reached Europe in 1346. They told of a death toll so devastating that all of India was said to be depopulated, whole territories covered by dead bodies, other areas with no one left alive. As added up by Pope Clement VI at Avignon, the total of reported dead reached 23,840,000. In the absence of a concept of contagion, no serious alarm was felt in Europe until the trading ships brought their black burden of pestilence into Messina while other infected ships from the Levant carried it to Genoa and Venice. By January 1348 it penetrated France via Marseille, and North Africa via Tunis. Ship-borne along coasts and navigable rivers, it spread westward from Marseille through the ports of Languedoc to Spain and northward up the Rhone to Avignon, where it arrived in March. It reached Narbonne, Montpellier, Carcassone, and Toulouse between February and May, and at the same time in Italy spread to Rome and Florence and their hinterlands. Between June and August it reached Bordeaux, Lyon, and Paris, spread to Burgundy and Normandy into southern England. From Italy during the summer it crossed the Alps into Switzerland and reached eastward to Hungary. In a given area the plague accomplished its kill within four to six months and then faded, except in the larger cities, where, rooting into the close-quartered population, it abated during the winter, only to appear in spring and rage for another six months."

Source: *Tuchman BW. A distant mirror: the calamitous fourteenth century. New York: Alfred A. Knopf; 1978.*

century. Furthermore, the plague continued into the twentieth century with epidemics in Australia (1900), China (1911), Egypt (1940), and India (1995). (See *The Plague*, a historical novel by Albert Camus.) The disease is endemic in rodents in many parts of the world, including the USA; however, modern sanitation, pest control, and antibiotic treatment have greatly reduced the potential for large-scale plague epidemics.

Guilds organized to protect the economic interests of traders and skilled craftsmen, and limited competition by regulating training and entry requirements of new members. They also placed high priority on mutual benefit funds to provide financial assistance and other benefits for illness, death, widows and orphans, and medical care, as well as burial benefits for members and their families. The guilds wielded strong political power during the late Middle Ages. These brotherhoods provided a tradition later expressed in the mutual benefit or friendly societies, sick funds, and insurance for health care based on employment groups. This tradition has continued in western countries, where labor unions are among the leading advocates for the health of workers and their families.

The fourteenth century saw a devastation of the population of Europe by plague, wars, and the breakdown of feudal society. It also set the stage for the agricultural revolution and later the industrial revolution. The period following the Black Death was innovative and dynamic. Shortages of farm laborers led to innovations in agriculture. Enclosures of common grazing land reduced the spread of disease among animals, increased field crop productivity, and improved sheep farming, leading to the development of the wool and textile industries and the search for energy sources, industrialization, and international markets.

THE RENAISSANCE (1400–1600s)

Commerce, industry, trade, merchant fleets, and voyages of discovery to seek new markets led to the development of a moneyed middle class and wealthy cities. During this period, mines, foundries, and industrial plants flourished, creating new goods and wealth. Partly as a result of the trade generated and the increased movement of goods and people, vast epidemics of syphilis, typhus, smallpox, measles, and the plague continued to spread across Europe. Malaria was still widespread throughout Europe. Rickets, scarlet fever, and scurvy, particularly among sailors, were rampant. Pollution and crowding in industrial areas resulted in centuries-long epidemics of environmental disease, particularly among the urban working class.

A virulent form of syphilis, allegedly brought back from America by the crews of Columbus, spread rapidly throughout Europe between 1495 and 1503, when it was first described by Girolamo Fracastoro (1478–1553). Control measures tried in various cities included examination and registration of prostitutes, closure of communal bath houses, isolation in special hospitals, reporting of disease, and expulsion of sick prostitutes or strangers. The disease gradually decreased in virulence, but it lingers as a diminishing public health problem to the present time.

The Ottoman conquest of Constantinople in 1453 resulted in the westward movement of many Greek thinkers and the end of the Hundred Years War brought stability to north-west Europe. In Europe, the growth of cities with commerce and industrialization and the massive influx of the rural poor brought the focus of public health needs to the doorsteps of municipal governments. The breakdown of feudalism, the decline of the monasteries, and the land enclosures dispossessed the rural poor. Municipal and voluntary organizations increasingly developed hospitals, replacing those previously run by monastic orders. In 1601, the British Elizabethan Poor Laws defined the local parish government as being responsible for the health and social well-being of the poor, a system later brought to the New World by British colonists. Municipal control of sanitation was weak. Each citizen was in theory held responsible for cleaning his part of the street, but hygienic standards were low, with animal and human waste freely accumulating.

During the Renaissance, the sciences of anatomy, physiology, chemistry, microscopy, and clinical medicine opened medicine to a scientific base. Medical schools in universities developed affiliations with hospitals, promoting clinical observation with increasing precision in the description of disease. The contagion theory of disease, described in 1546 by Fracastorus and later the German–Swiss physician Paracelsus (Phillipus von Hohenheim, 1493–1541), including the terms *infection* and *disinfection*, was contrary to the until-then sacrosanct miasma teachings of Galen.

In Russia, Czar Ivan IV (Ivan the Terrible) (1530–1584) in the sixteenth century arranged to hire a court physician of Queen Elizabeth I, who brought with him to Moscow a group of physicians and pharmacists to serve the court. The Russian army had a tradition of regimental doctors. In the mid-seventeenth century, the czarist administration developed pharmacies in major centers throughout the country for military and civilian needs, and established a State Pharmacy Department to control pharmacies and medications, education of doctors, military medicine, quarantine, forensic medicine, and medical libraries. Government revenues from manufacturing, sale, and promotion of vodka provided for these services. Preparation of military doctors (*Lekars*) with 5–7 years of training was instituted in 1654. Hospitals were mainly provided by monasteries, serving both civilian and military needs. In 1682, the first civic hospital was opened in Moscow, and in the same year, two hospitals were opened, also in Moscow, by the central government for the care of patients and training of *Lekars*.

From 1538, parish registers of christenings and burials were published in England as weekly and annual abstracts, known as the *Bills of Mortality*. Beginning in 1629, national annual Bills of Mortality included tabulation of death by cause. On the basis of the Bills of Mortality, novelist Daniel Defoe described the plague epidemic of London of 1665 over 60 years later (*A Journal of the Plague Year,* Daniel Defoe, 1722).

In England in 1662, John Graunt published *Natural and Political Observations Upon the Bills of Mortality*. He compiled and interpreted mortality figures by inductive reasoning, demonstrating the regularity of certain social and vital phenomena. He showed statistical relationships between mortality and living conditions. Graunt's work was important because it was the first instance of statistical analysis of mortality data, providing a foundation for the use of health statistics in the planning of health services. It established the sciences of demography and vital statistics and methods of analysis, providing basic measurements for health status evaluation with mortality rates by age, sex, and location. Also in 1662, William Petty took the first census in Ireland. In addition, he studied statistics on the supply of physicians and hospitals.

ENLIGHTENMENT, SCIENCE, AND REVOLUTION (1600s–1800s)

The Enlightenment, a dynamic period of social, economic, and political thought, provided great impetus for political and social emancipation and rapid advances in science and agriculture, technology, and industrial power. Changes in many spheres of life were exemplified by the American and French Revolutions, along with the economic theory of Adam Smith (author of *The Wealth of Nations*), which developed the political and economic rights of the individual.

In this influential and notable era, it became evident that advanced ideas and new ways of thinking could materialize into practical, tangible objects. This is exemplified by the development of microscopy, invented in 1676, as a tool that provided a method for the study of microorganisms (Box 1.2).

In the seventeenth century, the great medical centers were located in Leyden, Paris, and Montpelier. Bernardino Ramazzini published the first modern comprehensive treatise on occupational diseases in 1700.

In Russia, Peter the Great (1682–1725) initiated political, cultural, and health reforms. He sent young aristocrats to study sciences and technology, including medicine, in Western Europe. He established the first hospital-based medical school in St. Petersburg and subsequently in other centers as well, mainly to train military doctors. He established the Anatomical Museum of the Imperial Academy of Sciences in St. Petersburg in 1717, and initiated a census of males for military service in 1722. In 1724, V. N. Tatishev carried out a survey by questionnaire of all regions of the Russian empire regarding epidemic disease and methods of treatment.

BOX 1.2 The Invention of the Microscope

Of the many important medical and scientific discoveries, the creation of the microscope provides a crucial tool for the development of modern science applied to biological and medical progress. It has influenced the way in which scientists study, identify, diagnose, treat, and prevent diseases that have so greatly plagued and limited human life in the past.

The first compound microscope was created by Zacharias Janson and his father, Dutch spectacle-makers who experimented with lenses in 1595. They placed lenses in a tube, and noted that the object examined looked substantially enlarged. Robert Hooke (1635–1703) in England and Jan Swammerdam in the Netherlands built compound microscopes and made important discoveries with them. Hooke's book *Micrographia*, published in 1665, showed his compound microscope and illumination system, one of the best such microscopes of his time, and demonstrated at the Royal Society's meetings, with observations of insects, sponges, plant cells, fossils, and bird feathers.

However, credit for invention of the microscope and its medical use is given to Anton van Leeuwenhoek (1632–1723), a Dutch scientist and draper, who attained great success by creating efficient, better functioning lenses. His skill in grinding and polishing lenses provided remarkably high magnifying power. He was the first to see and describe bacteria (1674), yeast plants, the teeming life in a drop of water, and the circulation of blood corpuscles in capillaries. In 1678, after Leeuwenhoek had written to the Royal Society with a report of discovering "little animals" – bacteria and protozoa – Hooke was asked by the Society to confirm Leeuwenhoek's findings. He did so, paving the way for the wide acceptance of Leeuwenhoek's discoveries.

The initial scientific discoveries founded upon microscopy pertained to the circulating blood, microbiological organisms, and tissue cellular structure. As models of microscopes advanced, new capabilities were made possible so that more minute samples could be investigated for vital discoveries throughout the microbiological revolution. Subsequently, cellular structure opened up for scientific research with further advances such as the electron microscope.

Observations and new discoveries made through use of a microscope have shaped how we view disease, cellular processes, microorganisms, and the building blocks of life. From scientists investigating nerve cell function, to Koch studying bacilli responsible for tuberculosis infection, and Pasteur observing microbes as foreign organisms, the microscope has provided one of the key technological contributions to medical and health sciences of all time.

Sources: Nobelprize.org. *From thrilling toy to important tool [updated 2012]. Stockholm: Nobel Media. Available at:* http://www.nobelprize.org/educational/physics/microscopes/discoveries/ *[Accessed 10 August 2012].*
History of the microscope. UK: History of the Microscope [updated 2012]. Available at: http://www.history-of-the-microscope.org/terms.php *[Accessed 10 August 2012].*

Improvements in agriculture created greater productivity and better nutrition. These were associated with higher birth rates and falling death rates, leading to rapid population growth. The agricultural revolution during the sixteenth and seventeenth centuries, based on mechanization and larger land units of production with less labor, was associated with rural depopulation and provided excess workers to staff the factories, mines, ships, home construction, and shops of the industrial revolution. Other significant achievements of the agricultural revolution included expanding commerce and nourishing a growing middle class. Exploration and colonization provided the expansion of markets that fueled the industrial revolution, and stimulated the growth of science, technology, and wealth.

Colonization also contributed to the agricultural revolution through the introduction of new crops from the Americas, including the potato, the tomato, peppers, and maize. Thus, in addition to the new crops, animal husbandry, improved land use, and farm machinery all contributed to a general improvement in food security and nutrition. This was supplemented by increasing availability of cod from the Grand Banks of the Atlantic, adding protein to the common diet.

Industrialized urban centers grew rapidly. Crowded cities were ill-equipped to house and provide services for the growing working class. Urban areas suffered from crowding, poor housing, sanitation, poor nutrition, and harsh working conditions, which together produced appalling health conditions. During this period, documentation and statistical analysis developed in various forms, becoming the basis for social sciences including demography and epidemiology. Intellectual movements of the eighteenth century defined the rights of man and gave rise to revolutionary movements to promote liberty and release from tyrannical rule, as in the American and French Revolutions of 1775 and 1789, respectively. Following the final defeat of Napoleon at Waterloo in 1815, conservative governments were faced with strong middle-class movements for reform of social conditions, with important implications for health.

Eighteenth-Century Reforms

The period of enlightenment and reason was led by philosophers John Locke, Diderot, Voltaire, Rousseau, and others. These men produced a new approach to science and knowledge derived from observations and systematic testing and philosophical debate of ideas as opposed to instinctive or innate knowledge as the basis for human progress. The newness of the enlightenment was the idea of *progress*, *Sapere Aude* [dare to know and "have courage to use your own understanding!"], as the motto of enlightenment. The idea of the rights of man contributed to the American and French Revolutions, but also to a widening belief that society was obliged to serve all rather than just the privileged. This had a profound impact on approaches to health and societal issues.

The late eighteenth century was a period of growth and development of clinical medicine, surgery, and therapeutics, as well as of the sciences of chemistry, physics, physiology, and anatomy. From the 1750s onward, voluntary hospitals were established in major urban centers in Britain, America, and Eurasia. Medical–social reform involving hospitals, prisons, and lazarettos (leprosy hospitals) in Britain, led by John Howard (*On the State of Prisons,* published in 1777), produced substantive improvements in these institutions. Following the French Revolution, Philippe Pinel (1745–1826) was instrumental in the development of a more humane psychological approach to the custody and care of psychiatric patients. He fostered reform of insane asylums by removing the chains from patients at the Bicetre Mental Hospital and later Hospice de la Salpêtrière near Paris. Pinel made notable contributions to the classification of mental disorders, and he is often identified as the "father of modern psychiatry". Reforms in this field were also carried out in Britain by the Society of Friends (the Quakers), who built the York Retreat, providing humane care as an alternative to the inhuman conditions of the York Asylum.

In 1700, Bernardino Ramazzini (1633–1714) published a monumental piece on occupational diseases (*Diseases of Workers*), applying epidemiological principles and highlighting specific health hazards. These occupational risks included exposure to chemicals, dust, and metals, as well as musculoskeletal injury from unnatural postures and repetitive or violent motions. In his publication, he described other various disease-causative agents encountered by workers in 52 major occupations. Considered to be the "father of occupational medicine", Ramazzini established the basis for this field, although progress in the application of his views was slow. Despite the reluctance to apply his beliefs, the latter part of the century fostered interest in the health of sailors and soldiers, which led to important developments in military and naval medicine. Studies of prevalent diseases were carried out by pioneering physicians among workers in various trades, such as metalworkers, bakers, shoemakers, and hatmakers. Deeper understanding of these trades and the risks involved allowed for the identification of causative agents, and thus methods of prevention. The observational studies of Percivall Pott (1714–1789) identified scrotal cancer as an occupational hazard of chimney sweeps (1775). In 1767, George Baker (1722–1809) studied Devonshire colic, acquired from lead poisoning in cider production. Each of these and other similar studies helped to lay the basis for the development of investigative epidemiology.

Pioneers and supporting movements successfully agitated for reform in Britain through the parliamentary system. The anti-gin movement, aided by the popular newspapers (the "Penny Press") and the brilliant engravings of William Hogarth (1697–1764), helped to bring about legal, social, and police reforms in English townships. The reform spirit also produced an effective antislavery movement led by Protestant Christian churches, which goaded the British government to ban slavery in 1797 and the slave trade in 1807. This was achieved using the Royal Navy to sweep the slave trade from the seas during the early part of the nineteenth century.

Applied Epidemiology

Scurvy (the Black Death of the Sea) was a major health problem among sailors during long voyages. In 1498, Vasco da Gama (1460s–1524) lost 55 crewmen to scurvy during his voyages. Moreover, in 1535, Jacques Cartier's (1491–1557) crew suffered severely from scurvy on his voyage of discovery to Canada. During the sixteenth century, Dutch sailors knew of the value of fresh vegetables and citrus fruit in preventing scurvy.

Samuel Purchas (1577–1626) in 1601 and John Woodall (a British naval doctor, 1570–1643) in 1617 recommended the use of lemons and oranges in the treatment of scurvy, but this was not widely practiced. During the seventeenth to eighteenth centuries, Russian military practice included antiscorbutic preparations, and the use of sauerkraut for this purpose became common in European armies. Scurvy was a major cause of sickness and death among sailors when supplies of fruit and vegetables ran out, thus significantly limiting long voyages and contributing to frequent mutinies at sea.

Conditions for sailors in the British navy improved following the explorations of Captain James Cook during the period 1766–1779. As mentioned in Box 1.3, a British naval squadron of seven ships and nearly 2000 men led by Commodore George Anson left Plymouth to circumnavigate the globe in 1740–1744. The squadron returned to England comprised of only one ship and 145 men, after losing the majority of the crews to scurvy. In 1747, James Lind carried out his pioneering epidemiological investigation on scurvy among sailors on long voyages. His work led to the adoption of lemon or lime juice as a routine nutrition supplement for British sailors some 50 years later. Vitamins were not understood or isolated until almost 150 years later; however, Lind's scientific technique of hypothesis formulation, study design, careful observation and testing, followed by documentation and publication, was exceptional and monumental. This established the investigation of nutrition in public health in what is now recognized as the first clinical trial and epidemiological investigation.

This discovery was adopted by progressive sea captains and aided Captain Cook in his voyages of discovery in the South Pacific in 1768–1771. In 1795, the Royal Navy adopted routine issuance of lime juice to sailors to prevent scurvy. This measure effectively doubled the fighting strength of the Royal Navy by extending the capacity to remain longer at sea with a healthy crew. This was crucial during the Napoleonic wars of 1797–1814, so that "Lind as much as Nelson, broke the power of Napoleon". Lind also instigated reforms in living conditions for sailors, thus contributing to improvements in their health and fitness and the functioning of the fleet. The inquiries following the

BOX 1.3 James Lind and Scurvy, 1747

Captain James Lind (1716–1794), a physician serving in Britain's Royal Navy, developed a hypothesis explaining the cause of scurvy, founded upon clinical observations in what is currently regarded as the first clinical epidemiological study. It was the tragedy of Admiral Anson's expedition of circumnavigation, with the deaths of 380 men out of a crew of 510 on one of his ships, which led to Lind's interest in investigating scurvy.

In May 1747, on HMS *Salisbury*, Lind conducted his study by treating 12 sailors who had fallen sick to scurvy. He gave each sailor one of six different dietary regimens. The two sailors who were fed oranges and lemons recovered from their illness and were fit for duty within 6 days. This is in contrast to all of the other sailors, who were given different treatments, and consequently, remained sick. Lind concluded that citrus fruits would treat and prevent scurvy. In 1753, he published *A treatise of the scurvy*: *in three parts. Containing an inquiry into the nature, causes and cure of that disease together with a critical and chronological view of what has been published on the subject*.

