CHAPTER

1

Global Epidemiology of Chronic Diseases: The Epidemiologic Transition

GLOBAL PANDEMIC OF CHRONIC DISEASES

A silent pandemic of chronic diseases is gradually enveloping the world population, spreading to all corners of the globe. This distinct spectrum of human afflictions is systemically replacing infectious and parasitic diseases as the leading cause of morbidity and mortality worldwide, thereby producing one of the greatest public health challenges of all time. According to global mortality data reported by the World Health Organization (WHO), chronic disorders such as coronary heart disease, stroke, cancer, chronic obstructive pulmonary disease, diabetes mellitus type 2, neurodegenerative disease, and renal failure caused 38 million deaths in 2009, more than 62% of all deaths worldwide (WHO, 2009a). The following excerpts from the 2008 WHO global report entitled *Preventing Chronic Diseases: A Vital Investment* captures the essence of the global pandemic of chronic diseases (WHO, 2008a).

> *"Chronic diseases are the leading causes of death and disability worldwide. Disease rates from these conditions are accelerating globally, advancing across every region and pervading all socioeconomic classes. The World Health Report 2002 "Reducing Risks, Promoting Healthy Life" indicates that the mortality, morbidity and disability attributed to the major chronic diseases currently account for almost 60% of all deaths and 43% of the global burden of disease. By 2020 their contribution is expected to rise to 73% of all deaths and 60% of the global burden of disease. Moreover, 79% of the deaths attributed to these diseases occur in the developing countries. Four of the most prominent chronic diseases, cardiovascular diseases (CVD), cancer, chronic obstructive pulmonary disease (COPD), and type 2 diabetes, are linked by common and preventable biological risk factors, notably high blood pressure, high blood cholesterol and overweight, and by related major behavioral risk factors: unhealthy diet, physical inactivity, and tobacco use. Action to prevent these major chronic diseases should focus on controlling these and other key risk factors in a well-integrated manner."*

The global pandemic of chronic diseases has emerged in concert with the changing demography of the world population. Overall, the world birth rate exceeds the death rate and the number of living individuals on the planet continues to increase. At the same time, more and more people are living to older ages thereby creating the phenomenon of "global aging." Aging populations are particularly evident in the industrialized and developed nations of the world, such as Japan, Italy, and Germany, where the proportion of elderly people (over 65 years of age) has increased from approximately 10% to 20% in the past half century (Hayutin, 2007). In large developing nations such as China and India, the proportion of elderly people is also expected to increase from current levels of about 5% to nearly 10% in the next few decades. In smaller underdeveloped nations where less than 5% of the people currently live beyond 65 years of age, population aging is also progressing, but at a slower pace. As a general consequence of the aging world population, long-term mechanisms of pathogenesis are more likely to cause disease late in life, thus resulting in vastly increased rates of chronic diseases, particularly among the elderly.

INCREASE IN WORLD POPULATION

As of December 31, 2009, The United States Census Bureau estimated that the world population consisted of 6.82 billion living human beings (United States Census Bureau, 2009). In that year, approximately 61 million people died and 139 million new babies were born, a net gain of 78 million people. Based upon projections of death rates and birth rates, the world population is expected to increase to nearly nine billion people by the year 2040 (**Figure 1.1**).

AGING OF THE WORLD POPULATION

The world population is not only increasing in number, but it is also growing older. Two demographic parameters are driving these phenomena: *longevity is increasing and the fertility rate is decreasing*. Studies at the World Health Organization (WHO, 2009a) and the Stanford Center of Longevity (Hayutin, 2007) clearly show that people around the world are living longer and women are having fewer children.

INCREASING LONGEVITY (LIFE EXPECTANCY)

The average life expectancy (also called longevity) for members of the world population born during 2005–2010 is 67 years (65 years for men and 70 years for women) (CIA World Fact Book, 2009). In the past half century, life expectancy has increased dramatically throughout the world, particularly in populations of developing nations. Since 1950, life expectancy in highly populated nations such as China and India has increased from approximately 40 years to nearly 70 years (**Figure 1.2**).

In lesser developed nations, particularly those of central Africa where acute infectious and parasitic diseases prevail and greatly reduce the survival of children and young adults, life expectancy is much less, currently only about 50 years. In highly developed nations such as Japan, the United States, and European countries, longevity now approaches or surpasses 80 years and deaths are more likely due to chronic diseases of old age. The Japanese people currently enjoy the greatest longevity, about 82 years. Longevity in the United States currently stands at 78 years, only slightly higher than the average of more developed nations (**Figure 1.3**).

Life expectancy is the average number of years that a newborn could expect to live if he or she were to pass through life *subject to the age-specific death rates of the population of interest for the past year*. Derivation of life expectancy is usually presented as a "*two step*" process. For large populations, life expectancy is calculated by *first constructing a life table and recording the numbers of deaths and survivors that occur in a given year for successive intervals of the life span*. The numbers of deaths and survivors and corresponding age-specific death rates are usually tabulated for ages 0 to 1 years, 1 to 5 years, and successive 5-year age groups for ages 5 and above. From these data, a second life table is then constructed to represent the entire mortality

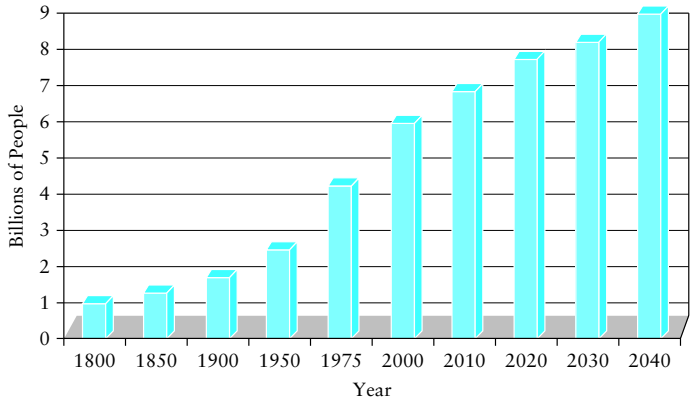

Figure 1.1 World Population.

Source: Data from the United States Census Bureau, International Data Base, 2009 (estimates for 2020–2040 are based on curvilinear regression).

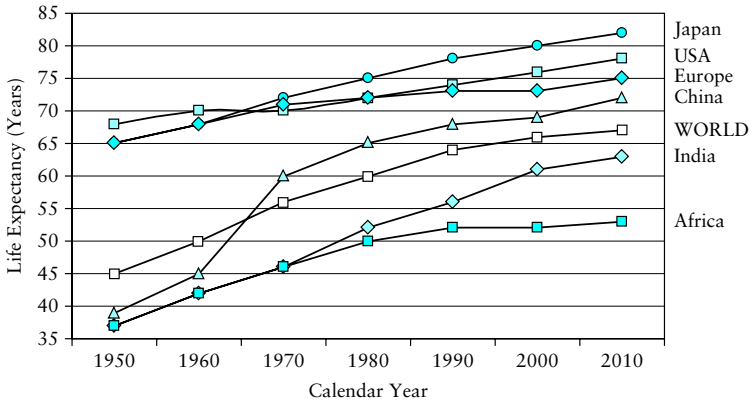

Figure 1.2 Longevity Trends in Selected Populations.

Source: Data from Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (2007). World Population Prospects: The 2006 Revision, Highlights. New York: United Nations. National Center for Health Statistics, 2009, USA.

experience from birth to death for a hypothetical cohort of 100,000 infants born alive and subject to the age-specific death rates that prevail in the population of interest for a particular year in time. Using the data from this second life table for 100,000 hypothetical individuals, life expectancy is simply calculated as the average years of life for all members since birth, e.g., life expectancy = total years of life for all members of the life table divided by the total number of persons at birth, *Life Expectancy* = Σ *years of life/100,000*. Life expectancy (longevity) at birth is therefore the mean years of life for individuals based entirely on the age-specific death rates for the population and year of interest (Colton, 1974).

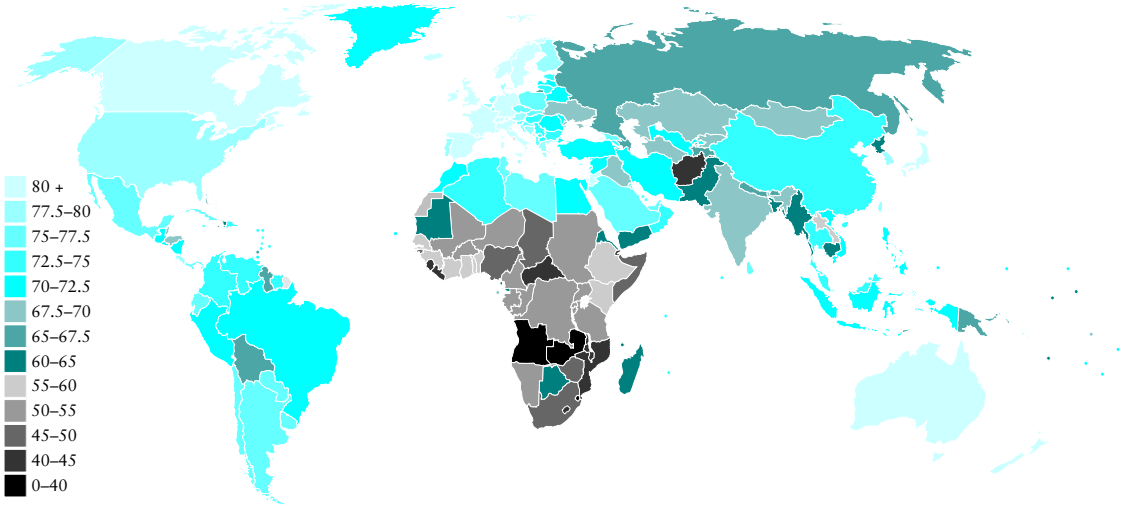

Figure 1.3 Global Longevity, 2011.

Source: CIA World Factbook, 2011 Estimates of Life Expectancy at Birth (Years).