Lind reported: "Scurvy began to rage after being a month or six weeks at sea … the water on board … was uncommonly sweet and good [and] provisions such as could afford no suspicion … yet, at the expiration of ten weeks, we brought into Plymouth 80 men, out of a complement of 350, more or less afflicted with the diseases". Captain Lind observed during his experiment that: "the most sudden and visible good effects were perceived from the use of oranges and lemons", and that in a short time this group was fit for duty, whereas all the other groups remained ill. He concluded that: "experience indeed sufficiently shows that as green or fresh vegetables with ripe fruit were the best remedies for it [i.e., scurvy], so they prove the most effectual preservatives against it", and that oranges are "the most effectual preservatives against the distemper".

Scurvy was eliminated in the Royal Navy by the end of the eighteenth century, but continued to plague merchant seaman during most of the nineteenth century until compulsory lime juice was imposed and steam ships led to shortened voyage times.

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Spithead mutiny of 1797 led to the adoption of Lind's nutrition and health recommendations in the same year. In 1798, the USA developed the Marine Hospitals Service for treatment and quarantine of sailors, which later became the US Public Health Service.

Jenner and Vaccination

Smallpox, a devastating and disfiguring epidemic disease, ravaged all parts of the world and had been recognized since the third century BCE. Described first by Rhazes in the tenth century, the disease was confused with measles and was widespread in Asia, the Middle East, and Europe during the Middle Ages. It was a designated cause of death in the Bills of Mortality in 1629 in London. Epidemics of smallpox occurred throughout the seventeenth to eighteenth and into the nineteenth centuries. Primarily a disease of childhood, mortality rates were 25 to 40 percent or more and the disease was characterized by disfiguring sequelae.

Smallpox was a key factor in the near elimination of the Aztec and other societies in Central and South America following the Spanish invasion. Traditions of prevention of this disease by inoculation or transmission of the disease to healthy people to prevent them from acquiring a more virulent form during epidemics were reported in ancient China. This practice, called variolation, was first brought to England in 1721 by Lady Mary Montagu, wife of the British ambassador to Constantinople, where it was common practice. It was widely adopted in England in the mid-eighteenth century, when the disease affected millions of people in Europe. Catherine the Great of Russia had her son inoculated by variolation by a leading English practitioner.

Edward Jenner (1749–1823) was the first to use vaccination with cowpox to prevent smallpox in 1796 (Box 1.4), initiating one of the most dramatically successful endeavors of public health. This revolutionary experiment culminated in the eventual eradication of this dreaded killing and disfiguring disease some 200 years later. In 1800, vaccination was adopted by the British armed forces, and the practice spread to Europe, the Americas, and the British Empire. Denmark made vaccination mandatory in the early nineteenth century and soon eradicated smallpox locally. Despite some professional opposition, the practice spread rapidly from the upper classes and voluntary groups to the common people as a result of the fear of becoming infected with smallpox. Vaccination later became compulsory in many countries, leading to the ultimate public health achievement: global eradication of smallpox in the late twentieth century.

BOX 1.4 Jenner and Smallpox

Variolation, or the exposure of people to the pustular matter of cases of smallpox, was originally documented in ancient China in 320 CE. This practice was used widely in the eighteenth century as a lucrative medical practice, and was a powerful tool in protecting armies from the ravages of smallpox. Variolation was made mandatory by George Washington in the Continental Army during the American Revolution.

In 1796, Edward Jenner (1749–1823), a country physician in Gloucestershire, England, investigated local folklore that milkmaids were immune to smallpox because of their exposure to cowpox. He took matter from a cowpox pustule on a milkmaid, Sarah Nelmes, and applied it with scratches to the skin of a young boy named James Phipps. This inoculated the boy with smallpox, and in turn, he did not develop the disease. Jenner's 1798 publication, *An enquiry into the causes and effects of the variolae vaccinia*, described his widescale vaccination and its successful protection against smallpox. Jenner prophesied that "the annihilation of the smallpox, the most dreadful scourge of the human species, must be the result of this practice". He then developed vaccination as a method to replace variolation.

Opposition to vaccination was intense, and Jenner's contribution was ignored by the scientific and medical establishment of the day, but he was later rewarded by Parliament. Vaccination was adopted as a universal practice by the British military in 1800 and by Denmark in 1803. A critical public health tool, vaccination became an increasingly widespread practice during the nineteenth century. In 1977, the last case of smallpox was identified; thus, smallpox eradication was declared by the World Health Organization in 1980.

Remaining stocks of the virus in the USA and Russia were to be destroyed in 1999. However, this was delayed, and following the 9/11 attack on the Twin Towers in New York City, the threat of bioterrorism was taken seriously, including the possibility of use of smallpox. Consequently, vaccination was reinstated for "first responders" including fire, police, and hospital staff in the USA and other countries.

Sources: *Riedel S. Edward Jenner and the history of smallpox and vaccination. Proc Bayl Univ Med Cent 2005;18:21–5. Available at: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1200696/ [Accessed 10 August 2012].*
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FOUNDATIONS OF HEALTH STATISTICS AND EPIDEMIOLOGY

Registration of births and deaths, originating in ancient societies, Egypt, China, India, Greece, and Rome, was used for tax purposes as well as the determination of potential military manpower. Birth and death rates form the foundation of demography, which is fundamental to epidemiology, a discipline which utilizes demography, sociology, and statistics. Churches maintained registries of births and deaths, and compulsory registration with local government was adopted in the UK in 1853.

Statistical and epidemiological methods emerged in the early seventeenth century with inductive reasoning put forward by Francis Bacon and applied by Robert Boyle in chemistry, Isaac Newton in physics, William Petty in economics, and John Graunt in demography. Bacon's writing inspired a whole generation of scientists in different fields and led to the founding of the Royal Society of London in 1660.

In Russia, in 1722, Peter the Great began a system of registration of births of male infants for military purposes. In 1755, Mikhail Vasilyevich Lomonosov (1711–1765) was central in establishing the study of demography, carrying out surveys and studies of birth statistics, infant mortality, quality of medical care, alcoholism, and workers' health. He brought the results of these studies to the government's attention, which led to improved training of doctors and midwives, as well as epidemic control measures. Lomonosov also helped to set up the medical faculty of Moscow University (1765).

Daniel Bernoulli (1700–1782), a member of a European family of mathematicians, constructed life tables based on available data showing that variolation against smallpox conferred lifelong immunity and vaccination at birth increased life expectancy. Following the French Revolution, health statistics flourished in the mid-nineteenth century in the work of Pierre Charles Alexandre Louis (1787–1872), who is considered the founder of modern epidemiology. Louis conducted several important observational studies, including one showing that bloodletting, then a common form of therapy, was ineffective. The importance of Louis's studies was demonstrated by the decline in this harmful practice. His students included Marc D'Epigne in France, William Farr in Britain, and others in the USA who became the pioneers in spreading *la méthode numérique* in medicine. *The Lancet*, one of the oldest, best known, and most respected medical journals, was founded in 1823 by Thomas Wakely, an English surgeon, and its creation played an important role in promoting statistical analysis in medical sciences.

Health statistics for social and public health reform took an important place in the work of Edwin Chadwick (1800–1890), Lemuel Shattuck (1793–1859), and Florence Nightingale (1820–1910). Recognizing the extraordinary significance of accurate statistical information in health planning and disease prevention, Edwin Chadwick's work led to legislation establishing the Registrar-General's Office of Britain in 1836. William Farr became its director-general and placed the focus of the office on public health. Farr's analysis of mortality in Liverpool, for example, showed that barely half of its native-born lived to their sixth birthday, whereas in England, the overall median age at death was 45 years. As a result, Parliament passed the Liverpool Sanitary Act of 1846, creating a legislated sanitary code, a medical officer of health position, and a local health authority.

In 1842 in Boston, Massachusetts, Lemuel Shattuck initiated a statewide registration of vital statistics, which later became a model elsewhere in the USA. His report was a landmark in the evolution of public health administration and planning. It provided a detailed account of data collection by age, sex, race, and occupation, and uniform nomenclature for causes of diseases and death. He emphasized the importance of a routine system for exchanging data and information. The London Epidemiological Society, founded in 1850, became an active investigative and lobbying group for public health action. Its work on smallpox led to the passage of the Vaccination Act of 1853, establishing compulsory vaccination in the UK.

In the later part of the nineteenth century, Florence Nightingale highlighted the value of a hospital discharge information system. She promoted the collection and use of statistics that could be derived from the records of patients treated in hospitals. Her work led to marked improvements in the management and design of hospitals, military medicine, and nursing as a profession.

SOCIAL REFORM AND THE SANITARY MOVEMENT (1830–1875)

Following the English Civil War in 1646, veterans of the Parliamentary Army called on the government to provide free schools and free medical care throughout the country as part of democratic reform. However, they failed to sustain interest or gain support for their revolutionary ideas amidst postwar religious conflicts and restoration of the monarchy.

In Russia, the role of the state in health was promoted following initiatives of Peter the Great to introduce western medicine to the country. During the rule of Catherine the Great, under the supervision of Count Orlov, an epidemic of plague in Moscow (1771–1772) was suppressed by incentive payments to bring the sick for care. In 1784, a Russian physician, I. L. Danilevsky, defended a doctoral dissertation on "Government power – the best doctor". In the eighteenth and nineteenth centuries, reform movements promoted health initiatives by government. Although these movements were suppressed (the Decembrists, 1825–1830) and liberal reform steps reversed, their ideas influenced later reforms in Russia.

Following the revolution in France, the Constituent Assembly established a Health Commission. A national assistance program for indigents was established. Steps were taken to strengthen the Bureaux de Sante (Offices of Health) of municipalities which had previously dealt primarily with epidemics. In 1802, the Paris Bureau addressed a wide range of public health concerns, including sanitation, food control, health statistics, occupational health, first aid, and medical care issues. The other major cities of France followed with similar programs over the next 20 years, and in 1848 a central national health authority was established. Child welfare services were also developed in France in the middle part of the nineteenth century. The reporting of vital statistics became reliable in the German states and even more so in France, fostering the development of epidemiological analysis of causes of death.

The governmental approach to public health was articulated by Johann Peter Franck for the Germanic states in his monumental series of books, *A Complete System of Medical Police* (1779–1817). This text explained the government's role in states with strong central governments and how to achieve health reform through administrative action. State regulations were to govern public health and personal health practices including marriage, procreation, and pregnancy. He promoted dental care, rest following obstetric delivery, maternity benefits, school health, food hygiene, housing standards, sanitation, sewage disposal, and clean water supplies. In this system, municipal authorities were responsible for keeping cities and towns clean and for monitoring vital statistics, military medicine, venereal diseases, hospitals, and communicable disease.

This system emphasized a strong, even authoritarian role of the state in promoting public health, including provision of prepaid medical care. It was a comprehensive and coherent approach to public health, emphasizing the key roles of municipal and higher levels of government. This work was influential in Russia, where Franck spent the years 1805–1807 as director of the St. Petersburg Medical Academy. Because of its primary reliance on authoritarian governmental roles, however, this approach was resisted in most western countries, especially following the collapse of absolutist government ideas following the Napoleonic period.

Municipal (voluntary) boards of health were established in some British and American cities in the late eighteenth and early nineteenth centuries. A Central Board of Health was established in Britain in 1805, primarily to govern quarantine regulations to prevent the entry of yellow fever and cholera into the country. Town life improved as sanitation, paving, lighting, sewers, iron water pipes, and water filtration were introduced. Despite the progress, organization for the development of such services was inadequate. Multiple agencies and private water companies provided unsupervised and overlapping services. London City Corporation had nearly 100 paving, lighting, and cleansing boards, 172 welfare boards, and numerous other health-related authorities in 1830. These were later consolidated into the London Board of Works in 1855.

In Great Britain, early nineteenth-century reforms were stimulated by the Philosophic Radicals led by Jeremy Bentham, who advocated dealing with public problems in a rational and scientific way, initiating a reform movement utilizing parliamentary, legal, and educational means. Economic and social philosophers in Britain, including Adam Smith and Jeremy Bentham, argued for liberalism, rationalism, free trade, political rights, and social reform, all contributing to "the greatest good for the greatest number". Labor law reforms (the Mines and the Factory Acts) banned children and women from underground work in the mines and regulated reduction in the workday to 10 hours. These reforms were adopted by the British Parliament in the 1830s to 1840s. The spread of railroads and steamships, the Penny Post (1840), and telegraphs (1846), combined with growing literacy and compulsory primary education introduced in Britain in 1876, dramatically altered local and world communication.

The British Poor Law Amendment Act of 1834 replaced the old Elizabethan Poor Laws, shifting responsibility for welfare of the poor from the local parish to the central government's Poor Law Commission. The parishes were unable to cope with the needs of the rural poor, whose condition was deteriorating with loss of land rights due to agricultural innovations and enclosures. Losing strength, the old system was breaking down, and the new industrialization needed workers, miners, sailors, and soldiers. The new conditions forced the poor to move from rural areas to the growing industrial towns. The urban poor suffered or were forced into workhouses while resistance to reform led to more radicalization and unsuccessful revolution, followed by deep political conservatism.

Deteriorating housing, sanitation, and work conditions in Britain in the 1830s resulted in rising mortality rates recorded in the Bills of Mortality. Industrial cities like Manchester (1795) had established voluntary boards of health, but they lacked the authority to alter fundamental conditions to control epidemics and urban decay. The boards of health were unable to deal with sewage, garbage, animal control, crowded slum housing, privies, adulterated foods and medicines, industrial polluters, or other social or environmental risk sources. Legislation in the 1830s in Britain and Canada improved the ability of municipalities and boards of health to cope with oversight of community water supplies and sanitation.

Under pressure from reformists and the Health of Towns Association, the British government commissioned Edwin Chadwick to undertake a study, which led to the *Report on the Sanitary Conditions of the Labouring Population of Great Britain* (1842), resulting in a further series of reforms through the Poor Law Commission (Box 1.5). The British Parliament passed the Health of Towns Act and the Public Health Act of 1848. This established the General Board of Health, mainly to ensure the safety of community water supplies and drainage, establishing municipal boards of health in the major cities and rural local authorities, along with housing legislation and other reforms. Despite setbacks due to reaction to these developments, the basis was laid for the "sanitary revolution", dealing with urban sanitation and health conditions, as well as cholera, typhoid, and tuberculosis (TB) control.

In 1850, the Massachusetts Sanitary Commission, chaired by Lemuel Shattuck, was established to look into similar conditions in the state. Boards of health established

BOX 1.5 Edwin Chadwick (1800–1900), Social Reform, and the Miasma Theory

Edwin Chadwick, a Manchester lawyer interested in political and social reform, was a leader in the reform movement in Great Britain. In 1832 he was appointed to a Royal Commission to investigate the revision of the Elizabethan Poor Laws, in effect since 1601, leading to the Poor Law Amendment Act of 1834.

In the 1830s a series of epidemics of cholera, typhoid, and influenza prompted the government to launch an investigation of sanitation. Chadwick, a strong believer in miasma theories, was convinced that measures such as cleaning, drainage and ventilation would make people healthier and thus less dependent on welfare. He was appointed to lead the inquiry and produced the report *The Sanitary Conditions of the Labouring Population* (1842). In this report, Chadwick used quantitative methods to show a direct link between poor living conditions and disease and life expectancy. This report inspired major efforts by local authorities to improve sanitation, and led to parliamentary adoption of the Public Health Act of 1848 establishing a General Board of Health, which Chadwick led. He was later forced from office and the national Board of Health was abolished; however, local Boards of Health at the municipal and county levels were developed to implement sanitary reform.

As an advocate of the miasma theory, he was sidelined by the growing strength of the rival germ theory advocates, whose scientific base was growing rapidly in the late nineteenth century. However, Chadwick's impact on promotion of sanitation and emphasis on the link between poverty and disease gave him a place among the most important pioneers in public health in the nineteenth century. While the miasma and germ theory advocates struggled bitterly for dominance for many years, each played a key role in modern public health.

In recent years, the association of poor sanitation, poverty, and adverse social conditions with health risk has re-emerged as being of central importance. Both the biomedical and the social hygiene models are seen to be interactive in the Inequalities in Health movement of the twenty-first century, recognizing the multidimensionality of societal and medical interaction to improve health and quality of life.

Sources: *Science Museum. Edwin Chadwick 1800–1900. London: Science Museum. Available at: http://www.sciencemuseum.org.uk/broughttolife/people/edwinchadwick.aspx [Accessed 11 August 2012].*
Rosen G. A history of public health. Expanded edition. Baltimore, MD: Johns Hopkins University Press; 1993.

earlier in the century became efficiently organized and effective in sanitary reform in the USA. The report of that committee has become a classic public health document. Reissued in the 1970s, it remains a useful model for a comprehensive approach to public health.

The Chadwick Report in Great Britain (1842) and the Shattuck Report in Massachusetts (1850) promoted the concept of municipal boards of health based on public health law with a public mandate to supervise and regulate community sanitation. This included urban planning, zoning, restriction of animals and industry in residential areas, and regulation of working conditions, setting the basis of public health infrastructure in the English-speaking world and beyond for the next century.

The interaction between sanitation and social hygiene was a theme promoted by Rudolf Virchow, the founder of cellular pathology and a social–medical philosopher. Virchow was a leading German physician in the mid-nineteenth century. He promoted the ideas of observation, hypothesis, and experimentation, helping to establish the scientific approach to medical issues. He was a social activist and linked the health of the people to social and economic conditions, emphasizing the need for political solutions. Virchow played an important part in the 1848 revolutions in Central and Western Europe, in the same year as the publication of the *Communist Manifesto* by Karl Marx. These all contributed to growing pressure on governments by workers' and political movements to promote better living, working, and health conditions in the 1870s. Virchow was an avowed anticontagionist, and his emphasis on and advances made in the social, economic, and political environment were as much a factor in public health progress as the bacteriological discoveries.

The Massachusetts State Board of Health was established in 1869, and in the same year a Royal Sanitary Commission was appointed in the UK. The American Public Health Association (APHA), established in 1872, served as a professional educational and lobbying group to promote the interests of public health in the USA, often successfully prodding federal, state, and local governments to act in the public interests in this field. The APHA definition of appropriate services at each level of government continues to set standards and guidelines for local health authorities. The organization of local, state, and national public health activities over the twentieth century in the USA owes much to the professional leadership and lobbying skills of the APHA.

Max von Pettenkoffer in 1873 studied the high mortality rates of Munich, comparing them to rapidly declining rates in London. His public lectures on the value of health to a city led to sanitary reforms, which were being achieved in Berlin at the same time under Virchow's leadership. Pettenkoffer introduced laboratory analysis to public health practice and established the first academic chair in hygiene and public health, emphasizing the scientific basis for public health; he is considered to be the first professor of experimental hygiene. A strongly outspoken anticontagionist until the beginning of the twentieth century, Pettenkoffer promoted the concept of the value of a healthy city, stressing that health is the result of a number of factors, and that public health is a community concern since the measures taken to help those in need benefit the entire community.