GENDER DIFFERENCES IN LONGEVITY

Throughout the world, life expectancy (longevity) for women is 5–10 years greater than for men. With some exceptions in nations where high maternal death rates prevail due to lack of prenatal care, women have lower death rates and better survival at every age. In the industrialized world, improvements in prenatal care have reduced maternal mortality during the childbearing years thereby widening the gender gap in longevity during much of the 20th century. For example, the gender divergence in longevity in the US population gradually increased from about 2 years in 1900 to approximately 8 years in 1970, after which the difference shrank back to about 6 years, currently 81 years for women versus 75 years for men (**Figure 1.4**). The slight shrinkage of the US gender gap during the past 40 years is believed to reflect equalizing smoking rates among men and women (Pampel, 2002).

The survival differential favoring females actually begins at conception. Only about 90% of male fetuses survive to birth compared to nearly 100% of female fetuses. While precise causative factors for this disparity remain unclear, the relatively high rates of spontaneous abortions, miscarriages, and stillbirths among male fetuses could be due to hormonal incompatibilities of the male genotype in a milieu of female hormones such as estrogen and progesterone throughout gestation (Austad, 2006). At the other end of the life span, approximately 70% of individuals over 90 years of age are female, and remarkably, about 90% of centenarians (individuals over 100 years of age) are female (Perls, Hutter Silver, and Lauerman, 1999).

While no single factor can satisfactorily explain the clear survival advantage of women throughout life, certain environmental and biological differences are worth pointing out. The longer life span of women compared to men is undoubtedly related to gender differences in lifestyle. Despite the fact that men are, on average, bigger, stronger, faster, and more economically self-sufficient, their lifestyle choices and risky health behaviors obviously confer a clear survival advantage to women. In general, men have greater exposure to classical risk factors of disease such as tobacco and alcohol and, as a consequence, are more likely to die earlier from associated chronic conditions such as cardiovascular disease, lung cancer, chronic obstructive pulmonary disease, and cirrhosis of the liver. Men are also more likely to die from injuries, whether unintentional (motor vehicle or occupational accidents) or intentional (suicide, homicide, war). Reciprocally, women have traditionally been the "*sentinels of health*" for their families and communities at large. Due to their instinctive "*nurturing maternal instinct*," women tend to take better care of themselves and make healthier lifestyle choices than men, thus contributing to their longer life span.

Hormonal differences between men and women may also influence their differences in lifestyle and longevity. Men are greater risk takers than women, particularly during the years of young adulthood when circulating levels of testosterone are highest. The biological effects of androgens and estrogens differ dramatically. Androgens have vasoconstrictive and inflammatory effects in blood vessels consistent with higher rates of cardiovascular disease in men whereas estrogens exert opposite effects and are thus cardioprotective in women, particularly during their reproductive years (Blackman et al., 2002; Parker et al., 2009). Moreover, gender differences in the balance of estrogens and androgens appear to confer heightened immunity and more resistance to

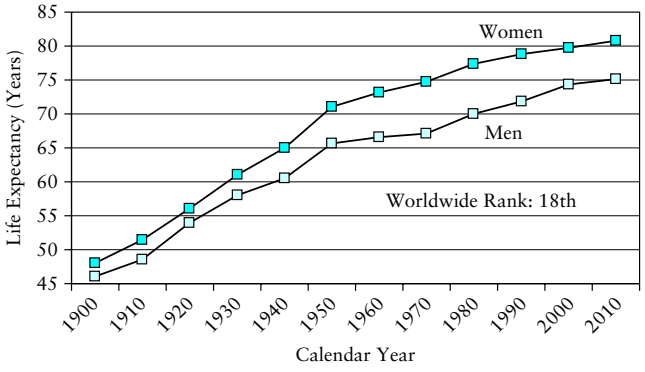

Figure 1.4 Life Expectancy, USA, Women and Men.

Source: Data from Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (2007). World Population Prospects: The 2006 Revision, Highlights. New York: United Nations. National Center for Health Statistics, 2009, USA.

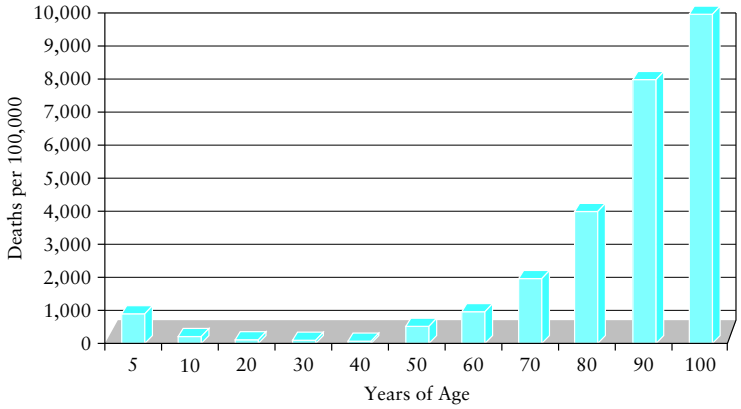

Figure 1.5 Characteristic Death Curve Modeled on the US Population 2002.

Source: Data from Aris, E. (2004). United States Life Tables, 2002. *National Vital Statistics Reports 53*(6):1–40.

infectious and degenerative diseases in women throughout life (Austad, 2006).

AGING AND DISEASE

Aging is a complex process involving a decline in physiological processes that are essential for life. As humans age, there is heightened susceptibility to life-threatening acute and chronic diseases. A characteristic "death curve" is depicted in **Figure 1.5**. The data points represent approximate all-cause annual mortality rates estimated for successive 10 year age brackets for the US population of 2002 (National Vital Statistics System, 2002). Note that the risk of death is elevated in the early years up to 5 years of age, after which there is a relatively long subtle increase in the risk of death until approximately 40 years of age, after which all-cause mortality exponentially rises for all successive age brackets.

Aging can thus be viewed as the general deterioration in human health over the life span generally associated with development of debilitating and life-threatening disease processes. Indeed, aging has been defined as the spectrum of changes that render human beings progressively more likely to die (Medawar, 1952). As shown in **Figure 1.6**, the prevalence of major chronic diseases (arthritis, heart disease, cancer, diabetes mellitus type 2, and chronic obstructive pulmonary disease) rises exponentially with age. It is obvious that the phenotype of human aging is one in which practically any system, tissue, or organ can fail, resulting in debilitation and death (Austad, 1997; Strehler, 1999). Nevertheless, it is important to stress that aging is not merely a collection of diseases. Rather, certain pathologic conditions progress

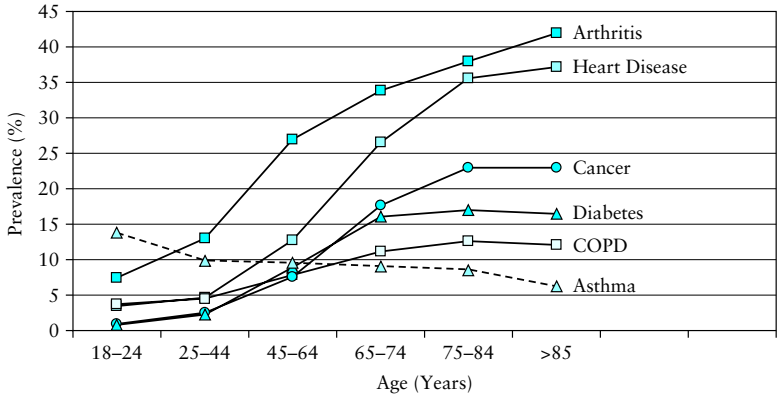

Figure 1.6 Prevalence of Selected Chronic Conditions Expressed as Percentages, as a Function of Age for the USA Population (2002–2003 Dataset).

Source: Data from National Center for Health Statistics, Data Warehouse on Trends in Health and Aging, 2003.

in parallel with the aging process while others, such as asthma, remain constant or even decline late in life.

AGING OF HUMAN CELL POPULATIONS

Aging is a complex and controversial subject. The aging phenomenon appears to be driven by deterioration in cellular health. It is estimated that the human body consists of tens of trillions of cells. This huge population of cells is divisible into subpopulations, each consisting of billions of cells that comprise certain anatomic structures, organs, and tissues. These component cell populations exist in a state of relative homeostasis performing the essential functions of life.

Studies of aging suggest that different cellular populations comprising the human body of a single individual do not all age at the same rate. Acceleration of the aging phenomenon in even one critical cell population may create a "weak link" for the entire system resulting in debilitation and death. However, as pointed out by Hayflick, the aging process does not share its elemental features with any particular disease (Hayflick, 2007). This observation led him to state that, "*the fundamental aging process is not a disease but it increases vulnerability to disease*." To paraphrase, aging may be the cause but not necessarily the effect of a disease process.

The preservation of homeostasis among populations of normally functioning cells in the human body depends primarily upon the balance of cell death and cell replacement. If cells die faster than they are replaced, then the progressively greater demands placed upon those cells that remain may eventually lead to pathologic changes and rapid deterioration in cellular health. Any one of multiple intrinsic and extrinsic factors capable of upsetting the balance of cell death and cell replacement may therefore have considerable impact on the aging phenomenon, particularly for those cell populations that do not normally undergo cell division, e.g., neurons and mature muscle cells.

Programmed cell death (called apoptosis) and cell division are tightly regulated by genetic factors; nevertheless, both processes are also subject to modulation by extracellular as well as intracellular molecular factors. Aging may thus result from extrinsic or intrinsic factors that cause an accumulation of cellular and tissue damage; or alternatively, changes in gene expression related to DNA damage and somatic mutations, epigenetic factors such as methylation or acetylation of DNA, or structural modification of DNA by the intrinsic biological clock that regulates the number of cell divisions, e.g., telomere shortening in chromosomes (Campisi et al., 2000). The etiology of the aging phenomenon therefore appears similar to most complex human traits. Aging is influenced by genetic and environmental factors that interact to produce significant phenotypic variability. Two key theories of aging are briefly discussed in the following sections: one involves the energy rich microenvironment of the cell and the other the genetically controlled biological clock of cell division.