Social Security

In 1861, Russia freed the serfs and returned independence to universities. Departments of hygiene were established in the university medical schools in the 1860s and 1870s to train future hygienists, and to carry out studies of sanitary and health conditions in manufacturing industries. F. F. Erisman, a pioneer in sanitary research in Russia, promoted the connection between experimental science, social hygiene, and medicine, and he established a school of hygiene in 1890, later closed by the czarist government. In 1864, the government initiated the Zemstvos system of providing medical care in rural areas as a governmental program. These health reforms were implemented in 34 of 78 regions of Russia, before the Revolution. Prior to these reforms, medical services in rural areas were practically non-existent. Epidemics and the high mortality of the working population induced the nobility and new manufacturers in rural towns to promote Zemstvos' public medical services. In rural areas previously served by doctors based in the towns traveling to the villages, local hospitals and delivery homes were established. The Russian medical profession largely supported free public medical care as a fundamental right.

In 1883, Otto von Bismarck (1815–1898), Chancellor of Germany, introduced legislation providing mandatory insurance for injury and illness for workers in industrial plants, and survivor benefits. In 1883, he introduced social insurance for health care of workers and their families, based on mandatory payments from workers' salaries and employer contributions. In the UK in 1911, Chancellor of the Exchequer David Lloyd-George established compulsory insurance for workers and their families for medical care for general practitioner services based on capitation payment. This was followed by similar programs in Russia in 1912 and in virtually all Central and Western European countries by the 1930s. In 1918, Vladimir Lenin (1870–1924) established the state-operated health program, named after its founder Nikolai Semashko (1874–1949), bringing health care to the vast reaches of the Soviet Union. These programs were based on wide recognition of the principle of social solidarity, with governmental responsibility for health of the population being established in virtually all developed countries by the 1960s (see Chapter 13). In the USA, pensions were established for Civil War veterans, widows and orphans, and were made a national social security system only in 1935. Health care insurance was developed through trade unions, and only extended to governmental medical care insurance for the elderly and the poor in 1965.

During the industrial revolution, the harsh conditions in the urban industrial and mining centers of Europe led to efforts in social reform preceding and contributing to sanitary reform. These changes occurred well before the germ theory of disease causation was proven and the science of microbiology was established. Pioneering breakthroughs were made based on trial and error, challenging then established dogmas and producing the sanitary revolution, still unfinished and perhaps the most basic of the foundations of public health.

The issues of universal access to health care and especially prevention are challenges to public health in the twenty-first century. In many of the industrialized countries with universal health care, social inequalities still exist, with gaps between rich and poor, urban and rural, minority groups and other groups at special risk. These are discussed in following chapters of this book. In the USA, the struggle to achieve universal health care is an ongoing political issue in the second decade of the twenty-first century and is still unresolved. In the countries in transition from the Soviet system of health protection, an epidemiological shift occurred but the health system has been slow to respond. In the developing countries universal access to health care is still a distant dream.

Snow on Cholera

The great cholera pandemics originated in India between 1825 and 1854 and spread via increasingly rapid transportation to Europe and North America. Moscow lost some 33,000 people in the cholera epidemic of 1829, which recurred in 1830–1831. In Paris, the 1832 cholera epidemic killed over 18,000 people (just over 2 percent of the population) in 6 months.

Between 1848 and 1854, a series of outbreaks of cholera occurred in London with large-scale loss of life. The highest rates were in areas of the city where two water companies supplied homes with overlapping water mains. One of these (the Lambeth Company) then moved its water intake to a less polluted part of the River Thames, while the Southwark and Vauxhall company left its intake in a part of the river heavily polluted with sewage. John Snow, a founding member of the London Epidemiological Society and anesthetist to Queen Victoria, investigated an outbreak of cholera in Soho from August to September 1854, in the area adjacent to Broad Street. He traced some 500 cholera deaths occurring in a 10-day period. Cases either lived close to or used the Broad Street pump for drinking water. He determined that brewery workers and poorhouse residents in the area, using uncontaminated wells, escaped the epidemic. Snow concluded that the Broad Street pump was probably contaminated. He persuaded the authorities to remove the handle from the pump, and the already subsiding epidemic disappeared within a few days.

During September to October, 1854, Snow investigated another outbreak, again suspecting water transmission. He identified cases of mortality from cholera by their place of residence and which water company supplied the home (Table 1.1). Snow calculated the cholera rates in a 4-week

TABLE 1.1 Deaths from Cholera Epidemic in Districts of London Supplied by Two Water Companies, 7 Weeks, 1854

Water Supply Company	Number of Houses	Deaths from Cholera	Cholera Deaths/10,000 Houses
Southwark and Vauxhall	40,046	1,263	315
Lambeth	26,107	98	37
Rest of London	256,423	1,422	59

Sources: Snow J. On the mode of transmission of cholera. 1854. In: Snow on cholera: a reprint of two papers. New York: Commonwealth Fund; 1936.
Sack DA, Sack RB, Nair GB, Siddique AK. Cholera. Lancet 2004;363:223–33. Available at: http://www.thelancet.com/journals/lancet/article/PIIS0140-6736(03)15328-7/abstract [Accessed 11 August 2012].

period in homes supplied by each of the two companies. Homes supplied by the Southwark and Vauxhall Water Company were affected by high cholera death rates while adjacent homes supplied by the Lambeth Company had rates lower than the rest of London. This observation provided overwhelming epidemiological support for Snow's hypothesis that the cholera epidemic source was the contaminated water from the River Thames, distributed to homes in a large area of south London. The risk to local residents of becoming infected and falling ill with cholera was dependent upon the specific water company as well as the pump utilized.

This investigation, with a study and control group occurring in an actual disease outbreak, strengthened the case of the germ theory supporters, who were still opposed by strong proponents of miasmatic theories. It also led to legislation mandating filtration of water companies' supplies in 1857. *Vibrio cholerae* was not isolated until 1883, during an investigation of waterborne cholera outbreaks in Egypt by Robert Koch. Snow's work on cholera has become one of the classic epidemiological investigations, studied to this day for its scientific imagination and thoroughness, despite preceding the discovery of the causative organism by nearly 30 years.

A landmark case, Snow's work on cholera stimulated more investigation of causes of enteric diseases. William Budd (1811–1880), a physician at the Bristol Royal Infirmary, carried out a number of epidemiological investigations of typhoid fever in the 1850s, finding waterborne episodes of the disease. He investigated an outbreak in 1853 in Cowbridge, a small Welsh village, where a ball attracted 140 participants from surrounding counties. Almost immediately afterwards, many of those attending the ball became sick with typhoid fever. He found that a person with typhoid had been at the location some days before, and that his excreta had been disposed of near a well, from which water was drawn for the ball. Budd then concluded that water was the vehicle of transmission of the disease. He investigated other outbreaks and summarized his reports in *Typhoid Fever: Its Nature, Mode of Transmission and Prevention*, published in 1873, which is a classic work on waterborne transmission of enteric disease. These investigations were very valuable, as they contributed to the movement to disinfect public water systems on a preventive basis.

The brilliant epidemiological studies of Snow and Budd set a new direction in epidemiology and public health practice, not only with waterborne disease. They established a standard for investigation of the distribution of disease in populations with the purpose of finding a way to interrupt the transmission of disease. Improved sanitation and water safety, developed in urban and rural population centers, contributed greatly to improved survival and a reduction in cholera and typhoid epidemics. However, globally, waterborne disease remains a major cause of morbidity and mortality, especially among children living in poverty.

The Germ and Miasma Theories

Until the early and middle parts of the nineteenth century, the causation of disease was hotly debated. The miasma theory, holding that disease was the result of environmental emanations or miasmas, went back to Greek and Roman medicine, and Hippocrates' treatise *On Air, Water, and Places*. Miasmists believed that disease was caused by infectious mists or noxious vapors emanating from filth in the towns and that the method of prevention of infectious diseases was to establish sanitary measures to clean the streets of garbage, sewage, animal carcasses, and wastes that were features of urban living. This provided the basis for the Sanitary Movement, with great benefit to improving health conditions. The miasma theory had strong proponents well into the later part of the nineteenth century.

The contagion or germ theory gained ground, despite the lack of scientific proof, on the basis of biblical and Middle Ages' experience with isolation of lepers and quarantine of other infectious conditions. In 1546, Fracastoro (1478–1553) published *De Contagione*, a treatise on microbiological organisms as the case of specific diseases. The germ theory was strengthened by the work of Antony van Leeuwenhoek (1632–1723), who invented the microscope in 1676. The invention of this apparatus is considered to be a groundbreaking discovery, a watershed in the history of science. His research showing small microorganisms led to his recognition as a Fellow of the Royal Society of England in 1680. The germ theorists believed that microbes, such as those described by van Leeuwenhoek, were the cause of diseases which could be transmitted from person to person or by contact with sewage or contaminated water.

Major contributions to resolving this issue came from the epidemiological studies of Snow and Budd in the 1850s, proving waterborne transmission of cholera and typhoid, suggesting that if the disease was not from a miasma source then it was due to germ (contagion) sources. The classic study of a measles epidemic in the remote Faroe Islands by Peter Panum in 1846 clearly showed person-to-person transmission of this disease, its incubation period, and the lifelong natural immunity that exposure gives (Box 1.6). The dispute continued, with miasmists or sanitationists and germ theorists arguing with equal vehemence.

While the science of the issue was debated until the end of the nineteenth century, the practical application of sanitary reform was promoted by both theories. Increasing attention was paid to sewage and water safety, and the removal of waste products by organized municipal activities was adopted in European and North American cities. The sanitary revolution proceeded while the debates raged and solid scientific proof of the germ theory accumulated, primarily in the 1880s. Fear of cholera stimulated New York City to establish a Board of Health in 1866. In the city of Hamburg, Germany, a Board of Health was established in 1892 only after a cholera epidemic attacked the city, while neighboring Altona remained cholera free because it had established a water filtration plant.

The specific causation of disease (the germ theory) has been a vital part of the development of public health. The bacteriological revolution (see later section entitled "The Bacteriological Revolution"), led by the work of Louis Pasteur and Robert Koch, provided enormous benefit to medicine and public health. Those who argued that disease is environmental in origin (the miasma theory), however, also contributed to public health because of their recognition of the importance of social or other environmental factors, such as poor sanitation and housing conditions or nutritional status, all of which increase susceptibility to specific agents of disease, or to the severity of disease.

BOX 1.6 Panum on Measles in the Faroe Islands, 1846

Peter Ludwig Panum (1820–1885), a 26-year-old newly graduated medical doctor from the University of Copenhagen, was sent to the Faroe Islands by the Danish government in 1846 to investigate an outbreak of measles. On the islands, located in the far reaches of the North Atlantic, there was no documentation of measles since 1781. During the 1846 epidemic, approximately 6000 of the 7782 islanders were stricken with measles and 102 of them died of the disease or its sequelae. Panum visited all isolated corners of the islands, tracing the chain of transmission of the disease from location to location, and the immunity of those exposed during the epidemic.

From his well-documented observations he concluded, contrary to the prevailing opinion, that measles is a contagious disease spread from person to person, and that one attack gives lifelong immunity. His superb report clearly demonstrated the contagious nature of the disease and its incubation period. It also proved that measles is not a disease of "spontaneous generation", nor is it generally dispersed in the atmosphere and spread as a "miasma", giving strength to and providing evidence for the germ theory.

Since the 1960s, the availability of an inexpensive, highly effective, and safe vaccine has led to the elimination of domestic circulation of the virus in many countries, yet measles remains a serious global health problem in 2013. An estimated 250,000 children died of this highly contagious disease in 2006.

A European-wide measles epidemic in 2010–2012 had over 50,000 cases in 2011 alone. As a result of imported cases and local spread, outbreaks of measles are occurring in countries that were thought to be measles free, including countries in North and South America. Measles elimination is possible with the two-dose policy with current vaccines, if immunization is given high priority with catch-up campaigns for vulnerable age groups and travelers, and pursued with determined national and international efforts.

Sources: *Emerson H. Panum on measles: observations made during the epidemic of measles on the Faroe Islands in the year 1846 (A translation from the Danish). Am J Public Health Nations Health 1940;30:1245–6. Available at: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1530953/ [Accessed 11 August 2012].*
Rosen G. A history of public health. Expanded edition. Baltimore, MD: Johns Hopkins University Press; 1993.
World Health Organization. Measles fact sheet [updated April 2012]. Geneva: WHO. Available at: http://www.who.int/mediacentre/factsheets/fs286/en/ [Accessed 11 August 2012].

HOSPITAL REFORM

Hospitals developed by monasteries as charitable services were supplanted by voluntary or municipal hospitals mainly for the poor during and after the Renaissance. Reforms in hospital care evolved along with the sanitary revolution. In eighteenth-century Europe, hospitals that were operated by religious orders of nuns and by municipal or charitable organizations were dangerous cesspools of pestilence. The dangers arose from lack of knowledge about and practice of basic hygiene for infection control, the concentration of patients with highly communicable diseases, and transmission of disease by medical and other staff.

Reforms in hospitals in England were stimulated by the reports of John Howard in the late eighteenth century, becoming part of wider social reform in the early part of the nineteenth century. Professional reform in hospital organization and care started in the latter half of the nineteenth century under the influence of Florence Nightingale, Oliver Wendel Holmes, and Ignaz Semmelweiss. Clinical–epidemiological studies of "antiseptic principles" provided a new, scientific approach to improvement in health care.

In the 1840s, puerperal fever was a major cause of death in childbirth, and consequently, was the subject of investigation by Holmes in the USA, who argued that it was due to a

BOX 1.7 Crede and Prevention of Gonococcal Ophthalmia Neonatorum

Gonorrhea was common in all levels of society in nineteenth century Europe. Ophthalmic infection of newborns was a widespread cause of infection, scarring, and blindness. Carl Franz Crede (1819–1892), professor of obstetrics at the University of Leipzig, attempted to treat neonatal gonococcal ophthalmic infection with many medications. Crede discovered the use of silver nitrate as a treatment and introduced its use as a preventive measure during the period 1854–1860, with astonishing success.

The prophylactic use of silver nitrate spread rapidly hospital by hospital. However, owing to widespread medical opposition to this innovation, decades passed before it was mandated widely. It was only in 1879 that the gonococcus organism was discovered by Albert Ludwig Neisser (1855–1916). Estimates of children saved from blindness by this procedure in Europe during the nineteenth century are as high as one million.

Sources: *Schmidt A. Gonorrheal ophthalmia neonatorum: historic impact of Crede's eye prophylaxis. Pediatr Infect Dis Revisited 2007;95–115. Available at: http://www.springerlink.com/content/xtu8475716207264/ [Accessed 11 August 2012].*
Dunn PM. Perinatal lessons from the past: Sir Norman Gregg, ChM, MC, of Sydney (1892–1966) and rubella embryopathy. Arch Dis Child Fetal Neonatal Ed 2007;92:F513–4. Available at: http://www.ncbi.nlm.nih.gov/pubmed/17951553 [Accessed 11 August 2012].

contagion. In 1846, Semmelweiss (1818–1865), a Hungarian obstetrician at the Vienna Lying-In Hospital, suspected that the deaths from puerperal fever were the result of contamination on the hands of physicians, who transmitted autopsy material to living patients. He showed that death rates among women attended by medical personnel were two to five times the rates among those attended by midwives. By requiring doctors and medical students to soak their hands in chlorinated lime after autopsies, he reduced the mortality rates among the medically attended women to the rate of the midwife-attended group.

Semmelweiss's work, although carefully documented, was slow to be accepted by the medical community, taking some 40 years for general adoption. His pioneering investigation of childbed fever (streptococcal infection in childbirth) in Vienna contributed to improvements in obstetrics and a reduction in maternal mortality. In the 1850s, prevention of blindness in newborns by prophylactic use of silver nitrate eyedrops, developed by Carl Crede (1819–1892) in Leipzig, spread rapidly through the medical world (Box 1.7). This practice continues to be a standard in the prevention of ophthalmia neonatorum.

Florence Nightingale's momentous work in nursing and hospital administration in the Crimean War (1854–1856) established the professions of nursing and modern hospital administration. In the 1860s, she emphasized the importance of the "Poor Laws", including workhouse reform and training special district nurses for care of the sick and poor at home. Nightingale's subsequent long and successful campaigns to raise standards of military medicine, hospital planning, supply services and management, hospital statistics, and community health nursing were outstanding contributions to the development of modern, organized health care and antisepsis.

Despite all of the cumulative progress over the past 150 years, including the advent of sterile techniques and antibiotics, hospital-acquired infection remains a serious public health problem today. This major medical challenge is exacerbated by multidrug-resistant organisms and a persistent failure of regular hand washing between patient care by doctors and nurses. It is also complicated by antiseptic measures needed for invasive procedures such as central venous and bladder catheters.

THE BACTERIOLOGICAL REVOLUTION

In the third quarter of the nineteenth century, the sanitary movement rapidly spread through the cities of Europe, America and elsewhere with demonstrable success in reducing disease in areas served by sewage drains, improved water supplies, street paving, and waste removal. At the same time, innovations occurred in hospitals, stressing hygiene and professionalization of nursing and administration. These were accompanied by breakthroughs in establishing scientific and practical applications of bacteriology and immunology.

Pasteur, Cohn, Koch, and Lister

Louis Pasteur (1822–1895), a French professor of chemistry, serves as one of the most notable figures in scientific history. One of his many groundbreaking achievements involves the science of immunology, through his work with vaccines (Box 1.8).

Rabies was widely feared as a disease transmitted to humans through the bites of infected animals, and was universally fatal. Pasteur reasoned that the disease affected the nervous system and was transmitted in saliva. He injected material from infected animals, attenuated to produce protective antibodies but not the disease. In 1885, a 14-year-old boy from Alsace was severely bitten by a rabid dog. Local physicians agreed that because death was certain, Pasteur, a chemist and not a physician, be allowed to treat the boy with a course of immunization. The boy, Joseph Meister, survived, and similar cases were brought to Pasteur and successfully immunized. Pasteur was criticized in medical circles, but both the general public and scientific circles soon recognized his enormous contribution to public health.

Ferdinand Julius Cohn (1828–1898), professor of botany at Breslau University, developed and systematized the science of bacteriology using morphology, staining, and media characteristics of microorganisms, and trained a key

BOX 1.8 Louis Pasteur, the Pioneer of Pasteurization, Microbes & Vaccines

Louis Pasteur was a French chemist and biologist who proved the germ theory of disease and invented the process of pasteurization. He brilliantly developed the basis for modern bacteriology as a cornerstone of public health, establishing scientific, experimental proof for the germ theory with his demonstration in 1854 of anaerobic microbial fermentation.

Pasteur was asked to investigate the threatened destruction of the French silk industry by epidemics destroying the silkworms. His analysis pointed to living microorganisms causing the disease. Consequently, he devised new growing conditions, which eliminated the problem.

This, in turn, raised both scientific and industrial interest in the germ theory. In the period 1856–1860, he showed how to prevent wine spoilage due to contamination from foreign organisms. His microscopic work helped him to observe that certain liquids went rancid owing to the multiplication of minute organisms in wine, then beer and milk. With more investigation, he saw that these microorganisms could be destroyed by heating the liquid, an important process later termed "pasteurization". As with the other liquids he worked with, he heated the wine to a certain temperature before bottling it, thus killing the undesired ferments.