FREE RADICAL THEORY OF AGING

More than half a century ago, Denham Harman developed the free radical theory of aging (Harman, 1956). His theory states that aging is a consequence of accumulating oxidative damage to cells and cellular components over time (reviewed in Beckman and Ames, 1998). Harman later extended his theory to include mitochondrial production of free radicals during normal cellular respiration (Harman, 1972).

Free radicals and oxidants, commonly called reactive oxygen species (ROS), are highly unstable reactive molecules that can damage many vital cellular components (**Figure 1.7**). Rebecca Gerschman and colleagues discovered that ROS can originate from exogenous sources such as ultraviolet and ionizing radiation and first suggested that free radicals are toxic agents (Gerschman et al., 1954).

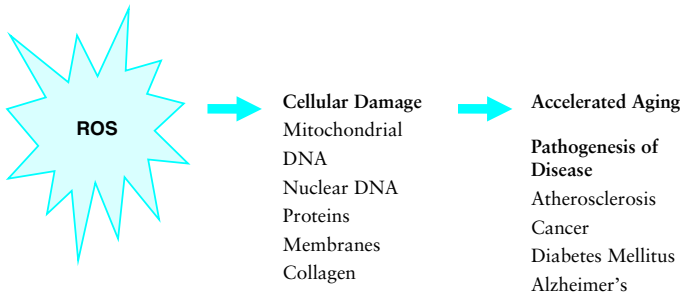

Figure 1.7 Free Radical Theory of Cell Damage, Aging, and Chronic Disease.

Reactive oxygen species (ROS) can be formed by exogenous processes such as irradiation and inflammation as well as normal cell metabolism. These short lived molecules include superoxide, peroxide, hydroxyl radicals, and reactive nitrogen species such as peroxynitrite, all of which are unstable and readily react with DNA to cause a variety of structural genetic alterations including base pair mutations, rearrangements, deletions, insertions, and DNA sequence amplification. While DNA mutations, alterations, and chromosomal abnormalities increase with age in mice and other laboratory animals, damage to nuclear diploid DNA by ROS remains an unproven cause of aging (Ames et al., 1993).

Oxidative phosphorylation is responsible for energy production within the mitochondria of virtually all cells. Since this process continually produces ROS such as superoxide and hydrogen peroxide, and since mitochondria possess haploid DNA unprotected by histones, many advocates of the free radical theory of aging consider that oxidative damage to mitochondria and the mitochondrial DNA has a primary role in the aging process (Harman, 1972; Linnane et al., 1989; de Grey, 1997; Barja, 2000).

Certain nutraceutical agents have gained favor as free radical scavengers that offer some protection against oxidation and the formation of ROS. These include ascorbic acid (vitamin C), tocopherol (vitamin E), carotenes, melatonin, and antioxidant enzymes such as superoxide dismutase (SOD), catalase, and glutathione peroxidase that are capable of degrading ROS into inert compounds (Ames et al., 1981).

TELOMERE SHORTENING AND AGING

Cell division is an extraordinarily precise process that gives rise to daughter cells that have *almost* exactly the same genetic constitution as their progenitors. However, with every cell division, there is incomplete duplication of the chromosomal tips (called telomeres). Successive cell divisions therefore result in shortening of chromosomes until a point is reached where the daughter cells are no longer capable of dividing (called the "*Hayflick Limit*" after its discoverer). Since cells that reach their Hayflick Limit cannot replicate, the balance of cell replication and cell death is interrupted and cellular health may deteriorate. This is the basis of the *Telomere Theory of Aging*; namely, as an ever-increasing percentage of cells reach their Hayflick Limit and are unable to reproduce, then defense, maintenance, and repair of the body becomes increasingly impaired. Thus, telomere attrition due to the Hayflick Limit could account for most of the decline in functional efficiency of cell populations and increases in vulnerability to chronic diseases that characterize the aging phenomenon (Hayflick, 1985, 2007; de Magalhaes and Faragher, 2008).

DECLINING FERTILITY IN WOMEN

Over the past half century, the worldwide fertility rate (*the average number of births per woman during the childbearing years*) has been cut in half, from 5.0 in the 1950s to 2.5 in the 21st century (**Figure 1.8**).

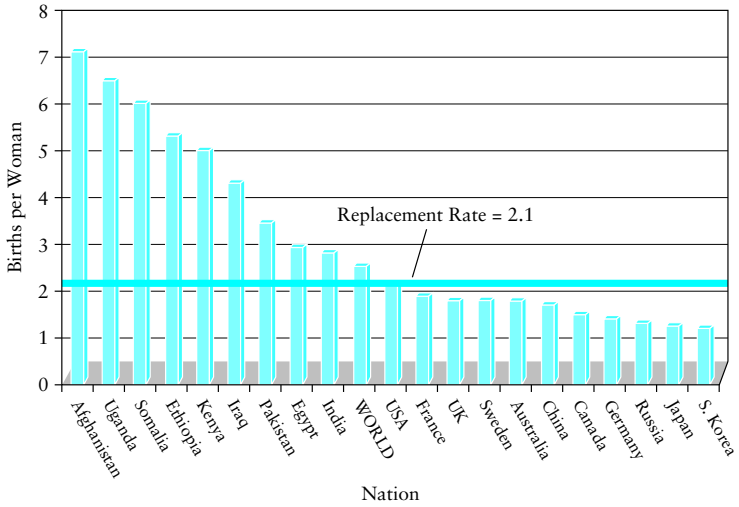

Figure 1.8 Selected Fertility Rates, 2006.

Source: Data from United Nations Department of Economic and Social Affairs, Population Division (2007). "United Nations World Population Prospects: 2006 revision, Table A.15." New York: UN; United Nations World Population Prospects 2006, CIA World Fact Book, 2009.

The decline in fertility rates has been sharpest in the most populous nations such as China, India, and Russia. For example, the fertility rate in China, which has the world's largest population (1.34 billion), decreased from more than 6 in 1970 to 1.6 births per woman in 2006, well below the worldwide replacement rate of 2.1. There are areas of Africa and the Middle East where fertility rates have remained high with populations consisting of predominately children and young adults. In industrialized nations such as Canada, Germany, Great Britain, and Japan, fertility rates are now well below the replacement rate. In the United States, the fertility rate has decreased from 3.5 in the 1960s to 2.0 currently, only slightly below the replacement rate. Worldwide birth control has likely contributed to the general decline in the global fertility rate (Hayutin, 2007).

A woman's potential for childbearing begins to gradually decline between 20 and 30 years of age and then exponentially decreases until the end of the reproductive years at menopause (Menken, Trussell, and Larsen, 1986; Rowe, 2006) (**Figure 1.9**). Widespread use of effective contraceptives, the accessibility of medical abortion, and the shifting paradigm for women to pursue professional careers rather than start families have combined to delay their having children. As a consequence of these factors, the reproductive window of childbearing years has been pushed back and dramatically reduced in women around the world. Furthermore, certain family planning incentives and policies such as China's "*one child policy*" in 1979 have further contributed to the steep decline in fertility in large populations of the world. These factors have all contributed to the global decline in fertility rates, particularly in the industrialized world (Hayutin, 2007).

CHROMOSOMAL ANEUPLOIDY AND OVARIAN RESERVE

Biological factors that reduce fertility in the aging female include increased chromosomal aneuploidy and diminished ovarian reserve with each successive menstrual cycle. As a woman ages, an ever-increasing proportion of the eggs she releases during each successive menstrual cycle are aneuploid (contain an abnormal number of chromosomes) and thus highly prone to spontaneous miscarriage.

The ovarian reserve (the remaining viable eggs in the ovaries) of each woman generally begins to decline about 15 years prior to menopause. Depletion of the ovarian reserve of eggs with aging is also an exponentially expanding phenomenon resulting in the markedly decreased fertility of women in their fifth decade of life. Notably, cigarette smoking is one of the most common and important factors that has been found to decrease ovarian reserve (Parker et al., 2009).

EPIDEMIOLOGIC TRANSITION

It is obvious that many developing and developed nations throughout the world are experiencing marked increases in life expectancy and decreases in fertility. This "*demographic transition*" has produced populations with a relative abundance of geriatric individuals compared to younger people and it is occurring in concert with a closely related phenomenon called the "*epidemiologic transition*."

In general, all nations of the world are in various stages of "*epidemiologic transition*," defined as the transition from acute infectious, parasitic, and

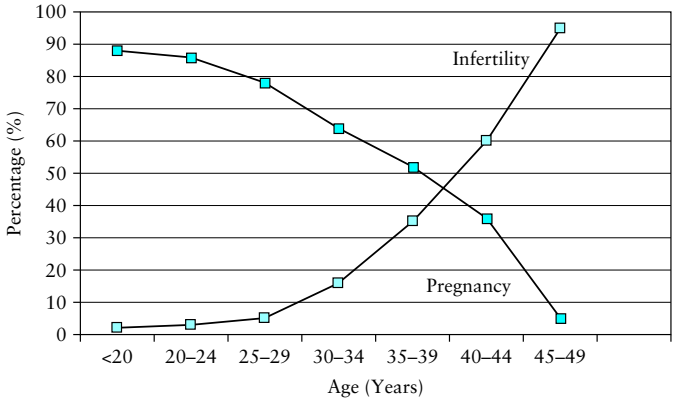

Figure 1.9 Pregnancy and Infertility Rates, Women, USA.

Source: Data from Menken et al. (1986). Age and infertility. *Science 233*:1389–1394; Rowe T (2006). Fertility and a woman's age. *J Reproductive Med 51*(3):157–163.

nutritional deficiency diseases as the predominant causes of morbidity and mortality to a predominance of noninfectious chronic diseases (Omran, 1971). This worldwide epidemiologic transition is undoubtedly a consequence of the improving economic standards of many nations, which has translated into better health and greater longevity for their native populations. Important contributing factors include adequate caloric intake throughout life, improved sanitation, vaccination against common infectious microbes, effective antibiotics to combat bacterial and parasitic diseases, effective drugs to reduce hypertension and other physiological disturbances, better health education for promotion of healthier lifestyles, advances in medical education, progress in medical technology, and overall improvements in healthcare systems.

From a historical perspective, until the beginning of the 20th century, epidemics of communicable (infectious) and parasitic diseases such as typhoid, cholera, smallpox, diphtheria, tuberculosis, bubonic plague, yellow fever, malaria, and influenza were the main causes of morbidity and mortality in all countries of the world. Although certain infectious and parasitic diseases such as tuberculosis and malaria remain epidemic in Third World countries, industrialization and progressive modernization of many nations have resulted in major improvements in housing, sanitation, water supply, nutrition, and health care. The discovery and availability of antibiotics and vaccines have radically changed the profile of diseases, initially in developed countries and later in many developing countries. Consequently, these improvements in medicine and public health have led to dramatic reductions in mortality from infectious and parasitic diseases.

Paradoxically, concurrent with decreases in morbidity and mortality from infectious and parasitic conditions, there has been a remarkable increase in the prevalence of chronic noncommunicable diseases such as cardiovascular disease, hypertension, stroke, chronic obstructive pulmonary disease, type 2 diabetes, and neurodegenerative pathologies such as Alzheimer's disease.

While good health coupled with increasing longevity is generally viewed as beneficial, it is also clear that the epidemiologic transition has produced a concomitant rise in chronic pathogenic processes typically manifested later in life. Cellular damage to vital tissues, organs, and systems of the human body by ROS, atherosclerosis, carcinogenesis, chronic inflammation, allergic reactions, insulin insensitivity, autoimmune reactions, and immunosuppression have produced a world pandemic of chronic diseases and conditions. Furthermore, the escalating spectrum of heart disease, cancer, hypertension, stroke, emphysema, chronic bronchitis, obesity, diabetes mellitus (type 2), cirrhosis of the liver, arthritis, autoimmune disease, kidney disease, and neurodegenerative disorders such as Alzheimer's disease is threatening to overwhelm the healthcare systems of many nations. As pointed out by Ernst L. Wynder, such chronic disease processes appear to be spurred by *metabolic overload* due to intake of high calorie diets with excessive fats and carbohydrates coupled with insufficient exercise and addictive use of tobacco and alcohol (Wynder, 1994). Fortunately, such metabolic insults are fundamentally preventable or correctable since they are largely controlled by personal behavior and lifestyle (please see discussion in the section on prevention).

It has become apparent that epidemiologic transitions are not necessarily unidirectional and should best be viewed as continuous transformation processes wherein some diseases may disappear while others may reappear. A case in point is the reemergence of infectious diseases in high income nations due to antibiotic or drug resistance of pathogenic bacteria, viruses, and other microbes. Epidemiologic transitions therefore reflect complex and dynamic patterns of health and disease due to demographic, socioeconomic, technological, cultural, environmental, and biological changes.

It is also important to realize that the populations of many lesser developed nations continue to manifest relatively short average life spans due to the impact of failing healthcare systems coupled with unstable governance, war, and pestilence. For example, life expectancy in sub-Saharan Africa is only about 45 years, largely due to infectious and parasitic diseases such as HIV/AIDS, tuberculosis, and malaria that produce life-threatening acute conditions such as diarrhea, pneumonia, and anemia. The following sections discuss the diseases and conditions that cause death in the world population and address the disparate profiles of disease among nations according to their economic status.

GLOBAL DEATH RATES

Crude annual death rates for the nations of the world are shown in **Figure 1.10**. The figure is derived from crude rates published by the World Health Organization in 2009 based upon data collected during 2002–2007 (WHO, 2009a; CIA World Factbook, 2009). It is stressed that crude rates are not adjusted for differences in the age distributions of the different populations. Hence, some populations with relatively

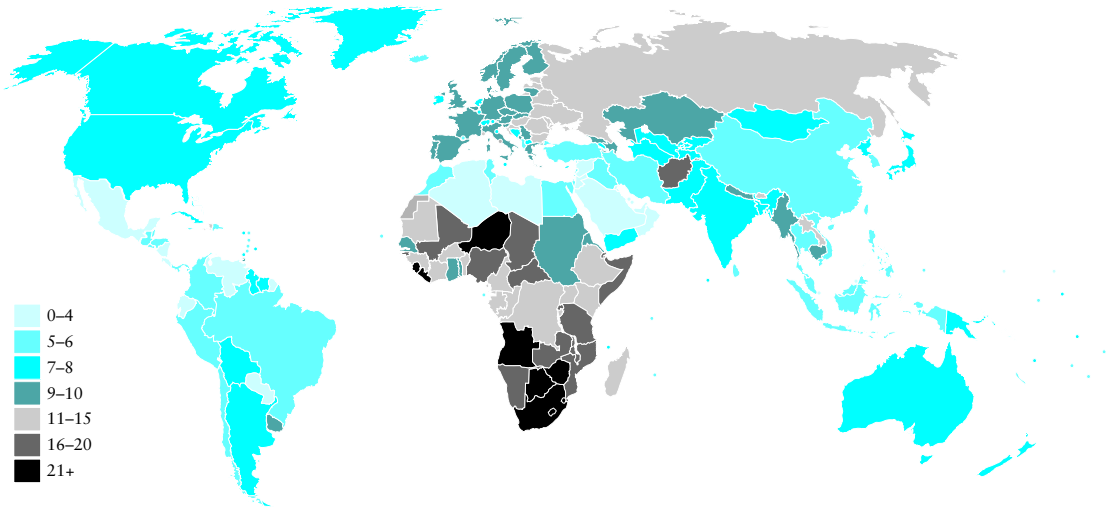

Figure 1.10 Global Death Rates, 2006.

Source: Data from CIA World Factbook, 2006 Estimates of Crude Death Rates per 1,000. Reprinted with permission: World Health Organization, 2009a: Annual Death Rates per 1,000.

more young people may have lower death rates than populations with more old people. Nevertheless, certain conclusions can be drawn by comparing the crude death rates among nations.

What is painfully obvious is that among the relatively young populations of central and southern Africa (sub-Saharan Africa), the death rates are the highest in the world. Compared to developed nations such as the United States, Canada, Japan, Great Britain, Australia, and many European nations, whose populations have far more older people, individuals in African nations such as Swaziland, Botswana, Angola, Niger, Chad, Mozambique, and Zimbabwe have a three to four times higher risk of dying. Even greater disparities in the crude death rates are apparent in the populations of sub-Saharan Africa (more than 20 deaths per 1,000) compared to those of the Mediterranean populations of northern Africa (less than 4 deaths per 1,000).

In sub-Saharan Africa, conditions of hunger and malnutrition cause life-threatening diarrhea in infants and children, killing 5 million every year before they reach the age of 5 years. Parasitic diseases such as malaria are left untreated, killing 1 million more children annually before they reach the age of 15 years. Infectious diseases such as HIV, hepatitis, and tuberculosis ravage the health of young adults, killing nearly 3 million young adults each year before they reach the age of 45 years. Wars and strife due to political unrest kill 100,000 more young adults every year. And if an individual manages to live through these early afflictions, chronic conditions such as cardiovascular disease, stroke, diabetes, chronic obstructive pulmonary disease, and others manifest early and kill 3 million more adults before they reach the age of 65 years. Indeed, of the 60 million deaths that occur every year in the world population of approximately 6.8 billion, nearly 20%, about 12 million, occur in the central/southern African population of 0.8 billion people. Hence, just a single stratification of the world data divides individuals into two camps of death risk: populations residing in sub-Saharan Africa with crude average death rates exceeding 20 per 1,000 per year, and the rest of the world with an average rate less than 10 per 1,000 per year (Adetunji and Bos, 2006; Baingana and Bos, 2006; Bradshaw and Timaeus, 2006; Hill and Amouzou, 2006; Rao, Lopez, and Herned, 2006).

Other nations with high death rates include Afghanistan and member nations of the Russian Federation. The crude annual death rate in Afghanistan (nearly 20 per 1,000) reflects a war-torn impoverished population with little access to health care. The Afghanistan population has high rates of infant and maternal mortality, childhood mortality from malnutrition, and mortality in young adults

from violence and diseases caused by addiction to tobacco, alcohol, and illicit drugs such as cocaine and opium (Duckett, 2005; WHO, 2009a).

In Russia, overall mortality has increased sharply since the disbanding of the Soviet Union during 1985–1991. Crude death rates for the Russian population during the 1980s were on par with other industrialized nations (about 8 per 1,000) but have since increased reaching a peak of nearly 15 per 1,000 in 2010. Recent studies have found a link between excessive alcohol consumption and mortality, particularly among men of working age. For example, Leon and colleagues reviewed the drinking habits of 2,835 men from the industrial city of Izhevsk who died at ages 25–54 years during 2003–2005 compared to 3,078 age-matched living controls. Results revealed that 51% of the men who died consumed *nonbeverage alcohol* (e.g., aftershave) or were problem drinkers compared to 13% of controls. Alcohol-related deaths included cirrhosis of the liver, hepatitis, certain malignancies (hepatocellular cancer, pancreatic cancer, and esophageal cancer), cardiovascular disease, accidents, and violence (homicide and suicide). The investigators estimated that 43% of deaths in men aged 25–54 years in Izhevsk were attributable to hazardous drinking (Leon et al., 2007).

In a recent study, a team of international investigators examined the drinking and smoking habits of 48,557 decedents from 3 Russian industrial cities (Tomsk, Barnaul, and Biysk) who died at ages 15–74 years during 1990–2001. Alcohol-related deaths included accidents, violence, heart disease, aerodigestive tract cancer, liver cancer, tuberculosis, pneumonia, hepatitis, liver cirrhosis, and pancreatic disease. Excess alcohol consumption accounted for 52% of all deaths at ages 15–54 years and 18% of deaths at later ages. The investigators concluded that alcohol and tobacco account for the large difference in adult mortality between Russia and other industrialized nations (Zaridze et al., 2009).

GLOBAL EPIDEMIOLOGY OF DISEASE

Figure 1.11 shows the number of deaths due to specific diseases based upon estimated mortality rates published by the World Health Organization (WHO) for the world population of 2009. Conditions of the heart (ischemic heart disease, congestive heart failure, valvular disease, cardiomyopathy) cause nearly 20% of deaths and various infectious/parasitic diseases (pneumonia, diarrhea, HIV, tuberculosis, malaria) rank a close second causing 19% of deaths. Cancer (12.5%), stroke (10%), and chronic obstructive pulmonary disease (7%) also rank high in relative mortality.