When he published the concept that the very microorganisms that contaminated the liquids also floated in the air, it was met with ridicule by the medical establishment. The germ theory is the idea that certain microorganisms are responsible for causing many specific diseases. Monumental and groundbreaking for its time, the germ theory drastically influenced the way in which medicine was practiced. Pasteur's work confirmed previous awareness of the existence of germs and development of the germ theory, so that the discoveries of many scientists were retrospectively recognized as contributing to the understanding of the germ theory.

Pasteur moved on to studying solid compounds through experimental trials, demonstrating that microbes were the reason behind the decay of meat. He was confident that this concept explained the development of disease, arguing that the multiplication of germs leads to a specific disease. This was a very significant realization, as it meant that microbes not only affected beer, milk, and various foods, but had the potential to affect humans as well.

He succeeded in producing vaccines through attenuation, or weakening an organism's strength by passing it successively through animals, recovering it, and retransmitting it to other animals. He calculated that if a vaccine can be developed for smallpox, then one can be created for all diseases. In collaboration with physician Charles Chamberland, he inoculated chickens with chicken cholera germs taken from an old culture. Following this, using cholera germs from a new, fresh culture, they inoculated two groups of chickens: those that had previously been inoculated with the old culture, and those that had not. The chickens initially inoculated with the old sample survived, while the other group of chickens did not, demonstrating the initial inoculation of the old culture to be successful in producing immunity to chicken cholera.

This experiment illustrated the principles of vaccination; Pasteur's explanation for it surrounded the idea of weaker germs creating a form of defense and establishing protection to fight the stronger, more potent germs later presented in the fresh sample. In 1883, he produced a similar protective vaccine for swine erysipelas, and then in 1884–1885, a vaccine for rabies.

Louis Pasteur was a brilliant scientific pioneer whose many outstanding achievements greatly contributed to the advance of medical sciences and public health.

Sources: *History Learning Site. Louis Pasteur [updated 2012]. UK: History Learning Site. Available at: http://www.historylearningsite.co.uk/louis_pasteur.htm [Accessed 11 August 2012].*
Science Museum. Louis Pasteur (1822–1895). London: Science Museum. Available at: http://www.sciencemuseum.org.uk/broughttolife/people/louispasteur.aspx [Accessed 11 August 2012].

generation of microbiological investigators. One student, Robert Koch (1843–1910), a German rural district medical officer, investigated anthrax using mice inoculated with blood from sick cattle, with transmission of the disease for more than 20 generations. He developed basic bacteriological techniques including methods of culturing and staining bacteria. He demonstrated the organism causing anthrax, recovered it from sick animals, and passed it through several generations of animals, proving the transmission of specific disease by specific microorganisms.

In 1882, Koch cultured and demonstrated the tubercle bacillus. He then headed the German Cholera Commission visiting Egypt and India in 1883, isolating and identifying *Vibrio cholerae* (Nobel Prize 1905). He demonstrated the efficacy of water filtration in preventing transmission of enteric disease including cholera. His development of "Koch's postulates", or criteria for causation of a disease by a specific organism that produced scientific evidence and substantiated the germ theory, was a long-lasting contribution to the science of medicine. He was awarded the Nobel Prize in Physiology or Medicine in 1905. In 1883, Koch, adapting postulates on causation of disease from clinician–pathologist Jacob Henle (1809–1885), established criteria for attribution of causation of a disease to a particular parasite or agent (Box 1.9). These were fundamental to the establishment of the science of bacteriology and the relationship of microorganisms to disease causation.

The Koch–Henle postulates serve as guidelines – in their pure form were later seen as too rigid, and would limit identification of the causes of many diseases – but they were important in establishing germ theory and the scientific basis of bacteriology, dispelling the many other theories of disease that were still widespread in the late nineteenth century. These postulates served as guidelines for evidence of causation, but had limitations in that not all microbiological agents can be grown in pure culture, some

BOX 1.9 Koch–Henle Postulates on Microorganisms as the Cause of Disease

1. The organism (agent) must be shown to be present in every case of the disease by isolation in pure culture.
2. The agent should not be found in cases of any other disease.
3. Once isolated, the agent should be grown in a series of cultures, and then must be capable of reproducing the disease in experimental animals.
4. The agent must then be recovered from the disease produced in experimental animals.

These criteria for disease causation by bacteria have been modified to accommodate new scientific knowledge, newly identified organism (e.g., viruses), asymptomatic infections, host and environmental and other factors. However, these postulates were important as basic tools in developing public health science.

Sources: *Last JM. A dictionary of epidemiology. 4th ed. New York: Oxford University Press; 2001.*
Last JM. A dictionary of public health. Oxford: Oxford University Press; 2006.
MedicineNet. Definition of Koch's postulates [updated 10 October 1998]. New York: MedicineNet. Available at: http://www.medterms.com/script/main/art.asp?articlekey=7105 [Accessed 11 August 2012].
Frederichs DN, Relman DA. Sequence-based identification of microbial pathogens: a reconsideration of Koch's postulates. Clin Microbiol Rev 1996;9:18–33. Available at: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC172879/pdf/090018.pdf [Accessed 11 August 2012].

BOX 1.10 Gregor Mendel: The Father of Genetics

Gregor Mendel (1822–1884) was an Augustinian monk in Brno (now in the Czech Republic) who was sent to study at the University of Vienna. He carried out botanical experimentation stimulated by a wide demand for knowledge of plant heredity. The introduction of new plants by explorations overseas since 1500 brought many new species of vegetables, fruit, and flora to Europe, while improved transportation and the rise of cities in the industrial revolution brought a need for improved agricultural production.

Mendel studied variation in plant height (tall or short) and seed color (green or yellow) in the monastery's experimental garden, focusing on 29,000 pea plants. He published his findings on the occurrence of paired elementary units of heredity, now known as important principles of genetics. Using his extensive data, Mendel was successful in demonstrating the concept that genes obey simple statistical laws.

His experiments led him to two generalizations, the Law of Segregation and the Law of Independent Assortment, later known as Mendel's Laws of Inheritance. His studies were published with little impact at the time, but were later recognized as the basics of genetic studies and Mendel posthumously became known as the "father of modern genetics".

Sources: *Nobelprize.org. The Nobel Prize in Physiology or Medicine 1962: Francis Crick, James Watson, Maurice Wilkins. Sweden: Nobelprize.org. Available at: http://www.nobelprize.org/nobel_prizes/medicine/laureates/1962/watson.html [Accessed 11 August 2012].*
Human Genome Project information. History of the Human Genome Project. Available at: http://www.ornl.gov/sci/techresources/Human_Genome/project/hgp.shtml [Accessed 2 August 2012].
Johns Hopkins School of Public Health. Genetically engineered bacteria prevent mosquitoes from transmitting malaria. Available at: http://www.jhsph.edu/news/news-releases/2012/jacobs_lorena_bacteria.html [Accessed 2 August 2012].

organisms undergo antigenic drift or change in antigenicity, and some organisms have no animal host. Koch's postulates were later adapted by Evans (1976) to include non-infectious disease-causing agents, such as cholesterol, following the changing emphasis in epidemiology of non-infectious diseases.

In the mid-1860s, Joseph Lister in Edinburgh, under the influence of Pasteur's work and with students of Semmelweiss, developed a theory of "antisepsis". His 1865 publication *On the Antiseptic Principle in the Practice of Surgery* described the use of carbolic acid to spray operating theaters and to cleanse surgical wounds, applying the germ theory with great benefit to surgical outcomes. Lister's work on chemical disinfection for surgery in 1865 was a pragmatic development and a major advance in surgical practice; it was also an important contribution to establishing the germ theory in nineteenth-century medicine.

The Basis of Genetics

The introduction of new plants from explorations overseas since 1500 brought many new species of vegetables, fruit, and flora to Europe, while improved transportation and the rise of cities in the industrial revolution brought a need and demand for improved agricultural production. This led to the wide practice of animal and plant breeding, but the basic science of genetics was lacking.

Gregor Mendel, an Augustinian monk, carried out botanical experimentation stimulated by a wide demand for knowledge of plant heredity. He studied variation in pea plants in terms of their characteristics and discovered that genes obey simple statistical laws (Box 1.10). His work was later defined as Mendel's laws of inheritance. These were recognized as the basics of genetic studies and Mendel became known as the "father of modern genetics".

Later in the nineteenth century, the discovery of chromosomes gave new life to genetic studies on human health. During the twentieth century many genetically determined diseases were identified and practical solutions were worked out to test and counsel families. These achievements allowed hereditary diseases such as Tay Sachs and thalassemia to be reduced or eliminated by public health programs of screening, education, and individual counseling.

The mid-twentieth century brought on Francis Crick, James Watson, and Maurice Wilkins's discovery of the famous "double helix" molecular structure of nucleic acid and its significance for information transfer in living material (DNA, Nobel Prize 1962). This was an enormous step forward in the field of genetics and provided the basis for the Human Genome Project (HGP), which defined thousands of human genes. The HGP was an international 13-year effort, begun in 1990 and completed in 2003. Its purpose was to discover all of the estimated 20,000–25,000 human genes in order to make them accessible for further biological study, and to determine the complete sequence of the 3 billion DNA subunits (bases in the human genome).

The application of these new sciences opened the fields of genetic screening and counseling, and drug development for specific genome-associated diseases, creating enormous potential for risk factor identification and targeted medical interventions. The applications will change medicine and public health in the coming decades in diverse fields of agriculture, biology, medicine, nutrition, and public health for the prevention and control of birth defects, cancer, and degenerative, infectious, allergic, and other diseases.

BOX 1.11 Havana and Panama: Control of Yellow Fever and Malaria, 1901–1906

The United States Army Commission on Yellow Fever, led by Walter Reed (1851–1902), a military physician, organized a team in Cuba in 1900, with physicians Carlos Finlay (1833–1915) and Jesse Lazear (1866–1900), to test hypotheses regarding yellow fever transmission. Working with volunteers, he demonstrated transmission of the disease from person to person by the specific mosquito *Stegomyia fasciata*. The Commission accepted that "the mosquito acts as the intermediate host for the parasite of Yellow Fever".

Another US army doctor, William Gorgas (1845–1920), applied the new knowledge of transmission of yellow fever and the life cycle of the vector mosquito. He organized a campaign to control the transmission of yellow fever in Havana, isolating clinical cases from mosquitoes and eliminating the breeding places for *Stegomyia* with Mosquito Brigades.

Yellow fever was eradicated in Havana within 8 months. This demonstrated the possibility for control of other mosquito-borne diseases, principally malaria with its specific vector, *Anopheles*. Gorgas then successfully applied mosquito control to prevent both yellow fever and malaria between 1904 and 1906, permitting construction of the Panama Canal.

Sources: *McCullough D. The path between the seas: the creation of the Panama Canal 1870–1914. New York: Touchstone; 1977.*
Harvard University Open Collections Program. Contagion historical views. William Gorgas 1854–1920. Available at: http://ocp.hul.harvard.edu/contagion/gorgas.html [Accessed 12 August 2012].

Vectorborne Disease

Studies of disease transmission defined the importance of carriers (i.e., those who can transmit a disease without showing clinical symptoms) in the transmission of diphtheria, typhoid, and meningitis, and promoted studies of diseases borne by intermediate hosts or vectors. Parasitic diseases of animals and humans, including Guinea worm disease, tapeworms, filariasis, and veterinary parasitic diseases such as Texas cattle fever, were investigated in many centers during the nineteenth century. David Bruce (1855–1931) demonstrated transmission of nagana (animal African trypanosomiasis), a disease of cattle and horses in Zululand, South Africa, in 1894–1895. Nagana is caused by a trypanosome parasite transmitted by the tsetse fly, and its study led to the use of environmental methods of control to halt disease transmission. Alexandre Yersin (1863–1943) and Shibasaburo Kitasato (1853–1931) discovered the plague bacillus in 1894, and in 1898 French epidemiologist P. L. Simmond demonstrated that the plague was a disease of rats spread by fleas to humans.

Malarial parasites were identified by French army surgeon Alphonse Laveran (1845–1922, Nobel Prize 1907) in Algeria in 1880. He referred to the organism as *Oscillaria malariae*, and as with many major public health discoveries, his was initially met with doubt. Laveran persisted, and after ending his military career he continued his research, producing irrefutable evidence that was later validated by other experts. Moreover, other nineteenth-century investigators suspected mosquitoes as the method of transmission, and in 1897, Ronald Ross (1857–1932, Nobel Prize 1902), a British army doctor in India, Patrick Manson (1844–1922) in England, and Benvenuto Grassi in Rome demonstrated transmission of malaria by the *Anopheles* mosquito. Yellow fever, probably imported by the slave trade from Africa, was endemic in the southern USA but spread to northern cities in the late eighteenth century. An outbreak in Philadelphia in 1798 killed nearly 8 percent of the population. Outbreaks in New York killed 732 people in 1795, 2086 in 1798, and 606 in 1803. The Caribbean and Central America were endemic with both yellow fever and malaria.

The conquest of yellow fever also contributed to the germ or contagion theory becoming established and accepted over the miasma theory, when the work of Cuban physician Carlos Finlay was confirmed by Walter Reed in 1901. His studies in Cuba proved the mosquito-borne nature of the disease as a transmissible disease via an intermediate host (vector), but which was not contagious between humans.

William Gorgas applied this to vector control activities and protection of sick people from contact with mosquitoes, resulting in an eradication of yellow fever in Havana within 8 months, and in the Panama Canal Zone within 16 months (Box 1.11). This work showed a potential for the control of vectorborne disease, which has had important success in the control of many tropical diseases, including yellow fever and, currently, Guinea worm disease and onchocerciasis. Despite being well controlled in many parts of the world, there has been a resurgence of malaria in many tropical countries since the 1960s.

MICROBIOLOGY AND IMMUNOLOGY

In Russia in 1883, Ilya Ilyich Mechnikov (1845–1916) described phagocytosis, a process in which white cells in the blood surround and destroy bacteria; his elaboration of the processes of inflammation and humoral and cellular response led to a joint Nobel Prize in 1908 with Paul Ehrlich (1854–1915). Other investigators searched for the bactericidal or immunological properties of blood that enabled cell-free blood or serum to destroy bacteria. This work greatly strengthened the scientific basis for bacteriology and immunology.

Pasteur's co-workers, Emile Roux (1853–1933) and Alexandre Yersin, isolated and grew the causative organism for diphtheria and suggested that the organism produced a poison or toxin which, in turn, caused the lethal effects of the disease. In Berlin in 1890, Karl Fraenkel published his work showing that inoculating guinea pigs with attenuated diphtheria organism could produce immunity. At the same time, also in Germany, Emile Behring (1854–1917) and Japanese co-worker Shibasaburo Kitasato produced evidence of immunity to tetanus bacilli in rabbits and mice. Behring also developed a protective immunization against diphtheria in humans with active immunization, as well as an antitoxin for passive immunization of an already infected person (Nobel Prize 1901). By 1894, diphtheria antitoxin was ready for general use. The isolation and identification of new disease-causing organisms proceeded rapidly in the last decades of the nineteenth century. The diphtheria organism was discovered in 1885 by Edwin Klebs (1834–1913) and Friedrich Loeffler (1852–1915), both students of Koch. A diphtheria vaccine was developed in 1912, leading to the control of this disease in many parts of the world. Between 1876 and 1898, many pathogenic organisms were identified, providing a strong foundation for advances in vaccine development.

During the last quarter of the nineteenth century, it was apparent that inoculation of attenuated microorganisms could produce protection through active immunization of a host by generating antibodies to that organism. This, in turn, would protect the individual when exposed to the virulent (wild) organism. Passive immunization could be achieved in an already infected person by injecting the serum of animals infected with attenuated organisms. The serum from that animal helps to counter effects of the toxins produced by an invading organism. Pasteur's vaccines were followed by those of Waldemar Haffkine (1860–1930), a bacteriologist working in India. A remarkable figure, he was the first microbiologist to develop and use vaccines against cholera and bubonic plague, after testing them on himself. Other pioneering achievements include those of Richard Pfeiffer (1858–1945), a bacteriologist studying under Robert Koch and Sir Almoth Wright (1861–1947), known for his work in co-developing the typhoid vaccine. Albert Calmette (1863–1933), a bacteriologist, and Camille Guérin (1872–1961) a veterinarian, worked together, examining the intestinal route of TB. Through persistence and the constant replanting of bacterial cultures, the two developed the TB vaccine, called BCG (bacille Calmette–Guérin), named after the remarkable pair of researchers. Further contributory achievements include those of Theobald Smith (1859–1934), a pathologist most recognized for his research in Texas cattle fever, and Max Theiler (1899–1972, Nobel Prize 1951), a prominent South African physician successful in discovering the vaccine against yellow fever.

The twentieth century produced a flowering of immunology in the prevention of important diseases in animals and in humans based on the pioneering work of Jenner, Pasteur, Koch, and those who followed. Many major childhood infectious diseases have been controlled by immunization, one of the outstanding achievements of twentieth-century public health. The success of vaccines and other infection control in preventing cancers such as of the liver (hepatitis B vaccine) and the cervix (human papillomavirus, HPV), and gastric cancer (*Helicobacter pylori*) marked the beginning of an important new stage in public health.

Poliomyelitis

Poliomyelitis was endemic in most parts of the world prior to World War II, causing widespread crippling of infants and children, hence its common name of "infantile paralysis". The most famous polio patient was Franklin Delano Roosevelt, crippled by polio in his early thirties, who went on to become president of the USA. Massive epidemics of poliomyelitis during the 1940s and 1950s affected thousands of North American children and young adults. Consequently, national hysteria and fear of this disease ensued because of its crippling and killing power. In 1952, 52,000 cases of poliomyelitis were reported in the USA, bringing a national response and support for the "March of Dimes" Infantile Paralysis Association for research and field vaccine trials.

Based on the development of methods for isolating and growing the virus by John Enders and colleagues, Jonas Salk developed an inactivated vaccine in 1955 and Albert Sabin a live attenuated vaccine in 1961. Salk's field trial proved the safety and efficacy of his vaccine in preventing poliomyelitis. Sabin's vaccine proved to be cheaper and easier to use on a mass basis and is still the mainstay of polio eradication worldwide (Box 1.12). The conquest of this dreaded, disabling, and disfiguring disease has provided one of the most dramatic achievements of public health in the twentieth and early twenty-first centuries. Despite setbacks and economic recession limiting donor funding, there are good prospects for the elimination of poliomyelitis by 2015 or soon thereafter.

BOX 1.12 Salk and Sabin Vaccines and Poliomyelitis Eradication

In the early 1950s, John Enders (1897–1985) and colleagues developed methods of growing polio virus in laboratory conditions, for which they were ultimately awarded a Nobel Prize. At the University of Pittsburgh, physician and epidemiologist Jonas Salk (1914–1995) developed the first inactivated (killed) vaccine under sponsorship of a large voluntary organization (The March of Dimes), which mobilized the resources to fight this much dreaded disease. In 1954, Salk successfully completed the largest field trial ever, involving 1.8 million children. The vaccine was rapidly licensed and quickly developed and distributed in North America and Europe, interrupting the epidemic cycle and rapidly reducing polio incidence to low levels.

Albert Sabin (1906–1994) at the University of Cincinnati developed a live, attenuated vaccine given orally (OPV), which was approved by the FDA in 1961. This vaccine was an immediate success as it has many advantages: it is administered easily, spreads its benefits to non-immunized people, and is inexpensive. It became the vaccine of choice and was used widely, thus reducing polio to a negligible disease in most developed countries within a few years. Sabin also pioneered application of OPV through national immunization days in South America, which contributed to the eradication of polio in that region, and more recently, in many other continents and countries.

In 1987, the World Health Assembly of the WHO declared the target of eradication of poliomyelitis by the year 2000. With the help of international and national commitment, the Americas were declared polio free in 1990. A worldwide campaign has been conducted with improved routine immunization coverage, mass immunization days, and localized control measures, resulting in a widening of successful eradication across all continents. By the end of 2010, polio was still active in four countries, with a substantial outbreak in Tajikistan. Total polio cases worldwide declined from 650 cases in 2011 to 97 cases up to 11 July 2012. In 2012, polio remains endemic in Afghanistan, Nigeria, Pakistan, the Congo (DRC), and Chad, while India seems to have been polio free in 2011. Eradication of the natural transmission of the disease is anticipated by 2015, and an end-stage strategy recommended by the WHO will include a combined use of OPV and IPV.

Salk vaccine has been adopted by most western countries since 2006, but OPV continues to be used as the basic immunization for polio in most parts of the world, both as routine immunization and in mass immunization campaigns.

In 2012, a policy shift in use of polio vaccines occurred: "The polio eradication endgame plan is to switch from the trivalent oral polio vaccine, currently the vaccine of choice in most countries, to two vaccines: a new bivalent oral polio vaccine for routine immunization backed up by judicious use of inactivated polio vaccine (IPV)".

Eradication is within sight and the end-game strategy is important. In 2013, spread of Wild Polio Virus type 1 in the sewage in highly immunized Israel suggested that IPV alone may not prevent recurrence of polio spread.

Sources: *Tulchinsky TH, Goldblum N. Poliomyelitis immunization [letter to the editor]. N Engl J Med 2001;344:61–2. Available at: http://www.ncbi.nlm.nih.gov/pubmed/11187114 [Accessed 11 August 2012].*
Global Polio Eradication Initiative. Polio this week – as of 8 August 2012 [updated August 2012]. Geneva: Global Polio Eradication Initiative. Available at: http://www.polioeradication.org/Dataandmonitoring/Poliothisweek.aspx [Accessed 11 August 2012].
Aylward B. Ending polio, one type at a time. Bull World Health Organ 2012;90:482–3. Available at: http://www.who.int/bulletin/volumes/90/7/12-020712/en/index.html [Accessed 6 August 2012].

Advances in Prevention and Treatment of Infectious Diseases

Treatment of infectious diseases has also played a vital part in reducing the toll of disease and limiting its spread. Paul Ehrlich (1854–1915), seeking a "magic bullet", discovered an effective antimicrobial agent for syphilis (Salvarsan) and was awarded the Nobel Prize in 1908, jointly with Ilya Ilych Metchnikov (1845–1916) for the discovery of cellular immunity. In 1928, Alexander Fleming discovered the antibiotic quality of the momoldicillium, and in 1935 the first sulpsulfa(Prontosil) was discovered by German chemist Gerhard Domakh (1895-1964; 1939 Nobel Prize) followed by streptomycin by Selman Waksman (1888-1973) (Nobel Prizes 1945 and 1952). These and later generations of antibiotics have proven powerful tools in the treatment of infectious diseases.

Antibiotics and vaccines, along with improved nutrition, general health, and social welfare, led to dramatic reductions in infectious disease morbidity and mortality. As a result, optimistic forecasts of the conquest of communicable disease led to widespread complacency in the medical and research communities by the late twentieth century. In the 1990s, organisms resistant to available antibiotics constituted a major problem for public health and health care systems. Resistant organisms are now evolving as quickly as newer generation antimicrobials can be developed, threatening a return of diseases once thought to be under control. The pandemic of AIDS and other emerging and re-emerging diseases like SARS will require new strategies in treatment and prevention including new vaccines, antibiotics, chemotherapeutic agents, and risk reduction through community education.

Infections and Chronic Diseases

Since World War II, advances in immunology as applied to public health, eradication of smallpox, and near eradication of polio as well as the control and in some cases potential eradication of diphtheria, pertussis, tetanus, poliomyelitis, measles, mumps, rubella, and more recently hepatitis B and *Haemophilus influenzae* type b. The advent of immunizations to prevent infectious disease, and even potentially eradicate it, heralds a whole new area of endeavor for the vaccine field. The future in this field is promising and will play a central role in public health well into the twenty-first century.

In the past several decades, evidence for the long-held association between microbiological agents and cancer has accelerated and has now reached the point where effective treatment with antibiotics (for *H. pylori*) is associated with the cure of chronic peptic ulcer diseases. This, in turn, is associated with the decline in gastric cancer seen in developed countries.

The advent of hepatitis B vaccine gives real hope to the goal of reducing liver cancer, which is the third leading cause of cancer mortality globally, causing 695,000 deaths out of a total of 7.6 million cancer deaths in 2008. Hepatitis B affects 2 billion people worldwide, with 600,000 deaths from cirrhosis and cancer, while the global prevalence of hepatitis C is reported as 150 million people, with 350,000 deaths from cirrhosis and cancer (WHO, 2012, 2013). The recent discovery of Human Papilloma Virus (HPV) and the production of safe and effective vaccines provide hope for reducing even further cancer of the cervix, which has already been greatly reduced in most developed countries by Pap smear screening, and other cancers. The discovery of *H. pylori* as the main cause of chronic peptic ulcer diseases and gastric cancer offers hope for new breakthroughs in infectious origins of non-communicable disease which can be controlled or prevented by biomedical as well as behavioral changes. This breakthrough provides encouragement that infectious causes of other chronic diseases may lead to the development of new vaccines or antimicrobials for diseases long thought to be of genetic or environmental origin; the successes and great potential of public health are evident as ways are developed to continue the reduction in mortality and morbidity from chronic diseases.

MATERNAL AND CHILD HEALTH

Preventive care for the special health needs of women and children developed as a result of public concerns in the late nineteenth century. Public awareness of severe working conditions, especially for women and children, grew to encompass the health effects of poverty, poor living conditions and general hygiene, home deliveries, lack of prenatal care, and poor nutrition.

Preventive care as a service separate from curative medical services for women and children was initiated in the unsanitary urban slums of industrial cities in nineteenth-century France, in the form of "milk stations" (*gouttes de lait*). The plan was later expanded to a complete child welfare effort, especially promoting breastfeeding and a clean supply of milk to children, which had dramatic effects in reducing infant deaths.

The concept of child health spread to other parts of Europe and the USA with the development of pediatrics as a specialty and an emphasis on appropriate child nutrition. Henry Koplik (1858–1927) in 1889 and Nathan Strauss (1848–1931) in 1893 promoted centers to provide safe milk to pregnant women and children in the slums of New York City in order to combat summer diarrhea. The Henry Street Mission, serving poor immigrant areas, developed the model of visiting nurses and public milk stations. The concept of the "milk station", combined with home visits, was pioneered by Lillian Wald (1867–1940), who coined the term *district nurse* or *public health nurse*. This became the basis for public prenatal, postnatal, and well-child care, as well as school health supervision. Visiting Nursing Associations (VNAs) gradually developed throughout the USA to provide such services. Physicians' services in the USA were mainly provided on a fee-for-service basis for those able to pay, with charitable services in large city hospitals. The concept of direct provision of care to those in need by local authorities and by voluntary charitable associations, with separation between preventive and curative services, is still a model of health care in many countries. Maternal mortality at the beginning of the twentieth century was at levels current in developing countries today. Since the 1920s, the maternal mortality rates drastically declined in the USA owing to improved access to professional prenatal care and delivery (Figure 1.1).

In Jerusalem in 1902, Shaare Zedek Hospital kept cows to provide safe milk for infants and pregnant women. In 1911, two public health nurses came from New York to Jerusalem to establish milk stations (*Tipat Halav*, "drop of milk") for poor pregnant women and children. This model became the standard method of Maternal and Child Health (MCH) provision throughout Israel, operating in parallel to the Sick Funds which provide medical care. The separation between preventive and curative services persists to the present, and is sustained by the Israeli national government's obligation to ensure basic preventive care to all, regardless of ethnicity, gender, prior conditions or ability to pay.

In the Soviet Union, institution of the state health plan in 1918 by Nikolai Semashko emphasized maternal and child health, along with epidemic and communicable disease control. All services were provided free as a state responsibility through an expanding network of polyclinics and prenatal and child care centers, including preventive checkups, home visits, and vaccinations and other services. Infant mortality declined rapidly even in the Asian republics with previously poor health conditions.

During the 1990s, the USA was having difficulty in immunizing children in areas of high poverty in urban centers. Immunization was adopted as part of the USA's excellent Women, Infants, and Children (WIC) food support program for poor pregnant women and children. WIC's inclusion of immunization contributed to much higher coverage levels being achieved than in previous years.

The emphasis placed on maternal and child health continues to be a keystone and a major pillar of public health.

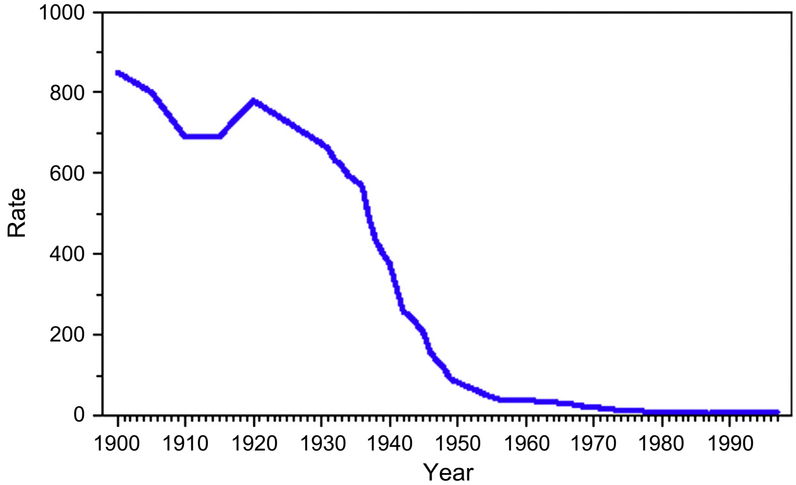

FIGURE 1.1 Maternal mortality per 100,000 live births, USA, 1900–1997. *Source: Centers for Disease Control and Prevention. Achievements in public health, 1900–1999: healthier mothers and babies. MMWR Morb Mortal Wkly Rep 1999;48:849–88. Available at: http://www.cdc.gov/mmwr/preview/mmwrhtml/mm4838a2.htm [Accessed 11 August 2012].*

Central to care of children and women in relation to fertility is the application of what later came to be called the "risk approach", where attention is focused on designing health programs for the most vulnerable groups in the population.

Maternal mortality remains a major public health issue globally, as currently approximately 800 women lose their lives to pregnancy or birth-related complications each day. Moreover, there is widespread serious morbidity due to anemia, susceptibility to infections and vesicovaginal fistulae causing drastic health and social effects. The 2001 Millennium Development Goals (MDGs) included reducing maternal mortality by one-third; this target has been met in some countries but largely failed in sub-Saharan Africa and in India. Child marriages and pregnancies, low levels of education, and lack of access to professional prenatal and delivery care are still widely prevalent causative conditions.

NUTRITION IN PUBLIC HEALTH

As infectious disease control and later maternal and child health became public health issues in the eighteenth to nineteenth centuries, nutrition gained recognition from the work of pioneers such as James Lind (see the earlier section entitled "Applied Epidemiology"). In 1882, Kanehiro Takaki (1849–1920), surgeon-general of the Japanese navy, reduced the incidence of beriberi among naval crews by adding meat and vegetables to their diet of rice. In 1900, Christiaan Eijkman (1858–1930), a Dutch medical officer in the East Indies, found that inmates of prison camps who ate polished rice developed beriberi, while those eating whole rice did not. He also produced beriberi experimentally in fowls on a diet of polished rice, thus establishing the etiology of the disease as a deficiency condition and fulfilling a nutritional epidemiological hypothesis. Eijkman was awarded the Nobel Prize in Physiology or Medicine in 1929.

In the USA, the pioneering Pure Food and Drug Act was passed in 1906, stimulated by journalistic exposures of conditions in the food industry and Upton Sinclair's famous 1906 novel *The Jungle*. The legislation established federal authority in food and labeling standards, originally for interstate commerce, but later for the entire country. This provided for a federal regulatory agency and regulations for food standards. The Food and Drug Administration (FDA) has pioneered nutritional standards now used throughout the world.

In the early part of the twentieth century, the United States Department of Agriculture (USDA) supported "land grant colleges" and extension services in rural counties to promote agricultural improvement and good nutrition in poor agricultural areas of the country. These services, along with local women's organizations, helped to create a mass movement to improve nutrition. Actions included canning surplus foods, house gardening, home poultry production, home nursing, furniture refinishing, and other skills that helped farm families to survive the years of economic depression and drought. These, in turn, promoted better nutrition through education and community participation.

In 1911, the chemical nature of vitamin D was discovered, and a year later, Kasimir Funk (1884–1967) coined the term vitamin ("vital amine"). Goldberger's work established the dietary causes of pellagra, and in 1928 he discovered the pellagra-preventing factor in yeast (Box 1.13). In 1916, US investigators defined fat-soluble vitamin A and water-soluble vitamin B; the latter was later shown to be more than one factor. In 1922, Elmer McCollum (1879–1967) identified vitamin D in cod liver oil, which became a staple in child care for many decades. Rickets, still common in

BOX 1.13 Goldberger on Pellagra

"Mal de la rosa", first described in Spain by Casal in 1735, was common in northern Italy. In 1771, Frappolli described "pelle agra" or farmers' skin, often mistaken for leprosy. Pellagra was a common disorder among poor farm families whose diet consisted mainly of corn flour. Pellagra is characterized by the "4 Ds": diarrhea, dermatitis, dementia, and death. In 1818, Hameau described a widespread skin disease among poor farmers in southern France. Theophile Roussel (1816–1903) investigated and concluded that pellagra was endemic and due to poverty rather than a diet heavy in corn. The French Department of Agriculture implemented his recommended reforms, raising standards of living among poor farmers by encouraging them to grow wheat and potatoes instead of corn. Consequently, the disease disappeared by the beginning of the twentieth century. Similar measures in Italy reduced the growth of corn, and here too the disease disappeared. Lambrozo, in Verona, Italy, reported many cases of pellagra among mental hospital patients, also concluding that it was due to toxic material in corn. At the beginning of the twentieth century, the corn theory was less accepted and the common view was that pellagra was an infectious disease. British investigator L. V. Sambon, discoverer of the role of the tsetse fly in trypanosomiasis in 1910, took the view that the disease was mosquito borne.

Pellagra was first reported in the USA in 1906 as an epidemic in a mental hospital in Alabama. In the first decades of the twentieth century, pellagra was considered the leading public health problem in the southern USA, where poverty was rampant, and generally believed to be infectious in origin. Between 1907 and 1940, approximately three million Americans contracted pellagra and 100,000 of them died.

In 1913, Joseph Goldberger (1874–1929) of the US Public Health Service was appointed by the Surgeon General to investigate the pellagra epidemic in the southern USA. Goldberger had previously worked on yellow fever, dengue, and typhus. He visited psychiatric hospitals and orphanages with endemic pellagra and was struck by the observation that the staff was not affected, suggesting that the disease was not infectious. He recognized that non-transmission from patients to staff suggested a non-infectious cause. He postulated that it may have been due to the diet. In one mental hospital, he eliminated pellagra by adding milk and eggs to the diet and concluded that the disease was due to a lack of vitamins and preventable by a change in diet alone. He went on to establish the nutritional basis of this disease: a landmark in nutritional epidemiology in public health.

In 1999, the Centers for Disease Control and Prevention reported:

"Pellagra is a good example of the translation of scientific understanding to public health action to prevent nutritional deficiency. Pellagra, a classic dietary deficiency disease caused by insufficient niacin, was noted in the South after the Civil War. Then considered infectious, it was known as the disease of the four Ds: diarrhea, dermatitis, dementia, and death. The first outbreak was reported in 1907. In 1909, more than 1000 cases were estimated based on reports from 13 states. One year later, approximately 3000 cases were suspected nationwide based on estimates from 30 states and the District of Columbia. By the end of 1911, pellagra had been reported in all but nine states, and prevalence estimates had increased nearly ninefold.

During 1906–1940, approximately 3 million cases and approximately 100,000 deaths were attributed to pellagra. From 1914 until his death in 1929, Joseph Goldberger, a Public Health Service physician, conducted groundbreaking studies that demonstrated that pellagra was not infectious but was associated with poverty and poor diet. Despite compelling evidence, his hypothesis remained controversial and unconfirmed until 1937. The near elimination of pellagra by the end of the 1940s has been attributed to improved diet and health associated with economic recovery during the 1940s and to the enrichment of flour with niacin. Today, most physicians in the United States have never seen pellagra although outbreaks continue to occur, particularly among refugees and during emergencies in developing countries.

The growth of publicly funded nutrition programs was accelerated during the early 1940s because of reports that 25% of draftees showed evidence of past or present malnutrition; a frequent cause of rejection from military service was tooth decay or loss. In 1941, President Franklin D. Roosevelt convened the National Nutrition Conference for Defense, which led to the first recommended dietary allowances of nutrients, and resulted in issuance of War Order Number One, a program to enrich wheat flour with vitamins and iron. In 1998, the most recent food fortification program was initiated; folic acid, a water-soluble vitamin, was added to cereal and grain products to prevent neural tube defects."

Sources: *Centers for Disease Control and Prevention. Ten great public health achievements – United States, 1900–1999. MMWR Morb Mortal Wkly Rep 1999;48:241–3. Available at: http://www.cdc.gov/mmwr/preview/mmwrhtml/00056796.htm [Accessed 11 August 2012].*
Office of NIH History. Dr Joseph Goldberger and the war on pellagra: Goldberger vs. the south. Bethesda, MD: Office of NIH History. Available at: http://history.nih.gov/exhibits/goldberger/docs/south_6.htm [Accessed 11 August 2012].

industrialized countries prior to World War II and into the 1950s, virtually disappeared following fortification of milk with vitamin D. In the period 1931–1937, fluoride in drinking water was found to prevent tooth decay, in 1932 vitamin C was isolated from lemon juice.