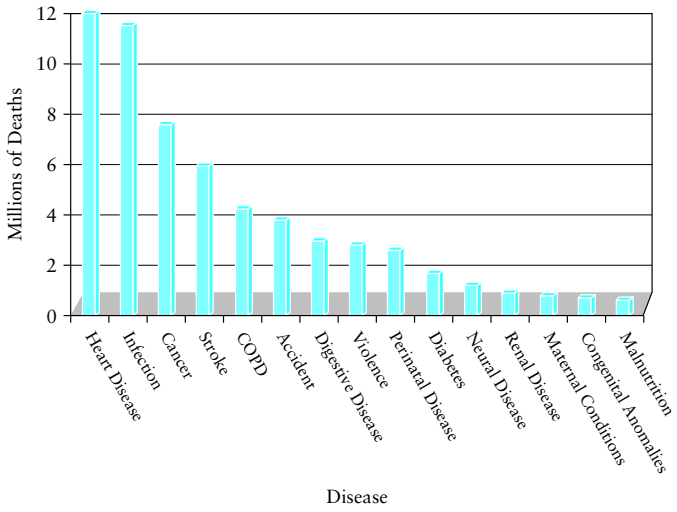

Figure 1.11 Worldwide Deaths from Disease, 2009.

Source: Data from WHO (2009a). World Health Statistics, 2009. World Health Organization, Geneva, Switzerland.

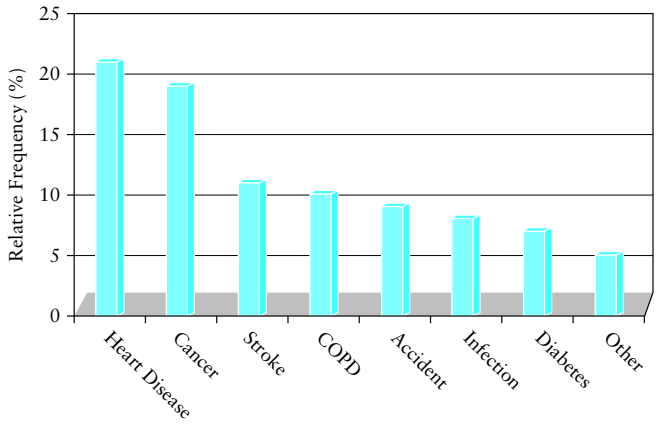

Figure 1.12 Relative Mortality for High Income Nations.

Source: Data from WHO (2009a). World Health Statistics, 2009. World Health Organization, Geneva, Switzerland.

Chronic noncommunicable diseases (heart disease, stroke, cancer, COPD; noninfectious digestive disease such as liver cirrhosis, diabetes, neurological disorders such as Alzheimer's disease, and chronic renal failure) caused approximately 60% (36 million) of all deaths whereas relatively acute conditions (infectious and parasitic diseases, accidents, violence, perinatal disease [low birth weight and failure to thrive], maternal conditions, congenital anomalies, and malnutrition) accounted for the remaining 40% (24 million) of deaths worldwide.

Diseases and conditions afflicting the human race show profound disparities arising from the prevailing environmental conditions and population susceptibilities. A crude but effective discriminant of the disease profile of a population is its economic status. Estimates of relative mortality for specific diseases in high income nations versus low income nations derived from WHO data are given in **Figures 1.12** and **1.13**.

In high income nations such as the United States, Japan, Canada, Australia, Great Britain, France, Germany, Italy, Finland, and Sweden (Figure 1.9), approximately 75% of deaths are due to noncommunicable chronic diseases such as heart disease (21%), cancer (19%), stroke (10%), chronic obstructive pulmonary disease (10%), diabetes mellitus (6%), and other chronic conditions (9%). The remaining 25%

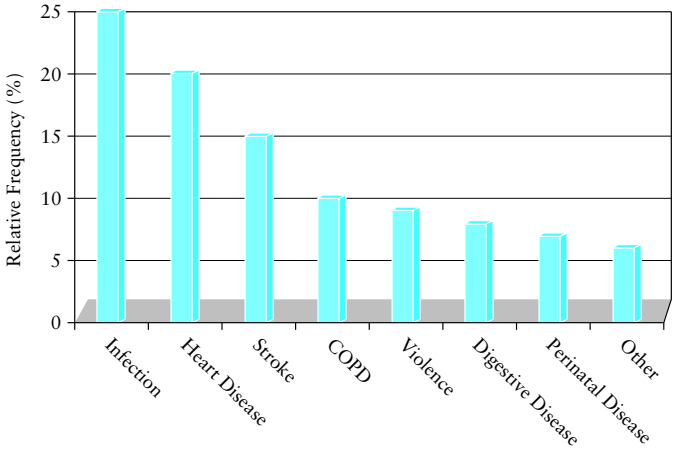

Figure 1.13 Relative Mortality for Low Income Nations.

Source: Data from WHO (2009a). World Health Statistics, 2009. World Health Organization, Geneva, Switzerland.

of deaths in these populations are attributable to relatively acute conditions such as pneumonia, influenza or other infections (16%), accidents (8%), suicide or homicide (2%).

The profile of life-threatening diseases for low income nations differs markedly from that of high income nations (Figures 1.12 and 1.13). In nations such as Afghanistan, Bangladesh, Cambodia, Central African Republic Chad, Democratic Government of Congo, Laos, Ethiopia, Guinea, Haiti, Laos, Liberia, Madagascar, Mali, Mozambique, Nepal, Niger, Rwanda, Somalia, Sudan, Tanzania, Uganda, Tanzania, Yemen, and Zambia, approximately 60% of deaths are attributable to relatively acute conditions such as infectious and parasitic diseases (24%), perinatal disease (16%), violence (10%), malnutrition (5%), and maternal or other acute conditions (5%). Remaining deaths are attributable to conditions associated with chronic disease processes such as heart disease (15%), cancer (12%), stroke (8%), and COPD (5%).

Remarkably, more than 5 billion people (about 75% of the world population) reside in the low income nations represented in Figure **1.**13 (United Nations Department of Economic and Social Affairs, Population Division, [2007]). These populations exist on less than US$3 per person per day and have *little or no access* to clean water, proper sanitation and sewer systems, adequate nutrition, and health care.

In Figure **1.14**, deaths from acute disease, chronic disease, and injury are further stratified according to the 2008 Gross National Income (GNI) per capita. The GNI groupings were calculated using the World Bank Atlas method for nations with populations exceeding 30,000 people (World Bank, 1993). Based on its 2008 GNI per capita, every economy was classified as low income, middle income (subdivided into lower middle income and upper middle income), or high income. The GNI groups translated into US dollars are as follows: low income, $975 or less; lower middle income, $976–$3,855; upper middle income, $3,856–$11,905; and high income, $11,906 or more.

Enormous differences are evident in the profiles of death-causing diseases according to economic level (**Figure 1.14**). Poverty with its attendant poor hygiene, malnutrition, inferior education, heavy use of tobacco and alcohol, and lack of access to effective health care is associated with acute diseases that tend to impact younger generations. Reciprocally, greater prosperity is associated with chronic diseases more likely to impact older individuals through improved public health practices, e.g., vaccination against infectious agents, adequate nutrition, higher education, avoidance of tobacco and alcohol, and more effective health care. Unfortunately, the latter scenario has created in many populations "*metabolic overload of caloric intake*" leading to an epidemic of obesity and related chronic diseases of adults and the elderly.

It is noteworthy that in lower middle income nations with large populations, such as India and China, deaths from chronic diseases now outnumber deaths from acute conditions by more than fivefold, and even in low income nations, the number of deaths from chronic diseases is approaching that of acute conditions. In higher middle income nations such as Poland, Russia, Mexico, and Argentina, mortality from chronic disease far outstrips that from acute disease. Their profile is similar to the mortality pattern of high income nations such as Sweden, the United States, the United Kingdom, Germany, and Japan.

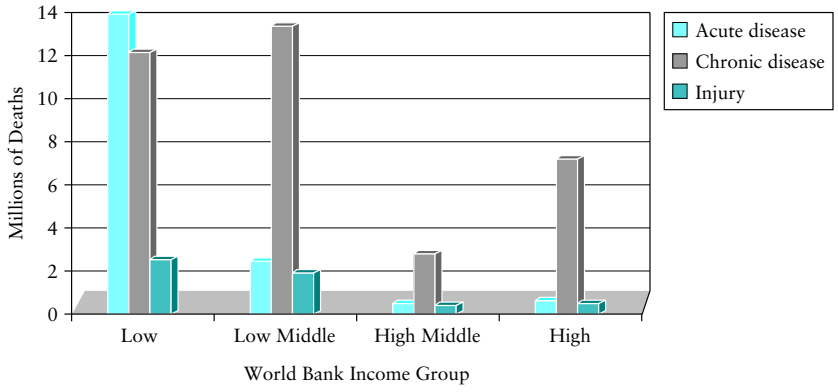

Figure 1.14 Worldwide Deaths by Major Cause and National Income, 2008.

Source: Data from WHO (2008a). Chronic Diseases: A Vital Investment. WHO Geneva, Switzerland.

These trends reflect the tremendous worldwide impact of the *epidemiologic transition*.

A disturbing trend in more prosperous nations is the heavy and indiscriminate use of antibiotics in the treatment of bacterial infections. Selection forces in these populations therefore favor the accumulation of resistant bacterial genes and plasmids resulting in the reemergence of certain infectious agents due to their evolving antibiotic resistance, e.g., *methicillin-resistant staphylococcus aureus* (*MRSA*).

Risk Factors and Mortality

Worldwide mortality rates can also be examined according to major risk factors that are known to cause disease. Two major risk factors, tobacco and obesity, rival one another as perhaps the greatest public health menaces of all time. Another devastating menace to the status of public health is the problem of undernutrition which currently impacts millions of children, particularly in the underdeveloped nations of the world.

Global Tobacco Pandemic

Several comprehensive reports have addressed the global pandemic of disease resulting from tobacco addiction (Peto et al., 1996; Guindon and Boisclair, 2003; Doll et al., 2004; Jha et al., 2006; WHO, 2009b). According to estimates from these sources, 100 million people died from tobacco addiction (primarily cigarette smoking) during the 20th century, and if current smoking rates and trends prevail, one billion people will die from tobacco addiction in the 21st century. Male smokers outnumber female smokers by more than fivefold in the populations of Africa, the Middle East, Asia, and the Western Pacific whereas female smoking rates are trending higher and may eventually approach male rates in the Americas and Europe (**Figure 1.15**). Worldwide, approximately 42% of men and 10% of women smoke, accounting for approximately 5.4 million deaths annually (**Figure 1.16**).

Prevention and Control of Tobacco Use

Recently, an international program of tobacco control titled the *Tobacco Free Initiative (TFI)* was ratified and implemented through the auspices of the World Health Organization to curb the epidemic of tobacco-related diseases throughout the world (WHO, 2009b). In addition to careful monitoring of tobacco use and prevention policies and their effectiveness in reducing tobacco-related morbidity and mortality, the *WHO TFI* advocates specific guidelines for the prevention of tobacco use and control of tobacco products. These are (1) primary prevention of initiating the smoking habit by early health education programs, (2) warning about the dangers of tobacco through hard-hitting antitobacco ads and graphic warnings on tobacco packaging, (3) protecting people from tobacco smoke by advocating smoke-free environments, (4) offering effective help to quit tobacco use through counseling and medications, (5) enforcing bans on tobacco advertising, promotion, and sponsorship, and, finally, (6) raising taxes on tobacco to generate revenues to support the program.

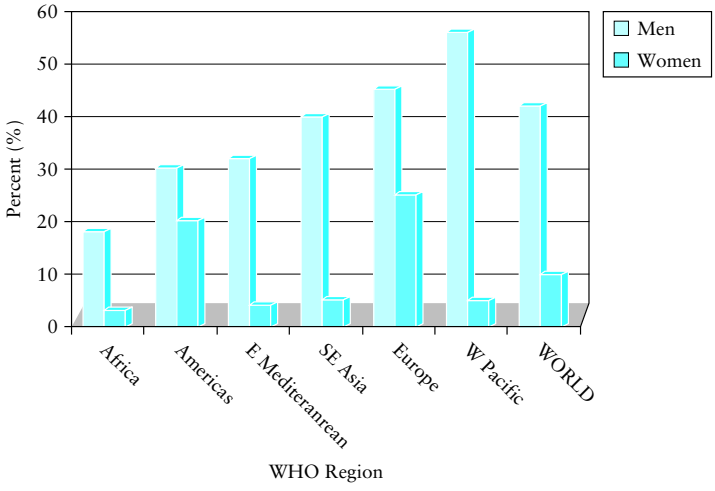

Figure 1.15 Worldwide Smoking Prevalence: 2005.

Source: Data from WHO (2009b). Report on the Global Tobacco Epidemic, 2009.

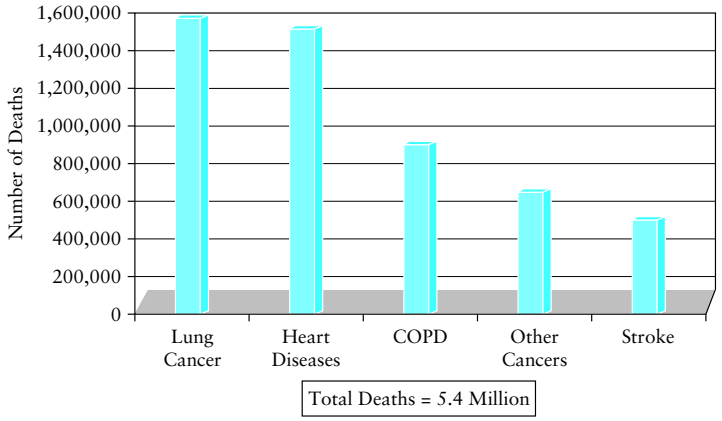

Figure 1.16 Worldwide Deaths Attributable to Cigarette Smoking, 2009.

Source: Data from WHO (2009b). Report on the Global Tobacco Epidemic, 2009.

Global Obesity Pandemic

The phenotype of an obese individual is characterized by an unnatural excess of body fat. This condition is commonly assessed by the body mass index (BMI) also known as the "*Quetelet Index*" calculated as weight in kilograms divided by the square of height in meters (kg/m^2). In adults, a BMI of 30 or more is defined as obese. In children, obesity is defined as weight above the 95th percentile for age-gender-specific growth charts.

As shown in **Figure 1.17**, approximately 10% of men and 12% of women are obese in the world population reflecting the global pandemic of overnutrition and metabolic overload (WHO, 2008a). The condition is particularly prominent in the developed nations of the Americas and Europe where over 20% of men and nearly 25% of women are in the obese category. According to surveys conducted by the WHO in 2009, there are more than 400 million clinically obese adults in the world population. Furthermore, the obesity pandemic is not restricted only to adults as the world population now contains approximately 22 million children under the age of 5 years that are either overweight or obese (International Obesity Task Force, 2009).

Obesity with its associated lipid engorgement of the fat cell (adipocyte) population often produces

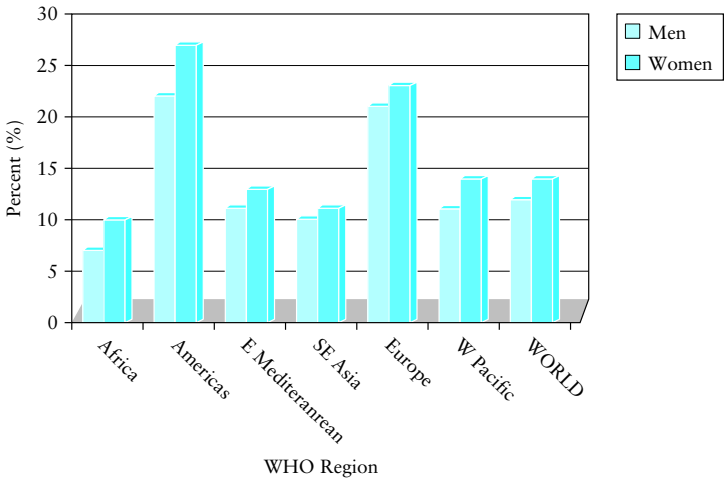

Figure 1.17 Worldwide Obesity Prevalence: 2009.

Source: Data from WHO (2009c). Obesity and Overweight. World Health Organization, Geneva, Switzerland.

adverse metabolic effects on blood pressure, cholesterol, triglycerides, and insulin resistance. Based on the results of recent epidemiologic investigations of diverse populations (Calle, 2007; Interheart, NCI bulletin), it is evident that as the BMI climbs above 30, there are corresponding risk increases in several chronic diseases including cardiovascular disease (hypertension, myocardial infarction, and stroke), chronic arthritis, type 2 diabetes, gallbladder disease, gastroesophageal reflux disease, and several cancers (Leach, Baumgard, and Broom, 1973; de Courten et al., 1997; Zimmet and Alberti, 2006; Caballero, 2007; Calle, 2007; Fisichella and Patti, 2009) (**Figure 1.18**). Gravid obesity (BMI > 40) has been found to be associated with greater than a twofold increase in the risk of all-cause mortality in both men and women (Calle, 2007).

Life-threatening conditions associated with obesity include hypertension, atherosclerosis, and hypercholesterolemia leading to catastrophic cardiovascular and cerebrovascular events such as myocardial infarction and stroke; insulin resistance resulting in type 2 diabetes; heightened carcinogenesis and development of certain types of malignant tumors, especially the hormonally related and large-bowel cancers. Nonfatal but debilitating health conditions associated with obesity include gastroesophageal reflux disease (GERD), cholelithiasis (genesis of gallstones), urolithiasis (genesis of kidney stones), and degenerative osteoarthritis.

The fundamental cause of obesity is an imbalance of energy input versus energy output. It should be realized that the development of obesity is *usually* not an acute process, but rather one that requires years or even decades of energy imbalance involving a sustained excess of calories consumed versus calories expended. Two primary risk factors are evident: (1) increased consumption of high calorie foods, particularly simple carbohydrates and other foods high in saturated fats and sugars, and (2) lack of sufficient physical activity. The inevitable consequence of calories taken in exceeding calories burned is obesity.

Societal changes and related behaviors are driving the obesity epidemic. With the globalization of food markets and continuing urbanization of the world population, low calorie diets with abundant complex carbohydrates are rapidly being replaced by high calorie diets with a high proportion of fats and sugars. At the same time, sedentary lifestyles characterized by little or no physical activity have become commonplace in the populations of modernized nations.

The International Obesity Task Force (IOTF) was established in 1996 to raise awareness and develop approaches to combat the emerging global pandemic of obesity. The IOTF membership consists of experts in the field of obesity research and represents 43 national organizations. The IOTF collaborates closely with the World Health Organization and other international health organizations concerned about the obesity problem.

The IOTF initiative on the prevention and management of obesity has four main goals: (1) to increase the awareness among governments, healthcare professionals, and the community that obesity is a serious medical condition and a major health problem with substantial economic costs; (2) to provide evidence and guidance for the development of better

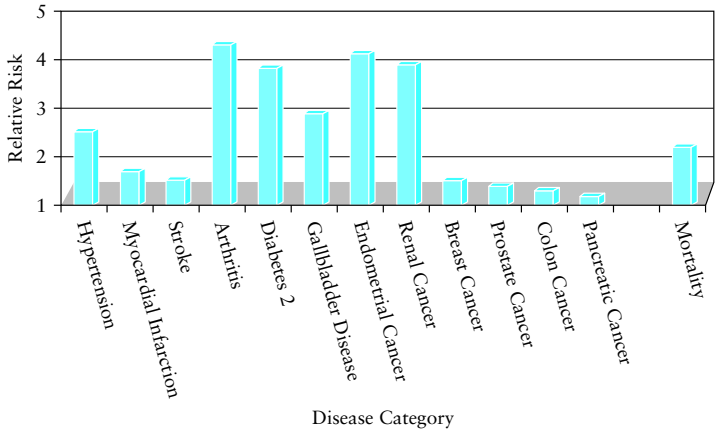

Figure 1.18 Obesity and Risk of Disease.