Iodization of salt to prevent iodine deficiency disorders (IDD) has been one of the greatest successes, and failures, of twentieth-century public health. From studies in Zurich and in the USA, the efficacy of iodine supplements in preventing goiter was demonstrated. In 1924 Morton's iodized salt became a national standard in the USA; it served as an early and noble example of voluntary public health action by private industry. In 1941, the USA initiated mandatory fortification of "iodine-enriched" salt, as well as flour (iron, vitamins B and later folic acid) and milk (with vitamin D). In Canada, iodized salt became mandatory in 1979 along with other vitamin and mineral fortification of bread and milk (see Chapter 8). Prevention of IDD by salt iodization has become an important goal in international health, and progress is being made towards universal iodization of salt in many countries where goiter, cretinism, and iodine deficiency are still endemic. In 1998, folic acid fortification of flour for prevention of birth defects was adopted in the USA, Canada, and Chile, and by 2013 had been adopted in over 60 other countries.

The international movement to promote proper nutrition is vital to reduce the toll of the malnutrition–infection cycle in developing countries. No less important is prevention of non-communicable diseases associated with overnutrition, including cardiovascular diseases, diabetes, and some cancers in industrialized nations. Nutrition is a key issue in the New Public Health, with international movements to eradicate vitamin and mineral (micronutrient) deficiency conditions, all of which are important, widespread, and preventable.

MILITARY MEDICINE

Professional armies evolved with urban civilizations and developed in the ancient world from about 4000 BCE. Since organized conflict began, armies have had to deal with the health of soldiers as well as treatment of the wounded. Injunctions on military and civilian camp placement and sanitation were clearly spelled out in the Bible (Old Testament). Roman armies excelled at construction of camps with care and concern for hygienic conditions, food, and medical services for the soldiers. Throughout history, examples of the defeat of armies by disease and lack of support services prove the need for paying serious attention to the health and care of the soldier. Studies of casualties of war in major conflicts contribute not only to military medicine but to knowledge of the care of civilian populations in natural or human-made disasters.

As the armies and weapons became increasingly powerful, the care of the sick and wounded became more complex. Military medicine perfected knowledge and skills in taking care of wounded on the battlefield and preventing loss of life. Epidemics in armies have killed more troops than weapons have; thus, treating and preventing disease is an integral part of military medicine. Many medical discoveries have been implemented in the army and later in civil society, including surgery, vaccination, antibiotics, and nutrition.

The Roman Empire developed military medicine as its professional armies spread across the known world. The Roman army included physicians to provide medical care for the legions, beginning with ensuring that only the best (and most intelligent) candidates were recruited. Once in service, the military medical corps strove to ensure the general health of the soldier by a continuous emphasis on hygiene. The design of legion fortifications and encampments ensured a healthy environment for the troops. Following the destruction of Rome and later the eastern empire, the Roman military medical tradition disappeared. Military medicine during the Middle Ages was relatively primitive.

Jean Henri Dunant (1828–1910), a young Swiss businessman, arrived in Solferino, Italy, on the evening of the battle fought on 24 June 1859, between the French–Sardinian allies against the Austrian army. Some 38,000 injured, dying, and dead soldiers remained on the battlefield, with little attempt to provide care. Dunant took the initiative to organize volunteers from the local civilian population, especially the women and girls, to provide assistance to the injured and sick soldiers. He organized the purchase of needed materials and helped to erect makeshift hospitals, providing care for all without regard to their affiliation in the conflict. He worked alongside volunteer doctors and Austrian doctors captured by the French.

After returning to Geneva, Dunant published a book about his experience, *A Memory of Solferino*, describing the battle, its costs, and the chaos afterwards. He proposed that in the future a neutral organization should be established to provide care to wounded soldiers. His work led to the First Geneva Convention on the treatment of non-combatants and prisoners of war, now ratified by 194 countries. Moreover, his experiences and achievements resulted in the foundation of the International Committee of the Red Cross in 1863. Dunant was awarded the first Nobel Prize for Peace in 1901.

The Crimean War was a medical disaster for the British Army, characterized by higher mortality from disease than from battle, largely due to poorly organized sanitation, supply, and medical services. Mortality rates among British amputees in the Scutari Hospital averaged nearly 30 percent. Of every 100 men in the French forces admitted to military hospitals, 42 percent died – a hospital mortality rate equivalent to that of the Middle Ages. In November 1854, after the battle of Balaklava, Florence Nightingale and her 18 trained nurses introduced basic standards of hygiene, nutrition, sanitation, and administration in the British military hospitals. Upon her arrival, Nightingale reported a hospital mortality rate at Scutari of 44 percent. As a result of her efforts, the rate dropped remarkably, to 2 percent by the end of the war.

Nightingale's work made an enormous contribution to the knowledge and practice of hospital organization and management. On the opposing side of the same Crimean War, Nikolai Perogov (1810–1881), a military surgeon in the Russian czarist army, developed rectal anesthesia for field surgery. He also established triage of the wounded by degree of severity, as well as hygiene of wounds. Perogov defined improved systems for the management of the wounded in war theaters, which had applicability in civilian hospitals. The French army in World War I further developed the triage system of casualty clearance, now used worldwide in military and disaster situations, in public health emergencies, and in hospital emergency rooms.

Nutrition of sailors on long sea voyages and Lind's classic epidemiological study of scurvy, followed a century later by the work on beriberi, were crucial steps in identifying the importance of nutrition to public health. Bismarck's establishment of national health insurance and other benefits for workers was partly based on the need to improve the health of the general population in order to build mass armies of healthy conscripts (see Chapter 13). During conscription to the US Army in World War I, the high rates of rejection of draftees who were considered medically unfit for military service raised concerns over national health standards. Finding high rates of goiter in the draftees to the US Army led to efforts to identify high-risk areas and to reduce iodine deficiency in the civilian population by iodization of salt.

In the wake of World War I, a massive pandemic of influenza killed some 20 million people. The "Spanish flu" pandemic lasted from 1918 to 1919. Current estimates reveal that 50–100 million people worldwide died in this pandemic, described as the "greatest medical holocaust in history" as it may have killed as many people as the Black Death. The Spanish flu, closely following the huge losses of World War I, was to a large degree spread in the close quarters of army camps and by the mass movement of troops, with a high percentage of the deaths occurring among young men, the group most affected by the war itself.

Epidemics of louse-borne typhus in Russia, following the war and the Russian Revolution, contributed to the chaos of the period and prompted Lenin's famous statement, "Either socialism will conquer the louse, or the louse will conquer socialism". In World War II, sulfa drugs, antimalarials, and antibiotics made enormous contributions to the Allied war effort and later to general health care and preserving the health of the population. Lessons learned in war for protection of soldiers from disease and treatment of burns, crash injuries, amputations, battle fatigue, post-traumatic stress disorder, and many other forms of trauma were brought back to civilian health systems. Much of modern medical technology was first developed for or tested by the military. As an example, sonar radio wave mechanisms developed to detect submarines were adapted after World War II as ultrasound, now a standard non-invasive instrument in medical care.

In the twentieth century, two world wars, with enormous loss of human life not only of combatants but also of civilians, the eugenics movement and its downstream effects of the mass murder of handicapped people and genocide in the Holocaust, brought wider challenges to public health ethics. Not only had the destructiveness of war increased enormously with chemical, biological, and nuclear weapons of mass destruction, but medical and public health ethics were to have severe consequences on the public acceptance of public health as a profession and in civil society. The Nuremberg Trials addressed the Holocaust and unethical medical experimentation by the Nazi military on civilian and military prisoners. The infamous Tuskegee experiment of untreated syphilis in African American men in the USA in the period 1932–1972 brought these issues into the open arena of public debate. The International Declaration of Human Rights (1948), Convention on the Prevention and Punishment of the Crime of Genocide (1948) and the Helsinki Declaration (1964) set new standards for medical and research ethics, with important implications for public health (see Chapter 15).

The brutalities of wars against civilian populations have tragically recurred even near the end of the twentieth century in genocidal warfare in Iraq, Rwanda, the former Yugoslavia and in Syria (2011-2013). Those tragedies produced massive casualties and numerous refugees, with resultant public health crises requiring intervention by local and international health agencies. International and national public health agencies have a major responsibility for preventing the mass tragedies of the twentieth century from recurring, perhaps on a larger scale in the twenty-first century, with the spread of the potential for chemical, biological, and nuclear terrorism.

GLOBALIZATION OF HEALTH

Cooperation in health has been a part of international diplomacy from the first international conference on cholera in 1851 in Cairo to the health organization of the League of Nations after World War I, and further, into modern times. Following World War II, international health began to promote the widespread application of public health technology, such as immunization, to developing countries. Established in 1948, the World Health Organization's (WHO's) constitution was signed in 1946, with the charter defining health as "the complete state of physical, social and mental well-being, and not merely the absence of disease".

The tradition of international cooperation continues by organizations such as the WHO, the International Red Cross/Red Crescent (IRC), the United Nations Children's Fund (UNICEF), and a myriad of others. Under the leadership of the WHO, the eradication of smallpox was achieved by 1977, through united action, demonstrating that major threats to health could be controlled through international cooperation. The potential eradication of polio further demonstrates this principle.

The international spread of disease has taken enormous tolls on human life globally and the threat continues in the twenty-first century. Public health threats can emerge and spread rapidly, as seen with the human immunodeficiency virus (HIV) pandemic since the 1980s and SARS in 2003. More recently, concerns have grown over potentially devastating pandemic influenza, such as the H5N1 virus strain known as avian influenza.

Chronic diseases, including mental health, characterized the most common causes of mortality and disability in the industrialized countries in the latter half of the twentieth century. They are now also predominant in most developing countries with growing per capita incomes and middle-class communities. Obesity, diabetes, heart disease, and cancer are among the leading causes of morbidity and mortality in the modern world. The toll of violence, often overlooked as a public health problem, cannot be overstated. Many other factors affect health globally, including environmental degradation as it relates to global warming, accumulation of toxic wastes, acid rain, nuclear accidents, loss of biodiversity with the destruction of natural ecosystems such as the Amazon basin rainforests, and the human tragedy of chronic poverty of many people in developing countries and some even in the wealthiest of countries. Global health issues and social disparities are by their very nature beyond the capacity of individual or even groups of countries to solve. They require organized common efforts of governments, international agencies, and non-governmental organizations, cooperating with each other, with industry, and with the media to bring about change and reduce the common hazards caused by abuse of the environment and social gaps.

Tobacco is the leading preventable risk factor for premature mortality worldwide. Estimates of 5 million annual deaths attributable to smoking do not adequately measure the impact of the tobacco pandemic. Tobacco use contributes to and exists as a comorbidity factor in a very wide spectrum of diseases and has justly become a major issue of public health. Over half of the estimated 650 million people currently smoking will die from effects of this addiction and if current smoking patterns continue, it will cause more than 10 million deaths yearly by 2020. Recognition of tobacco control is gaining the support of researchers, medical professionals, politicians, and communities around the world. The Centers for Disease Control and Prevention (CDC) sees recognition of tobacco as a public health hazard as one of the greatest public health achievements of the twentieth century in the USA. The WHO's Framework Convention on Tobacco Control, adopted by the 56th World Health Assembly in 2003, placed elimination of tobacco use as one of the greatest public health challenges, but one far from fruition.

Bringing health care to all is as great a challenge as feeding a rapidly growing global population. Successes in the eradication of smallpox and the control of many other diseases by public health measures show the potential for concerted international cooperation and action targeted at specific objectives that reduce disease and suffering.

EPIDEMIOLOGICAL TRANSITION

As societies evolve, so do patterns of disease. These changes are partly the result of public health and medical care but just as surely are due to improved standards of living, nutrition, housing, and economic security, as well as changes in fertility and other family and social factors. As disease patterns change, so do appropriate strategies for intervention.

During the first half of the twentieth century, infectious diseases predominated as causes of death even in the developed countries. Since World War II, a major shift in epidemiological patterns has taken place in the industrialized countries, with the decline in infectious diseases and the growth in non-infectious diseases as causes of death. Increases in longevity have occurred primarily from declining infant and child mortality, improved nutrition, control of vaccine-preventable diseases, and the advent of antibiotics for treatment of acute infectious diseases. The rising incidence of cardiovascular diseases and cancer affects primarily older people, leading to a growing emphasis in epidemiological investigations on causative risk factors for these non-infectious diseases.

Studies on the distribution of non-infectious diseases in specific groups go back many centuries to when the Romans reported excess death rates among specific occupational groups. These studies were updated by Ramazzini in the early eighteenth century. As noted earlier, in eighteenth-century London, Percivall Pott documented that cancer of the scrotum was more common among chimney sweeps than in the general population. Nutritional epidemiological studies, from Lind on scurvy among sailors in 1747 to Goldberger on pellagra in the southern USA in 1914, focused on nutritional causes of non-infectious diseases in public health.

Observational epidemiological studies of "natural experiments" produced enormously important data in the early 1950s, when pioneering investigators in the UK, Richard Doll (1912–2005), Austin Bradford Hill (1897–1991), and Richard Peto (1943–present), demonstrated a relationship between tobacco use and lung cancer. They followed the mortality patterns of British patients from different causes, especially lung cancer. They found that mortality rates from lung cancer were 10 times higher in smokers than in non-smokers. Epidemiological studies pointing to the relationship of diet and hypertension with cardiovascular diseases also provided critically important material for public health policy. This raised public concern and consciousness in western countries of the impact and influence of lifestyle on public health. In this new era of public health, the complementary relationship between miasma and germ theories is recognized (Box 1.14). These issues are discussed subsequently throughout this book.

In the mid-twentieth century, while communicable diseases were coming under control, risks related to modern living developed. These include cardiovascular disease, trauma, cancer, and other chronic diseases, which have become the predominant causes of premature death, hospitalization, and disability. These conditions are more complex than the infectious diseases, both in causation and in the means of prevention. Despite the complexity and associated challenges, public health interventions have shown surprising success in combating this set of mortality patterns, with a combination of improved medical care and activities under the general title of health promotion.

BOX 1.14 Complementarities of the Miasma and Germ Theories

In the mid-nineteenth century, the miasma theory (i.e., the concept that airborne vapors or "miasmata" caused most diseases) competed with the germ theory (i.e., specific microorganisms cause specific diseases). The latter gained pre-eminence among scientists and biological sciences, yet the miasma theory was the basis for action by sanitary reformers. Miasma explained why cholera and other diseases were epidemic in places where the undrained sewage water was foul smelling. Their endeavors led to improved sanitation systems, which resulted in decreased episodes of cholera. The connection between dirtiness and diseases led to public health reforms and encouraged environmental and personal cleanliness. The miasma theory was consistent with the observations that disease was associated with poor sanitation and foul odors, and that sanitary improvements were successful in reducing disease.

Echoes of these two theories continue to compete even today. Applied to chronic disease related to toxins (e.g., smoking) or nutritional indicators (e.g., blood lipids and micronutrient deficiency conditions), the environmental focus of the sanitary reformers is reflected in the idea that environmental and social conditions are the main factors in these diseases. This is in contrast to the more biomedically oriented approach of the intellectual descendants of germ theory of infectious diseases. Clearly, both are operative, with improved infectious disease control and environmental and social conditions all contributing to improved longevity and reduced burden of many diseases. However, large gaps remain between rich and poor as a result of differential social, economic, and cultural differences.

In 2007, the *British Medical Journal* conducted an opinion survey of the most important medical innovations of all time. The clear winner was the "sanitary revolution as greatest medical advance since 1840". Major problems remain today, as millions of people die annually from lack of modern sanitation of safe drinking water and poor sewage and solid waste disposal. Other large-scale killers are infectious diseases for which highly effective vaccines or other management tools exist.

Even in developed countries, management of infectious diseases is still a major public health issue, and includes the annual loss of life from influenza, pneumonia, medically related diseases such as multidrug-resistant tuberculosis, and the rise of drug-resistant organisms, which were easily controlled by antibiotics a short generation ago. Biomedical and socioecological approaches will need to be combined in the future to address these major issues.

Sources: *Ferriman A. BMJ readers choose the "sanitary revolution" as greatest medical advance since 1840. BMJ 2007;334:111. Available at: http://www.bmj.com//content/334/7585/111.2?variant=full-text [Accessed 11 August 2012].*
Mackenbach JP. Sanitation: pragmatism works. BMJ 2007;334:s17. Available at: http://www.bmj.com/content/334/suppl_1/s17.full [Accessed 11 August 2012].

At the beginning of the twenty-first century, the need to link public health with clinical medical care and organization of services became increasingly apparent. The decline in coronary heart disease mortality has been accompanied by a slow increase in morbidity, and recent epidemiological evidence shows new risk factors not directly related to lifestyle, but requiring longitudinal preventive care to avert early recurrence and preventable premature death. Progress continues into the twenty-first century as new challenges arise.

ACHIEVEMENTS OF PUBLIC HEALTH IN THE TWENTIETH CENTURY

The foundations of public health organization were established in the second half of the nineteenth and first half of the twentieth centuries. Water sanitation, waste removal, and food control developed at municipal and higher levels of government, the establishment of organized local public health offices with state and federal grants, and improved vaccination technology all contributed to the control of communicable diseases. Organized public health services implemented the regulatory and service components of public health in developed countries, with national standards for food and drug safety, state licensing, and discipline in the health professions.

At the beginning of the twentieth century, there were few effective medical treatments for disease, but improved public health standards resulted in reduced mortality and increased longevity. As medical technology improved following World War II with antibiotics, antihypertensives, and psychotherapeutic drugs, much focus shifted to curative medical care, with a widening chasm between public health and medicine. In our time, a new interest in the commonality between the two is emerging, as new methods of organizing and financing health care develop. The aim is to contain the rising costs of health care, while simultaneously increasing the utilization of preventive medicine.

National and state efforts to promote public health during the twentieth century widened in scope of activities and financing programs. This required linkage between governmental and non-governmental activities for effective public health services. Dramatic scientific innovations brought vaccines and antibiotics that, in conjunction with improved nutrition and living standards, helped to control infectious disease as the major cause of death. In the developed countries, the advent of national or voluntary health insurance on a wide scale opened access to health care to all of the population.

The modern era of public health from the 1960s to today has brought a new focus on non-infectious disease epidemiology and prevention. Important epidemiological studies of the impact of diet and smoking on cardiovascular diseases, and smoking on lung cancer, identified crucial

BOX 1.15 Ten Great Achievements of Public Health in the USA in the Twentieth Century

During the twentieth century, health and life expectancy in the USA improved dramatically. Since 1900, average lifespan has lengthened by over 30 years, and 25 years of this gain is attributable to advances in public health. *Morbidity and Mortality Weekly Report* (*MMWR*) profiled 10 public health achievements in a series of reports published in 1999. These reflect similar public health achievements in many industrialized countries:

- Control of infectious disease
- Vaccination
- Motor vehicle safety
- Safer workplaces
- Decline in deaths from coronary heart disease, strokes
- Safer and healthier foods
- Healthier mothers and babies
- Family planning
- Fluoridation of drinking water
- Recognition of tobacco as a health hazard.