Source: Data from WHO (2008a). Chronic Diseases: A Vital Investment. WHO Geneva, Switzerland. Caballero B (2007). The Global Epidemic of Obesity: An Overview. *Epidemiologic Reviews* 29:1–5. Calle EE (2007). Obesity and cancer. *BMJ* 335(7630):1107–1108.

prevention and management strategies; (3) to secure the commitment of policy makers to action; and (4) to foster the development of national, regional, and international structures that will enable and support the implementation of action on the overweight and obesity.

The IOTF recommends several long-term strategies for the prevention and treatment of obesity and obesity-related diseases. Treatment centers incorporating effective weight loss programs should be developed with well-trained staff to ensure effective support to help individuals safely lose weight and maintain their optimum weight. Existing healthcare facilities should strive to develop and maintain an integrated team of physicians, dieticians, physical therapists, and other healthcare professionals, plus the necessary resources for the accurate diagnosis and effective treatment and management of obesity and obesity-related diseases.

A key element for success is primary prevention through promotion of healthy diets and regular physical activity beginning with health education programs initiated early in life. The following consensus statement from the British Medical Association is timely:

> *"Such interventions at the family or school level will need to be matched by changes in the social and cultural context so that the benefits can be sustained and enhanced. Such prevention strategies will require a coordinated effort between the medical community, health administrators, teachers, parents, food producers and processors, retailers and caterers, advertisers and the media, recreation and sport planners, urban architects, city planners, politicians, and legislators. Environments that encourage healthy eating and active living are vitally important. The focus of such strategies should be to make it easier for the public to make healthy choices. Such strategies require funding for implementation, but should ultimately lead to a reduction in the costs from obesity related ill health."*

Global Undernutrition and Malnutrition

Global estimates of relative mortality rates are shown for children under the age of 5 years in **Figure 1.19** (WHO, 2008b). It is evident that underweight children suffer from malnutrition and near starvation and are highly predisposed to infectious and parasitic diseases leading to diarrhea, dehydration, energy depletion, immunosuppression, and death. Such conditions currently exist in epidemic proportion in low income nations, particularly in sub-Saharan Africa.

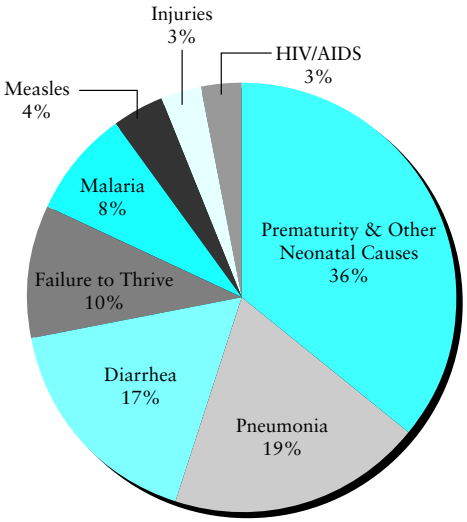

Figure 1.19 Relative Mortality Associated With Malnutrition and Underweight in Children Less Than Five Years of Age.

Source: Data from WHO (2008b). Global tuberculosis control 2008 report; WHO, UNAIDS, UNICEF (2008). Towards universal access: scaling up priority interventions in the health sector: progress report 2008.

Among the *10 million* children who die annually, WHO estimates that *6 million (60%)* succumb to conditions attributable to malnutrition and starvation (Caulfield et al., 2004).

Overall, the proportion of children under 5 years of age suffering from undernutrition (according to the WHO Child Growth Standards) declined from 27% in 1990 to 20% in 2005. However, progress has been uneven and an estimated 112 million children are underweight. Furthermore, every year some 536,000 women die of complications during pregnancy or childbirth, 99% of them in developing countries primarily in the populations of sub-Saharan Africa.

Reducing child mortality increasingly depends on approaches to improve neonatal survival. Globally, an estimated 37% of deaths among children under 5 years of age occur in the first month of life, most in the first week. Countries making the least progress are generally those affected by high prevalence rates of malnutrition and low birth weight, HIV/AIDS, indigenous infectious and parasitic diseases such as tuberculosis and malaria, economic hardship, and conflict. Much of the progress in reducing child mortality can be attributed to improved nutrition particularly during gestation and the neonatal period, increased immunization coverage

against common infectious diseases such as measles, antiretroviral therapy for HIV/AIDS, use of oral rehydration therapies during episodes of diarrhea, use of insecticide-treated mosquito nets and access to combination therapies to combat malaria, efforts to eliminate disease due to *Haemophilus influenzae* type B infection, and ready access to clean water and sanitation facilities. However, because the availability and use of proven interventions at the community level remain low, pneumonia and diarrhea still kill 3.8 million children less than 5 years of age annually.

BODY MASS AND ALL-CAUSE MORTALITY

While no single biological factor can satisfactorily explain the disparate profiles of disease-specific mortality for different nations, there is one factor that does provide a crude but effective discriminant of all-cause mortality. Perhaps surprisingly, that factor is the body mass index (or Quetelet index) defined as weight in kilograms divided by height^2 in meters; $BMI = kg\ wt/(m\ ht)^2$. Its potential value as a measure of disease versus health is that BMI is a continuous variable that is easily calculated for every individual. The expectation is that low values are associated with nutritional deficiencies and high values with nutritional excesses.

Figure 1.20 shows all-cause mortality rates for adult men and women by eight categories of BMI ranging from extremely underweight (<14) to morbidly obese (>35) based upon a review of epidemiologic studies of 34 different populations from around the world. These data clearly reflect a U-curve for both genders where the optimum value corresponding to the lowest all-cause mortality is a BMI range of 21–25. As with most physiological factors, BMI shows a window of homeostasis wherein the potential for good health is optimized and individuals with a BMI that is either too low or too high significantly increase their risk of dying. In particular, high BMI carries a fivefold increase of dying from obesity-linked conditions such as cardiovascular disease, stroke, diabetes, pulmonary disease, renal disease, and selected cancers such as breast cancer, colorectal cancer, and prostate cancer.

DISABILITY-ADJUSTED LIFE YEARS (DALY)

The *Disability-Adjusted Life Years* (*DALY*) is a measure of overall disease burden, expressed as the *number of years lost due to ill-health, disability, or early death*. The measure was originally developed by Christopher Murray and Alan López at Harvard University in order to characterize the overall burden of disease in populations (Murray and López, 1990, 1994). The World Health Organization subsequently adopted the measure in its *Global Burden of Disease Studies*.

The DALY is now widely used in the field of public health to assess the impact of death and disability in populations. This parameter is designed to extend the concept of potential years of life lost due to premature death to include equivalent years of "healthy" life lost due to states of poor health or disability. One DALY represents *one lost year of healthy life* and the sum of DALYs for all individuals of a population therefore quantifies the "gap" between current health status and ideal health where the entire population lives to an advanced age, free of disease and disability. The DALY therefore attempts to quantify mortality and morbidity in a single, common metric.

Traditionally, health liabilities were expressed as the expected or average number of *Years of Life*

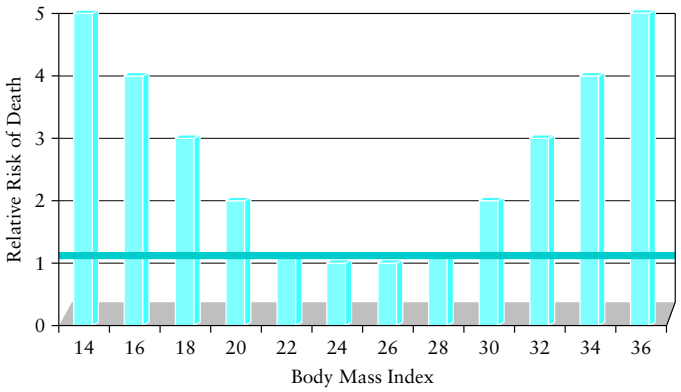

Figure 1.20 Body Mass Index & Mortality Window of Homeostasis.

Lost (*YLL*). This measure does not take into account the impact of disability or the number of years an individual lives with a severe disability. The population DALY for a disease or health condition is thus calculated as the sum of the years of life lost due to premature mortality in the population and the *Years Lost Due to Disability* (*YLD*) for incident cases of the specific health condition:

$$DALY = YLL + YLD$$

The YLL in a population for a particular disease is the product of the average life expectancy at average age of death for all individuals who died from that disease during a certain period of time (e.g., one year). The basic formula for YLL for a given cause, age, and gender is thus

$$YLL = N \times L_1$$

where N is the number of individuals who died from the disease in the population during the time period (year) of interest and L_1 is their standard life expectancy in years. Standard life expectancies for different ages are currently based upon life tables for the Japanese population, which has the highest biological life expectancy (80 years for men and 82.5 years for women).

To estimate YLD in a population for a particular disease in a particular time period, the average duration of disease (L_2) in years is weighted by a factor (DW) that reflects the severity of the disease on a scale from 0 (perfect health) to 1 (dead). The basic formula for YLD is thus

$$YLD = I \times DW \times L_2$$

where I denotes the number of new cases of disease, DW is the disability weight, and L_2 is the average duration of disease.

In calculating DALYs, the years of future life lost are weighted according to the formula

$$f(y) = 0.16243\ y\ e^{-0.04y}$$

where y = the age at death or diagnosis of disease. This technique gives less weight to years of future life lost during periods of lesser productivity in the life span (childhood and late in life) and greater weight to years of future life lost during periods of higher productivity (late adolescence and adulthood). Furthermore, since a year of present life is considered more important than a year of future life, years of future life lost are discounted (reduced) at a standard rate of 3% per annum. Population estimates of DALYs for specific diseases are usually presented for a particular year per either 1,000 or 100,000 inhabitants (Murray and López, 1990, 1994, 1997).