Source: *Centers for Disease Control and Prevention. Ten great public health achievements – United States, 1900–1999. MMWR Morb Mortal Wkly Rep 1999;48:241–3. Available at: http://www.cdc.gov/mmwr/preview/mmwrhtml/00056796.htm [Accessed 11 August 2012].*

preventable risks factors for chronic disease. As a result of these and similar studies of disease and injury related to the environment, modern public health has, through health promotion and consumer advocacy, played a significant role in mortality and morbidity reduction for a spectrum of diseases. For prevention of premature disease and death, more comprehensive approaches will be needed by public health and health care providers than have been developed to date.

The twentieth century saw great achievements in public health in the industrialized countries, indeed throughout the world. The CDC reviewed these achievements in a series of publications in 1999, which represent the potential for public health and, if not a universal "gold standard", at least a well-documented set of achievements and potential for public health everywhere (Box 1.15).

The dream of international and national health agencies to achieve *Health for All* faces serious obstacles of inequities, lack of resources, distortions with overdevelopment of some services at the expense of others, and competing priorities. Managing health care to use resources more effectively is now a concern of every health professional. At the same time, public expectations are high for unlimited access to care, including the specialized and highly technical services that can overwhelm the available budgetary and personnel resources. All nations, wealthy or poor, face the problem of managing limited resources, exacerbated since 2008 by a severe global recession. How that will be achieved is part of the challenge we discuss as the New Public Health.

CREATING AND MANAGING HEALTH SYSTEMS

Provision of medical care to the entire population is one of the great challenges of public health. Governments as insurers, providers, or regulators of health care have broad responsibilities for health of the people. As will be discussed in subsequent chapters, nations have many reasons to ensure health for all, just as they promote universal education and literacy. National interests in the late nineteenth and early twentieth centuries were defined to include having healthy populations, especially of workers and soldiers, and for national prestige. Responsibility for the health of a nation included measures for the prevention of disease, but also financing and prepayment for medical and hospital care. National policies gradually took on measures to promote health, structures to evaluate the health of the nation, and modification of policies to keep up with changing needs.

The health of a population requires that people have access to medical and hospital services as well as preventive care, a healthy environment, and a health promotion policy orientation. Greek and Roman cities appointed doctors to provide free care for the poor and the slaves. Medieval guilds provided free medical services to their members. In 1883, Germany introduced compulsory national health insurance to ensure healthy workers and army recruits, which would provide a political advantage. In 1911, Britain's Chancellor of the Exchequer, Lloyd-George, instituted the National Insurance Act, providing compulsory health insurance for workers and their families. In 1918, following the October Revolution, the Soviet Union created a comprehensive state-operated health system with an emphasis on prevention, providing free comprehensive care in all parts of the country.

During the 1920s, national health insurance was expanded in many countries in Europe. Following the Great Depression of the 1930s and hopes raised by the Allied victory in World War II, important social and health legislation was enacted to provide health care to the populations of Britain, Canada, and the USA. In Britain the welfare state including the National Health Service (NHS) was developed by the Labour Government. In Canada, a more gradual development took place in the period from 1946 to 1971, including the establishment of national pensions and a national health insurance program. In the USA, social legislation has been slow in coming following the defeat of national health insurance legislation in Congress in 1946 and long-standing ideological opposition to "socialized medicine". In 1965, however, universal coverage of the population over age 65 (Medicare) was instituted and coverage for the poor under Medicaid soon followed. Inadequate coverage of workers and low-income American families is still a serious problem, although health reforms initiated by President Barak Obama in 2009 and approved by Congress in 2010 promise to extend health coverage to millions of Americans in the coming years. The Affordable Care Act is politically controversial; however, when challenged in the Supreme Court it was ruled as within constitutional limits. It will add many millions of Americans to health insurance but not yet to universal health care, which is the gold standard in all other developed countries. In the first decade of the twenty-first century, virtually every country has in principle undertaken responsibility to provide for the health and social well-being of its population, but the gaps and inequities in their achievements are wide. The term *health systems* may imply a formalized structure or a network of functions that work together to meet the needs of a population through health insurance or health service systems. Private health insurance is still the dominant mode in the USA, but the elderly and the poor are covered by government health insurance (see Chapter 13). The American public health community is currently seeking means to achieve universal health coverage. Prepayment for health is financed through general tax revenues in many countries, and in others through payment by workers and employers to social security systems. Both developed and developing countries are involved in financing health care, as well as research and training of health professionals.

Industrialized countries share increasing concerns of cost escalation, with health expenditure costs impacting general economic growth. While health care is a large-scale employer in all developed countries, high and rising expenditures for health, reaching over 16 percent of gross domestic product in the USA, and around 10 percent in many other western countries, is a major factor in stimulating health care reform. Many countries are struggling to keep up with the rising costs of technology and competition from other social needs, such as education, employment, and social welfare, all of which are important for national health and well-being. Some economic theories allocate no economic value to a person except as an employee and a consumer. Liberal and social democratic political philosophies advocate an ethical concern and societal responsibility for health. Both approaches now concur that health has social and economic value. The very success of public health has produced a large increase in longevity, thus increasing the percentage of elderly people in the population, raising ethical and economic questions regarding improved preventive, therapeutic and diagnostic techniques, health care consumption, allocation of services, and social support systems.

For developing countries, providing health care for the entire population is a distant dream. Limited resources and overspending on high-technology facilities in larger cities leave little funding for primary care for the rural and urban poor. Despite this, there has been real progress in implementing fundamental services such as immunization and prenatal care. Still, millions of preventable deaths occur annually because of a lack of basic primary care programs.

CHALLENGES IN THE TWENTY-FIRST CENTURY

Dramatic events in the late decades of the twentieth century and the first decade of the twenty-first have deeply affected public health. Since the 1960s, the capacity of public health has widened, with local, national, and global perspectives. The public sector has come to work with private sector influences on activities such as the global eradication of polio and the control of AIDS and malaria in sub-Saharan Africa. New attention has come to focus on many unmet human rights issues such as slave trafficking and genocide, which are still inadequately addressed in the international development agenda. Economic globalization is increasingly associated with health and human rights in academic and public discourse. They have met partial success and some failures in achieving global health goals in the context of political, economic, and public health values. The global recession that began in 2008 will undoubtedly have a negative impact on such global health goals, but the clear advantage of cost-effective prevention interventions will become more and more apparent.

The understanding of the enormous impact of smoking reduction, healthier diets, improved road safety, improved medical care for hypertension, and long-term management of chronic conditions, mainly in the developed countries, is now being recognized as essential for developing countries at all stages of the development process. Public health achievements are reaching mid-level developing countries and the emerging economies such as Brazil, India, China, South Africa, and South-East Asia. Despite powerful economic growth, China and India especially still remain poor for the majority of their citizens. The countries lagging behind in sub-Saharan Africa still suffer from weak infrastructure, corruption, and political instability, which prevent the use of their natural resources to build modern economies and civil structures of public health. Political instability and inadequate infrastructure and the mixed effects of globalization and recession also negatively influence public health.

Scientific advances in the discovery of causes of some chronic diseases in the late twentieth century are coming as public health advances in the prevention of birth defects (by folic acid consumption before and during pregnancy), cancers of the stomach (from *H. pylori* infection), liver (from hepatitis B infection), and cervix (from HPV infection). These remarkable discoveries hold out hope for further advances in immunology in the years ahead. Similarly, advances in knowledge of nutrition, genetics, nanotechnology and chronic disease are already contributing to reductions in cardiovascular disease and cancer mortality, and perhaps incidence, with more benefits to come in the years ahead. Success in reducing mortality from HIV as a result of the wider availability and lower costs of antiretroviral drugs has opened a new phase in HIV control by reducing transmission, such as from mothers to infants, but also for preventive care after exposure and prevention of infection in high-risk groups. Here again, economic recession may hinder the sustainability of such programs, such as in preventing maternal–fetal HIV transmission.

At the same time, malaria control is disappointingly difficult in many countries where it is still a major cause of childhood mortality; the search for an effective vaccine is one of the great challenges so far unsuccessfully met in immunology. Drug-resistant diseases are also an increasing challenge awaiting scientific advances.

The first decade of the new century saw the enormous effects of terrorism, such as the 9/11 attack in New York and the 7/7 attack in London, and these effects are not limited to the direct deaths and casualties. Major wars and chronic low-grade warfare in Afghanistan and Pakistan have serious consequences not only in military and civilian casualties, but in financial burden and economic downturn. Recurrent civil wars such as those plaguing some African countries have tragic local effects but also hinder the adequate development of public health infrastructure and public policy. Disasters such as the Thailand tsunami and floods in Pakistan and China in 2010, the enormous earthquake in Haiti and the Japanese tsunami of 2011 caused huge devastation, loss of life, and the subsequent effects of homelessness, poor sanitation, and consequent disease and death.

The world now faces a long-term threat of weapons of mass destruction in the hands of fanatically religious, transnational groups who may promote the use of such weapons in genocidal acts following years of incitement, a known precursor to genocide. The public health consequences may be devastating and result in new genocides, perhaps on an unimaginable scale, with weapons of mass destruction available to radical regimes and terrorist organizations.

Climate change has serious and far-reaching health implications, now and in the future. It is already changing the distribution of some infectious disease vectors; of death, disease, and injury from heat waves; of floods, storms, fires, and droughts. Climate change may also cause social disruption, economic decline, and displacement of populations, all of which may impact health substantially, affecting especially the very young and the elderly, the physically and mentally disabled, the poor and economically disadvantaged, and other marginalized groups. Local public health agencies are tasked with showing leadership in dealing with the effects of disasters on this issue. Budget and labor cuts in a time of recession can seriously jeopardize emergency preparedness planning and preparation.

Great challenges and opportunities lie ahead for public health, including access to future scientific and health technology achievements in genomics, nanotechnologies, and other scientific advances in vector control, vaccines, cancer prevention and management, and coping with diseases associated with aging and mental illness. The economics of health care will be challenged by rising costs, economic recession, and still prevalent inequalities in health status. The economic crisis building since 2008 will push more people into poverty and unemployment while reducing spending on public services, including public health and social support systems. Privatization of health care and public health services will reduce access to needed care.

Migration, civil strife, and threats of genocide will continue to challenge human rights and public health. Natural and human-made disasters now and in the future will cause large-scale loss of life and social disruption. Yet health technology and the widening use of currently available preventive measures will increase longevity in more and more countries. The translation of scientific and technical capacity to meet human needs will continue to be a challenge for civil societies and public health. Human resources for health continues to be a serious challenge for health systems, and with aging societies, new health disciplines such as community health workers will be needed to meet human needs. These and many other issues in public health will raise important ethical questions and challenges for health promotion in mandating risk reduction, such as in smoking and dealing with apathy or opposition to essential programs of public health protection such as immunization for population as well as individual health. Inequalities will perhaps be the greatest ethical challenge to face.

History has shown that societies can achieve greater longevity and a healthier quality of life by the application of public health and health promotion measures. The achievements of the past can be equaled in the future with the brilliant achievements of individual and systems research and the application of findings. Many innovations face apathy and serious resistance, with a high cost in unnecessary morbidity and mortality. These and related issues will be discussed in the chapters that follow and in recommended readings, and in specialized courses in the broad context of public health.

SUMMARY

The history of public health is directly related to the evolution of thinking about health. Ancient societies in one way or another realized the connection between sanitation and health and the role of personal hygiene, nutrition, and fitness. The sanctity of human life (*Pikuah Nefesh*), which established an overriding human responsibility to save life, and improving the world (*Tikkun Olam*), were both derived from Mosaic Law from 1500 BCE. The scientific and ethical basis of medicine was also influenced largely by the teachings of Hippocrates in the fourth century BCE. Sanitation, hygiene, good nutrition, and physical fitness all had roots in ancient societies, including the obligations of the society to provide care for the poor. These ethical foundations support efforts to preserve life even at the expense of other religious or civil ordinances.

Social and religious systems linked disease to sin and punishment by higher powers. Moreover, they viewed investigation or intervention by society (except for relief of pain and suffering) as interference with God's will. Childbirth was associated with pain, disease, and frequent death as a general concept of "in sorrow shall you bring forth children". Health care was seen as a religious charitable responsibility to ease the suffering of sinners. In the modern world, the effectiveness of medical and preventive care is widely accepted, yet religious and cultural issues are still expressed as limitations in funding for family planning, birth-related care, and many other public health issues.

The clear need and responsibility of society to protect itself by preventing the entry or transmission of infectious diseases was driven home by pandemics of leprosy, plague, syphilis, smallpox, measles, and other communicable diseases which occurred in the Middle Ages. The diseases themselves evolved and pragmatic measures were gradually found to control their spread, including the isolation of lepers, quarantine of ships, and closure of public bath houses. Epidemiological investigations of cholera, typhoid, occupational diseases, and nutritional deficiency disorders in the eighteenth and nineteenth centuries began to show causal relationships and effective methods of intervention before scientific proof of causation was established.

Public health practice continued to evolve on a pragmatic basis, often before full scientific basis of the causation of many diseases had been worked out. Public health organizations to ensure basic community sanitation and other modalities of prevention evolved through the development of local health authorities, fostered, financed, and supervised by civic, state, or provincial and national health authorities, as governments became increasingly involved in health issues. Pioneers such as Lillian Wald brought public health nursing to the homes of the sick and poor immigrants in New York City at the beginning of the twentieth century. Through Wald's efforts, we now understand that the application of outreach, home care, and preventive work by community health workers of all kinds is part of the complex of modern public health.

Freeing human thought from restrictive dogmas that limited the scientific exploration of health and disease fostered the search for the natural causation of disease. During the Enlightenment, scientific inquiry emerged and natural philosophy was strongly tied to spiritual and religious motives. This was of paramount importance in seeking interventions and preventive activities. This concept, first articulated in ancient Greek medicine, provided the basis for clinical and scientific observations leading to the successes of public health over the past two centuries. The epidemiological method led to public health interventions before the biological basis of disease was determined. Sanitation to prevent disease was accepted in many ancient societies, and codified in some as part of civil and religious obligations. Lind's investigation of scurvy, Jenner's discovery of vaccination to prevent smallpox, and Snow's investigation of cholera in London demonstrated the investigation of disease using modern scientific epidemiological methods. Their results were eventually accepted despite a lack of contemporary biochemical or bacteriological proof. Their remarkable contributions helped to formulate the core methodology of public health.

Public health has developed through pioneering epidemiological studies, devising forms of preventive medicine, and community health promotion. Reforms pioneered in many areas, from the abolition of slavery and serfdom to the provision of state-legislated health insurance, have all improved the health and well-being of the general population. In the last years of the twentieth century, the relationship between health and social and economic development gained recognition internationally. The twentieth century has seen a dramatic expansion of the scientific basis for medicine and public health. Immunology, microbiology, pharmacology, toxicology, and epidemiology have provided powerful tools and resulted in improved health status of populations. New medical knowledge and technology have come to be available to the general public in many countries in the industrialized world through the advent of national health insurance. In this century, virtually all industrialized countries established systems of ensuring access to care for their whole population as essential for the health of both the individual and the collective.

Major historical concepts have had profound effects on the development of public health. The idea of sickness as punishment for sin prevented attempts to control disease over many centuries. This mentality persists in modern times through "blaming the victim". AIDS patients are seen as deserving their fate because of their behavior; workers are believed to become injured because of their own negligence; and the obese person and the smoker are believed to deserve their illnesses because of weakness in the way they conduct their lives. The sanctity of human life, improving the world, and human rights are fundamental to the ethics and values of public health, as is charity in care, in which there is a societal and professional responsibility for kindness and relief of suffering. Ethical controversies pitting individual rights versus community benefit are still ongoing in many diverse areas such as universal health insurance, food fortification, fluoridation of water supplies, managed care, reproductive health, cost–benefit analysis, euthanasia, the care of sex workers and prisoners, and many others.

Acceptance of the right to health for all by the founders of the United Nations and the WHO added a universal element to the mission of public health. This concept was embodied in the constitution of the WHO and given more concrete form in the *Health for All* concept of Alma-Ata, which emphasized the right of health care for everyone and the responsibility of governments to ensure that right. This concept also articulates the primary importance of prevention and primary care, which became a vital issue in competition for resources between public health and hospital-oriented health care.

The lessons of history are important in public health. Basic issues of public health need to be revived because new challenges for health appear and old ones re-emerge. The philosophical and ethical basis of modern public health is a belief in the inherent worth of the individual and his or her human right to a safe and healthful environment. The health and well-being of the individual and the community are interdependent. Investment in health, as in education, is a contributor to economic growth, as healthy and educated individuals contribute to a creative and economically productive society.

Globalization in health has entered a new phase in the twenty-first century with the articulation of the MDGs in 2001, accepted by virtually all countries in the world as a basis for poverty reduction, improved education and health standards, especially for women and children, and in the control of HIV, malaria, and other diseases. The progress made up to 2013 has been substantial in many regions, with reduction in rates of extreme poverty, enrolling children into primary schools, addressing AIDS, malaria and child health, and a good likelihood of reaching the target for access to clean drinking water. Despite this progress, progress in sub-Saharan Africa has been very slow, with no advances at all in addressing maternal mortality rates.

The New Public Health emerges from the experience of history. Organized activity to prevent disease and promote health had to be relearned from the ancient and postindustrial revolution worlds. Over the coming decades of the twenty-first century, we must learn from a wider framework how to use all health modalities, including clinical and prevention-oriented services, health promotion, and proactive efforts in the public and private sectors to effectively and economically preserve, protect, and promote the health of individuals and of greater society. The New Public Health, as public health did in the past, faces ethical issues that relate to health expenditures, priorities, and social philosophy. Throughout the course of this book, we discuss these issues and attempt to illustrate a balanced, modern approach towards the New Public Health.

HISTORICAL MARKERS

3000 BCE	Dawn of Sumerian, Egyptian, and Minoan cultures – drains, flush toilets
2000 BCE	Indus valley – urban society with sanitation facilities
1700 BCE	The Code of Hammurabi – rules governing medical practice
1500 BCE	Mosaic Law – personal, food, and camp hygiene, segregating lepers, overriding duty of sanctity of human life (Pikuah Nefesh) and improving the world (Tikkun Olam) as religious imperatives
400 BCE	Greece – personal hygiene, fitness, nutrition, sanitation, municipal doctors, occupational health; Hippocrates – clinical and epidemic observation and environmental health
500 BCE to 500 CE	Rome – aqueducts, baths, sanitation, municipal planning, and sanitation services, public baths, municipal doctors, military, and occupational health
170 CE	Galen – physiology, anatomy, humors dominated western medicine until 1500 CE
500–1000	Europe – destruction of Roman society and the rise of Christianity; sickness as punishment for sin; mortification of the flesh, prayer, fasting, and faith as therapy; poor nutrition and hygiene, pandemics; antiscience; care of the sick as religious duty
700–1200	Islam – preservation of ancient health knowledge, schools of medicine, Arab–Jewish medical advances (Ibn Sinna and Maimonides)
1000+	Universities and hospitals in Middle East and Europe
1000+	Rise of cities, trade, and commerce, craft guilds, municipal hospitals
1096–1272	Crusades – contact with Arabic medicine, hospital orders of knights, leprosy
1268	Roger Bacon publishes treatise on use of eyeglasses to improve vision
1348	Venice – board of health and quarantine established
1348–1350	Black Death – origins in Asia, spread by armies of Genghis Khan, world pandemic kills 60 million in fourteenth century, one-third to one-half of the population of Europe
1300	Pandemics – bubonic plague, smallpox, leprosy, diphtheria, typhoid, measles, influenza, tuberculosis, anthrax, trachoma, scabies, and others until eighteenth century

1400–1600s	Renaissance and Enlightenment, decline of feudalism, rise of urban middle class, trade, commerce, exploration, new technology, printing, arts, science, anatomy, microscopy, physiology, surgery, clinical medicine, hospitals (religious, municipal, voluntary)
1518	Royal College of Physicians founded in London
1532	Bills of Mortality published
1546	Girolamo Fracastorus publishes De Contagione – the germ theory
1562–1601	Elizabethan Poor Laws – responsibility for the poor on local government
1628	William Harvey publishes findings on circulation of the blood
1629	London Bills of Mortality specify causes of death
1639	Massachusetts law requires recording of births and deaths
1660s	Leyden University strengthens anatomical education
1661	John Graunt founds medical statistics
1661	Rene Descartes publishes first treatise on physiology
1662	Royal Society of London founded by Francis Bacon
1665	Great Plague of London
1673	Antony van Leeuwenhoek – microscope, observes sperm and bacteria
1667	Pandemics of smallpox in London; pandemic of malaria in Europe
1687	William Petty publishes Essays in Political Arithmetic
1700	Bernardino Ramazzini publishes compendium of occupational diseases
1701	London – 75% of newborns die before fifth birthday
1701	Variolation against smallpox practiced in Constantinople, isolation practiced in Massachusetts
1710	English Quarantine Act
1720+	London – voluntary teaching in hospitals; Guy's, Westminster
1721	Lady Mary Montagu introduces inoculation for smallpox to England
1730	Science and scientific medicine; Rights of Man, encyclopedias, agricultural and industrial revolutions, population growth – high birth rates, falling death rates
1733	Obstetrical forceps invented
1733	Stephen Hales measures blood pressure
1747	James Lind – case–control study of scurvy in sailors
1750	British naval hospitals established
1750	John Hunter establishes modern surgical practice and teaching
1752	William Smellie publishes textbook of midwifery
1762	Jean Jacques Rousseau publishes the Social Contract
1775	Percivall Pott investigates scrotal cancer in chimney sweeps
1777	John Howard promotes prison and hospital reform in England
1779	Johann Frank promotes Medical Police in Germany
1785	William Withering – discovers foxglove (Digitalis) treatment of dropsy
1788	UK legislation to protect boys employed as chimney sweeps
1796	Edward Jenner – vaccinates 24 children against smallpox from milkmaid's cowpox pustules
1796	British Admiralty adopts daily issue of lime juice for sailors at sea to prevent scurvy
1797	Massachusetts legislation permitting local boards of health
1798	Philippe Pinel removes chains from insane in Bicetre Asylum in France
1798	President John Adams signs law for care of sick and injured seamen, establishing marine hospital service, later becoming US Public Health Service (1912)
1800	Britain and US establish Municipal Boards of Health
1800	Vaccination adopted by British army and navy
1800	Adam Smith, Jeremy Bentham – economic, social philosophers
1801	Vaccination mandatory in Denmark, local eradication of smallpox
1801	First national census, UK
1804	Modern chemistry established – Humphrey Davey, John Dalton
1807	UK Abolition Act – mandates eradication of international slave trade enforced by the Royal Navy

1827	Carl von Baer in St. Petersburg establishes science of embryology
1834	UK Poor Law Amendment Act documents harsh state of urban working class in the USA
1837	UK National Vaccination
1830s–1840s	Sanitary and social reform, growth of science; voluntary societies for reform, boards of health, mines and factory acts – improving working conditions
1842	Edwin Chadwick – UK Poor Law Commission on Sanitary Conditions of the Labouring Population of Great Britain – links poverty and disease
1844	Horace Wells – anesthesia in dentistry, then surgery in the USA
1848	UK Parliament passes Public Health Act establishing the General Board of Health
1850	Massachusetts – Shattuck Report of Sanitary Commission
1852	Adolph Chatin uses iodine for prophylaxis of goiter
1854	John Snow – waterborne cholera in London: the Broad Street pump
1854	Florence Nightingale, modern nursing and hospital reform – Crimean War
1855	London – mandatory filtration of water supplies and consolidation of sanitation authorities
1858	Louis Pasteur proves no spontaneous generation of life
1858	Rudolf Virchow publishes *Cellular Pathology*; pioneer in political–social health context
1858	Public Health and Local Government Act and Medical Act in UK – local health authorities and national licensing of physicians
1859	Charles Darwin publishes *On the Origin of Species*
1861	Emancipation of the serfs in Russia
1861	Ignaz Semmelweiss publishes *The Cause, Concept and Prophylaxis of Puerperal Fever*
1862	Louis Pasteur publishes findings on microbial causes of disease
1862	Florence Nightingale founds St. Thomas' Hospital School of Nursing
1862	Sanitary Commission during US Civil War
1862	Emancipation of slaves in the USA
1864	Boston bans use of milk from diseased cows
1864	Russia – rural health as tax-supported local service through Zemstvos
1864	First International Geneva Convention and founding of International Committee of the Red Cross
1866	Gregor Johann Mendel, a Czech monk, publishes basic laws of heredity establishing the scientific basis of genetics
1867	Joseph Lister describes use of carbolic spray for antisepsis
1869	Dimitri Ivanovitch Mendeleev – periodic table
1872	American Public Health Association founded
1872	Milk stations established in New York immigrant slums
1876	Robert Koch discovers anthrax bacillus
1876	Neisser discovers Gonococcus organism
1879	US National Board of Health established
1879	US Food and Drug Administration established
1880	Typhoid bacillus discovered (Laveran); leprosy organism (Hansen); malaria organism (Laveran)
1882	Robert Koch discovers the tuberculosis organism, tubercle bacillus
1883	Otto von Bismarck introduces social security with workmen's compensation, national health insurance for workers and their families in Germany
1883	Robert Koch discovers bacillus of cholera
1883	Louis Pasteur vaccinates against anthrax
1885	Kanehiro Takaki of the Japanese navy describes beriberi; recommends diet change eliminating the sailor's disease
1884	Diphtheria, Staphylococcus, Streptococcus, tetanus organisms identified
1885	Pasteur develops rabies vaccine; Escherich discovers coli bacillus
1886	Karl Fraenkel discovers the Pneumococcus organism
1887	Malta fever or brucellosis (Bruce) and chancroid (Ducrey) organisms identified
1887	US National Institutes of Health founded
1892	Gas gangrene organism discovered by Welch and Nuttal
1893	Lillian Wald organizes Henry Street Mission and the Visiting Nurses Association of New York for care of the poor and disabled in their own homes
1894	Plague organism discovered (Yersin, Kitasato); botulism organism (Van Ermengem)
1895	Louis Pasteur develops vaccine for rabies

1895	Wilhelm Roentgen – discovers electromagnetic waves (X-rays) for diagnostic imaging
1895	Emil von Behring develops diphtheria vaccine (Nobel Prize 1901)
1897	Edmond Nocard develops antitetanus serum (ATS) for passive immunity
1897	London School of Hygiene and Tropical Medicine founded
1897	Felix Hoffman – synthesizes acetylsalicylic acid (aspirin)
1904	Ivan Petrovitch wins Nobel Prize for work in conditioned reflexes, neurophysiology
1905	Abraham Flexner – major report on medical education in the USA
1905	Workman's Compensation Acts in Canada
1906	US Pure Food and Drug Act passed by Congress
1910	Paul Ehrlich – chemotherapy use of arsenical salvarsan for treatment of syphilis
1911	Lloyd-George, UK compulsory health insurance for workers
1911	Kasimir Funk investigates "vital amines" and names them vitamins
1912	Health insurance for industrial workers in Russia
1912	US Children's Bureau and US Public Health Service established
1914	Joseph Goldberger of US Public Health Service investigates cause and prevention of pellagra
1915	Johns Hopkins and Harvard Schools of Public Health founded
1915	Tetanus prophylaxis and antitoxin for gas gangrene
1918–1919	Pandemic of Spanish flu (influenza) kills some 20 million people
1918	Nikolai Semashko introduces USSR national health plan
1921	Frederick Banting and Charles Best discover insulin in Toronto (Nobel Prize 1923)
1923	Health Organization of League of Nations established
1924	David Cowie promotes widespread ionization of salt in the USA; Morton's iodized salt popular in North America
1924	Tetanus toxoid vaccine developed
1926	Pertussis vaccine developed
1928	Alexander Fleming discovers penicillin (Nobel Prize 1945)
1928	George Papanicolaou develops Pap smear for early detection of cancer of cervix
1929–1936	The Great Depression – widespread economic collapse, unemployment, poverty, and social distress in industrialized countries
1930	US Food and Drug Administration established
1935	President Roosevelt – Social Security Act and the New Deal in the USA
1939	UK National Hospital Service – wartime nationalization of hospitals
1940	Charles Drew describes storage and use of blood plasma for transfusion
1941	Norman Gregg reports rubella in pregnancy causing congenital anomalies
1941	President Roosevelt initiates food fortification in the USA, adopted in Canada and UK
1942	William Beveridge Report in the UK – the "Welfare State"
1942	USA establishes National Centers for Disease Control and Emergency Maternity and Infant Care for families of servicemen
1939–1945	World War II, with catastrophic military and civilian loss of life, wartime emergency medical structure; Nazi Holocaust of 6 million Jews and many others
1945	Diphtheria, pertussis, tetanus (DPT) vaccine developed
1945	Trial of fluoridation of community water supplies, Grand Rapids MI; Newburgh, NY; and Brantford, Ontario
1946	World Health Organization founded
1946	National health insurance defeated in US Congress
1946	US Communicable Disease Center (CDC) established in Atlanta; later called the Centers for Disease Control and Prevention
1946	US Congress Hill–Burton Act supports local hospital construction up to 4.5 beds per 1000 population
1946	Tommy Douglas – Saskatchewan provincial hospital insurance plan
1947	Nuremberg Doctors Trial of Nazi crimes against humanity
1948	International Declaration of Human Rights
1948	UK establishes National Health Service
1950	CDC establishes the Epidemiological Intelligence Service (EIS)
1953	James Watson and Francis Crick discover the double helix structure of DNA (Nobel Prize 1962)

1954	Framingham study of heart disease risk factors
1954	Richard Doll reports on link between smoking and lung cancer
1954	Jonas Salk's inactivated poliomyelitis vaccine licensed
1955	Michael Buonocore develops dental sealants
1956	Gregory Pincus reports first successful trials of birth control pills
1960	Albert Sabin – live poliomyelitis vaccine licensed
1961	American Academy of Pediatrics recommends routine vitamin K for all newborns
1961	CDC publishes *Morbidity and Mortality Weekly Report* (*MMWR*)
1963	Measles vaccine licensed
1964	US Surgeon General's Report on Smoking (Luther Terry)
1965	The USA enacts Medicare for the elderly, Medicaid for the poor
1966	US National Traffic and Motor Vehicle Safety Act
1967	Mumps vaccine licensed
1970	Rubella vaccine licensed
1971	Canada has universal health insurance in all provinces
1971	US National Center for Health Statistics conducts the first National Health and Nutrition Examination Survey (NHANES) to capture the health status of Americans.
1972	US Stanford Three Community Study starts (later The Stanford Five-City Project); a 23% reduction in coronary heart disease risk by community-based interventions to change lifestyle risk factors – physical activity, dietary habits, and tobacco use
1972	Finland's North Karelia Project begins, to prevent cardiovascular disease; cardiovascular mortality rates for men aged between 35 and 64 years decreased by 57% from 1970 to 1992
1973	*MMWR* reports that lead emissions in a residential area constitute a public health threat
1974	Marc Lalonde New Perspectives on the Health of Canadians
1977	WHO adopts Health for All by the Year 2000
1977	Last known outbreak of smallpox reported in Somalia
1977	Framingham study shows effects of triglycerides and LDL- and HDL-cholesterol on heart disease
1978	Alma-Ata Conference on Primary Health Care
1978	Hepatitis B vaccine licensed
1979	Canada adopts mandatory vitamin/mineral enrichment of foods
1979	WHO declares eradication of smallpox achieved
1981	AIDS – first recognition of cases of acquired immunodeficiency syndrome
1983	CDC – Violence Epidemiology Branch to apply prevention strategies to child abuse, homicide, and suicide
1984	Harald zur Haisen discovers link between human papillomavirus and cancer of cervix (Nobel Prize 2008)
1985	WHO European Region Health Targets
1985	*Haemophilus influenzae* b (Hib) vaccine licensed by FDA
1985	Luc Montaignier publishes genetic sequence of HIV (with Francoise Barre-Sinoussi, Nobel Prize 2008)
1986	First coronary stent implanted by Jacques Puel and Ulrich Sigwart in France
1988	American College of Obstetricians and Gynecologists recommends annual Pap smears for all women
1988	Framingham study shows isolated systolic hypertension linked to increase risk of heart disease
1988	Framingham study shows cigarette smoking increases risk of stroke
1989	WHO targets eradication of polio by the year 2000
1989	Warren and Marshall discover *Helicobacter pylori* as treatable cause of peptic ulcers (Nobel Prize 2005)
1989	International Convention on the Rights of the Child
1990	World Summit on Children, New York
1990	World Conference on Education for All, Jomtien, Thailand
1990	W. F. Anderson performs first successful gene therapy
1990	Newly emerging and re-emerging diseases (HIV, Marburg, Ebola, cholera, BSE, TB) and multidrug-resistant organisms
1991	Folic acid proven to prevent neural tube defects
1992	United Nations Conference on Environment and Development, Rio de Janeiro

1992	International Conference on Nutrition
1992	The Victoria Declaration in Canada on Heart Health affirms that CVD is largely preventable, that scientific knowledge exists to eliminate most CVD, and that public health infrastructure and capacity to address prevention are lacking
1993	World Conference on Human Rights, Vienna
1993	World Development Report: Investing in Health published by World Bank
1993	Russian Federation approves compulsory national health insurance
1994	International Conference on Population and Development, Cairo
1994	Clinton National Health Insurance plan defeated in US Congress
1995	World Summit for Social Development, Copenhagen
1995	United Nations Fourth World Conference on Women, Beijing
1996	Second United Nations Conference on Human Settlement (Habitat II), Istanbul
1996	Explosive growth of managed care plan coverage in the USA
1997	Legal action for damages against tobacco companies for costs of health effects of smoking, 33 states in the USA and other countries
1997	US President Clinton apologizes for Tuskegee study of syphilis among black American men (1932–1972)
1998	US President Clinton proposes legislation on patients' rights in managed care
1998	FDA approves rotavirus vaccine
1998	WHO Health for All in the Twenty-First Century adopted
1998	US National Academy of Sciences recommends routine vitamin supplements for adults
1998	Bologna Declaration on postgraduate education in Europe adopts BA, MA, and PhD levels
1998	The USA, Canada, and Chile adopt mandatory fortification of flour with folic acid to prevent birth defects
1999	US Congress passes legislation regulating patients' rights in managed care
1999	Master Settlement Agreement between US states and tobacco companies for $206 billion for Medicaid damages
1999	*MMWR* publishes Ten Great Public Health Achievements – United States, 1900–1999
2000	The entire human genome is mapped
2000	WHO 53rd World Health Assembly endorses global strategy for non-communicable disease (NCD) prevention and control, with monitoring, preventing, and managing major NCDs with common risk factors and determinants: cardiovascular disease, cancer, diabetes, and chronic respiratory disease
2001	9/11 Terrorism and mass casualties in destruction by Islamic terrorists of Twin Towers in New York City
2001	Anthrax bioterrorism threats in USA
2001	Millennium Development Goals proposed by the United Nations accepted by most member states as global effort to reduce poverty, and improve education and health in poor countries
2003	SARS epidemic in China reaches Toronto; 8098 total cases with 774 deaths
2003	WHO's Framework Convention on Tobacco Control adopted by the 56th World Health Assembly
2004	Tsunami and mass casualties in South-East Asia
2004	WHO Global Strategy on Diet, Physical Activity and Health endorsed by World Health Assembly
2005	Hurricanes Katrina and Rita cause widespread devastation and mass casualties
2005	Bangkok Charter for Health Promotion in a globalized world
2005	International Health Regulations promoted by WHO adopted by 194 countries
2006	Bird flu of H5N1 virus threatens world pandemic
2006	Human papillomavirus (HPV) vaccine approved by FDA for prevention of cervical cancer
2006	Medicare Part D prescription drug plan for seniors instituted in the USA
2007	HPV vaccine in wide use for preteen girls in industrialized countries
2008	China – milk products deliberately contaminated with melanine; over 14,000 hospitalized
2008	Commission on Social Determinants of Health reveals the appalling levels of health inequality resulting in premature deaths and stunted lives
2008	Global tuberculosis control – progress to control the TB epidemic slowed in 2006
2009	Creuzfeldt–Jakob disease – outbreaks of BSE in animals in several countries

2009	WHO and UNICEF launch the Global Action Plan for the prevention and control of pneumonia (GAPP) in 65 countries to prevent up to 5.3 million child deaths from pneumonia by 2015
2009	World malaria report 2009 – reduced impact of malaria needed to achieve Millennium Development Goals; 243–311 million malaria cases worldwide and 863,000 to 1 million early deaths per year, almost all in the poorest countries
2009	H1N1 pandemic announced by WHO
2010	Haiti suffers 7.0 magnitude earthquake with massive loss of life and displacement; many deaths from cholera
2010	Massive floods in Pakistan and China: Pakistan's flood crisis affects over 215 million people, with 6 million needing life-saving humanitarian and health care; in China more than 400 million
2010	Millennium Development Goals 2010 status report – progress in some regions, but in sub-Saharan Africa goals will not be achieved by 2015
2010	US Congress enacts President Obama's Patient Protection and Affordable Care Act (PPACA or "Obamacare") to extend health insurance coverage to millions of uninsured Americans
2011	HPV vaccine recommended by US CDC for boys as well as girls
2012	US Supreme Court upholds legality of PPACA

Source: Deutsche Welle Focus: Millennium Development Goals [updated 21 September 2012]. Bonn: Deutsche Welle. Available at: http://www.dw-world.de/dw/article/0,,6003071,00.html [Accessed 17 July 2012].

NOTE

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