Global Disability-Adjusted Life Year (DALY): All Causes

In 1997, Murray and López reported results of the first Global Burden of Disease Study using a standardized approach to epidemiologic assessment based upon estimates of DALY for various regions of the world. Estimates were calculated by age and gender for 107 disorders based upon cause-specific mortality and incidence rates, average age at onset, duration of disease, and severity of disability. Of the total DALY, 44% were due to communicable, maternal, perinatal, and nutritional disorders, 41% were due to noncommunicable diseases, and 15% were due to injuries. Among noncommunicable diseases, neurologic disease accounted for 10.5%; cardiovascular disease, 9.7%; and cancer, 5.1% of the total DALY. Communicable, maternal, perinatal, and nutritional disorders accounted for two-thirds of the disease burden in sub-Saharan Africa while noncommunicable diseases accounted for 80% of the burden in established market economies. The highest disease burdens were in sub-Saharan Africa and India (21.4% and 20.9% of the global DALY total, respectively). The authors noted that "*developing countries carried almost 90% of the global disease burden yet were recipients of only 10% of global health care funding*" (Murray and López, 1997).

Figure 1.21 depicts the worldwide pattern of DALY in 2004. The average DALY across all regions was 237 per 1,000 persons of which about 60% was due to years of life lost from premature death and 40% due to years of healthy life lost due to disability from nonfatal diseases (WHO, 2009c).

In the nations of sub-Saharan Africa, the DALY are more than twofold higher than the rest of the world, largely due to high mortality rates from both acute and chronic conditions as discussed earlier in this chapter. Higher than average DALY are also evident in the war torn nations of Afghanistan and Iraq.

The DALY and contributions of years of life lost due to premature death (YLL) and years of healthy life lost due to disability (YLD) are contrasted for various regions of the world in **Figure 1.22**. In regions with the highest DALY (Africa, East Mediterranean, and Southeast Asia), premature deaths account for more than two-thirds of the DALY whereas in Europe, America, and the Western Pacific, premature deaths and disability each account for roughly half of the disease burden. This pattern clearly reflects the impact of the *epidemiologic transition*, vis-à-vis the greater disease burden of communicable diseases and maternal, perinatal, and nutritional conditions in developing nations compared to the noncommunicable diseases that are more prominent in developed nations.

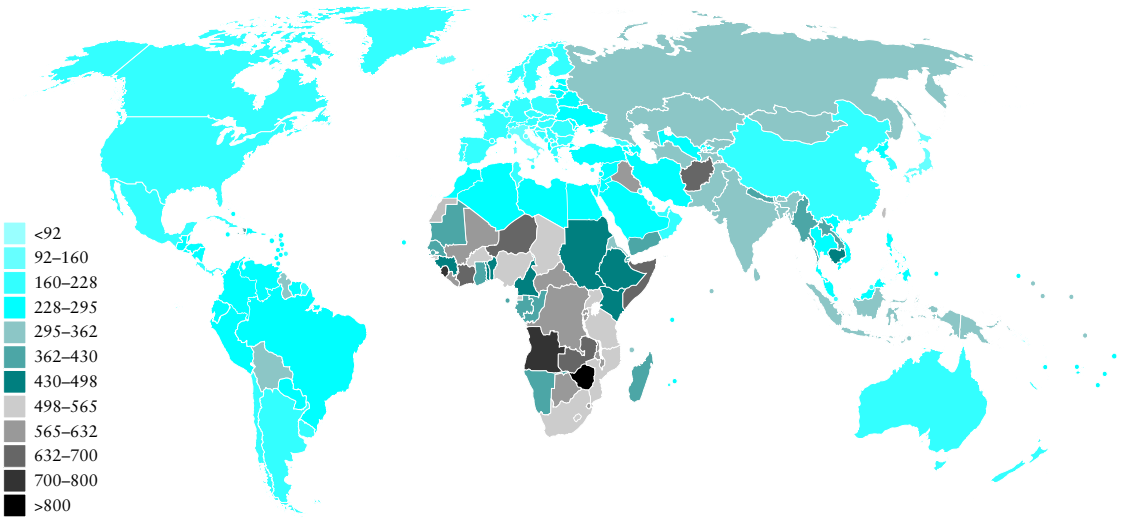

Figure 1.21 Disability Adjusted Life Years, 2004.

Source: Data from World Health Organization. The global burden of disease: 2004 update. Geneva, WHO, 2008. Available at www.who.int/evidence/bod

GLOBAL PREVENTION OF CHRONIC DISEASES

Four major groups of chronic diseases: cardiovascular diseases, cancers, chronic respiratory diseases, and diabetes represent the greatest burden to human health. These four diseases are the world's biggest killers, causing an estimated 36 million deaths each year and approximately 60% of all deaths globally.

Fortunately, these diseases are largely preventable. Up to 80% of heart disease, stroke, and type 2 diabetes, and over 30% of cancers can be prevented by eliminating shared risk factors, mainly tobacco addiction, unhealthy diet and obesity, sedentary lifestyle, and the harmful use of alcohol.

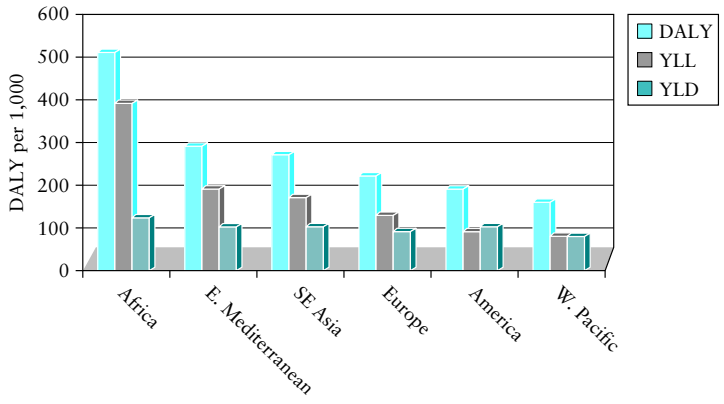

Figure 1.22 DALY, YLL, YLD by Region.

Source: Data from World Health Organization (2009). Death and DALY estimates for 2004 by cause for WHO Member States: Persons, all ages.

However, unless appropriately addressed with well-designed and effective disease prevention and health promotion programs, the mortality and disease burden from these health problems will continue to increase. WHO projects that, globally, deaths from these conditions will increase by 10–20% over the next 10 years. Due to high rates of smoking and alcohol abuse, increasing intake of diets ladened with salt, fat, and sugar, and a deficit in the access to health care, the populations of developing nations in Africa, Asia, and the Middle East are particularly susceptible.

Though proven cost-effective strategies currently exist to prevent and control the growing health burden of chronic diseases, high-level commitment, and concrete action are often missing or underfunded at the national level. On a global basis, it will be necessary to raise the priority accorded to chronic diseases and develop and implement effective disease prevention and health promotion strategies and policies for the populations at risk. There is an immediate call for the international public health communities to lobby and mobilize politicians, other international and regional agencies such as the United Nations Development Programme (UNDP), the United Nations Children's Fund (UNICEF), WHO, and the World Bank, and other international nongovernmental agencies to address the socioeconomic, behavioral, nutritional, and public health issues that have led to the current chronic disease epidemic. A multidisciplinary approach by governments that involves multiple ministries such as health, finance, education, sports, and agriculture can all contribute to a reversal of the underlying socioeconomic causes of the problem (Simpson et al., 1997; WHO, 1999; Zimmet, 1999, 2000; Zimmet, Alberti, and Shaw, 2001; Zimmet, Shaw, and Alberti, 2003; Alberti et al., 2004; WHO, UNAIDS, UNICEF, 2008).

Effective interventions should obviously target tobacco use, unhealthy diets, physical inactivity, and excessive alcohol consumption. Programs must also be implemented to promote research and develop international partnerships for the prevention and control of chronic diseases. To this end, improved registration systems of vital statistics are needed in order to monitor the incidence, prevalence, and mortality of chronic diseases, as well as their determinants, and to evaluate progress at the national, regional, and global levels (WHO, 1999; WHO, 2008a).

The World Health Organization working closely with its 193 Member States, has developed an Action Plan to prevent chronic diseases from occurring and to help the millions who are already affected to cope with these lifelong illnesses. This Action Plan, endorsed at the 61st World Health Assembly in May 2008, builds on the report of the Global Strategy for the Prevention and Control of Noncommunicable Diseases, 53rd World Health Assembly, May 2000. Key components of the plan are addressed in the following statement by Dr. Ala Alwan, Assistant Director-General, Noncommunicable Diseases and Mental Health, World Health Organization (Alwan, 2008).

> *"The action plan builds on the WHO Framework Convention on Tobacco Control and the WHO Global Strategy on Diet, Physical Activity, and Health. The Action Plan provides Member States, WHO, and the international community with a roadmap to establish and strengthen initiatives for the surveillance, prevention, and management of noncommunicable diseases. Furthermore, the Action Plan highlights the pressing need to invest in noncommunicable disease prevention as an integral part of sustainable socioeconomic development. NCD prevention is an all-government responsibility. Considerably more gains can be achieved by influencing policies of nonhealth sectors than by health policies alone. All stakeholders will need to intensify and harmonize their efforts to avert these preventable conditions and to save millions from suffering needlessly and dying prematurely."*

For every individual, effective prevention of chronic disease is contingent upon the total avoidance of major known risk factors. Many of these risk factors are well established and primary prevention is straightforward; avoidance of cigarette smoking (and other forms of tobacco addiction), avoidance of excessive alcohol consumption, control of blood pressure by avoidance of high-salt fat-laden diets, control of blood glucose by avoidance of high carbohydrate (sugar-based) diets and foods with high glycemic indices, maintenance of body weight within normal limits, intake of calories matched to energy expenditure, daily intake of antioxidant and anti-inflammatory nutraceutical agents (fresh fruits and vegetables), daily aerobic exercising, daily stress release, and maintenance of a positive attitude in meeting life's challenges.

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