Chapter Five

Mortality

THE DECLINE IN MORTALITY RATES from their historically high levels initiated the demographic transition. In much of Europe and North America, declines in mortality were apparent shortly after the onset of the Industrial Revolution. These improvements to human survival and longer life spans resulted in rapid population growth, aided by modernization and advances in sanitation and nutrition, with Europe's population more than doubling between 1800 and 1900.[1] By the first half of the twentieth century, developed countries had completed their mortality transition, characterized by long life expectancies, low infant death rates, and slow population growth rates. In the developing world, the initiation of mortality declines in the postwar era during the second half of the twentieth century brought rapid population growth. Here, the pace of mortality decline tended to be much more rapid than that experienced in the developed world, assisted by the importation of modern medicines, health care, immunizations, and improved nutrition and sanitation.

This chapter explores mortality differences and the related subject of morbidity, or illness within populations. It begins by discussing the mortality transition, or the decline in mortality rates, and the epidemiological transition. It then explores differences in the rates and causes of mortality between black and white Americans and increasing mortality in Russia. The chapter also discusses the significance of IPDs and their reemergence before focusing on HIV/AIDS and its impact on population mortality. The "Focus" section contrasts

the mortality experiences of the United States, Zimbabwe, and Mexico, and the "Measures, Methods, and Tools" section defines the common measures of mortality.

MORTALITY TRANSITIONS

For much of human history, the average person could probably expect to live only twenty to thirty years. Infant mortality rates were high, and approximately half of all deaths occurred before age five, usually associated with poor nutrition or infanticide. With advances in agriculture and the domestication of animals, humans were able to establish year-round settlements. Infectious diseases such as bubonic plague found a new home in human settlements and became the prevalent cause of death, as denser populations and relatively poor sanitation allowed infectious diseases to thrive. Trade between settlements transported illness and disease across space.[2] The nineteenth and twentieth centuries saw improvements in housing, sanitation, and nutrition, allowing mortality to decrease and life expectancy in Europe and North America to increase to forty years.

The poor health standards and living conditions observed in American, Canadian, and British cities during the Industrial Revolution gave rise to new public health initiatives. This intervention was spearheaded by the elite not out of goodness but out of fear that their own health and, perhaps more importantly, their profits, hinged upon the conditions of the working poor.[3] Although infectious diseases, including tuberculosis, bronchitis, pneumonia, influenza, and measles, remained the main cause of death, their incidence declined with environmental improvements, such as improved living conditions, and occurred long before medical intervention was widely available.[4] However, some diseases, such as diphtheria, did not respond to societal improvements, declining only when large-scale immunization programs began. In fact, it wasn't until the 1950s that a decline in mortality, particularly amongst the older population, could be associated with the application of low-cost public health programs. Since then, improvements to life expectancy within developed countries have generally been attributed to advances in medical and biological sciences as opposed to general economic improvements or public health. The mortality transition also results in a shift in the ages when the majority of deaths occur. In countries at the beginning of the transition, younger age groups are at greater risk of dying, since children are particularly susceptible to many infectious diseases. Even now, approximately 40 percent of deaths in the developing world occur among children less than five years old. In the developed world, most deaths occur among the elderly, with less than 2 percent of deaths occurring among those less than twenty years old.

Despite improvements in indicators such as life expectancy or infant mortality within the past fifty years, widespread variations remain, even in the developed world (figure 5.1). As of 2009, life expectancy in the developed world averaged seventy-seven years, being slightly longer for women (eighty-one) than men (seventy-four). In the developing world (excluding China), life expectancies are lower, averaging sixty-seven and sixty-three years from birth among women and men, respectively.[5] Improvements have been slower in sub-Saharan Africa than in any other region,[6] with life expectancies in sub-Saharan Africa just fifty-one years, compared to seventy-eight years in North America, seventy-three years in Latin America, and sixty-nine years in Asia. At eighty deaths per one thousand births, infant mortality rates are similarly higher in sub-Saharan Africa. In comparison, infant mortality rates are only six per one thousand in the developed world.

Omran's Epidemiological Transition

Abdel Omran's epidemiological transition provides a useful framework for looking at these temporal trends in mortality,[7] echoing the decline in mortality set out in the demographic transition theory. However, Omran's theory asserts that

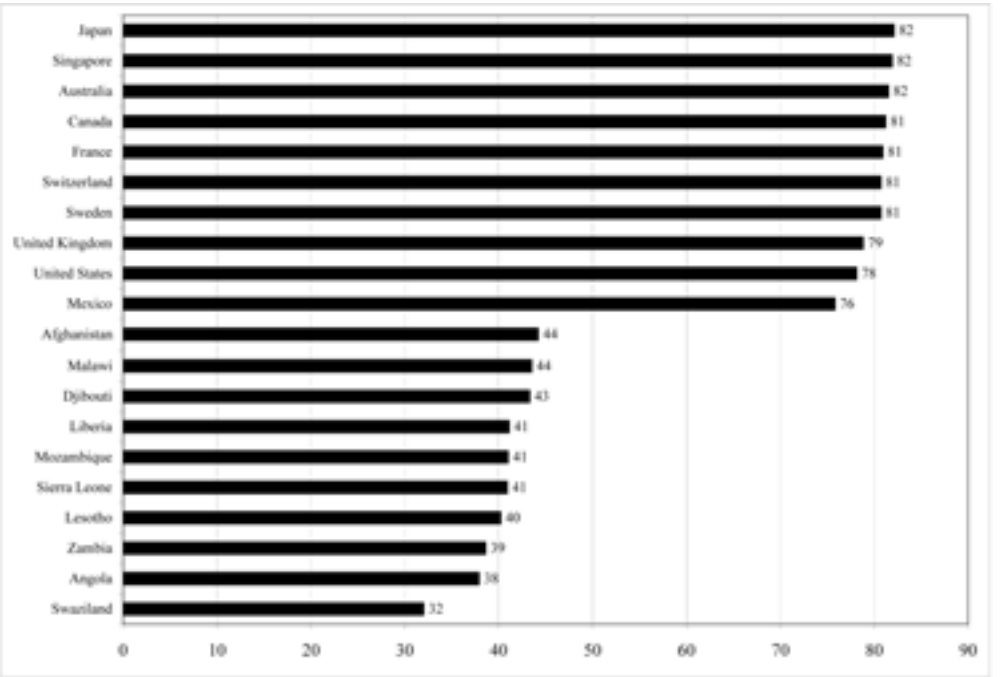

Figure 5.1 Life Expectancy in Selected Countries, 2009.

Source: PRB.

modernization not only brings about reductions in overall mortality levels and the timing of death, but also results in a shift in the major causes of death from infectious and contagious diseases to chronic, degenerative disorders. As recently as the mid-eighteenth century, tuberculosis, cholera, diarrhea, and pneumonia-influenza were the leading causes of death throughout the world. Through much of the latter half of the twentieth century, resources were marshaled to control infectious and parasitic diseases. By the late 1990s, only pneumonia and influenza remained among the top ten causes of premature death within the developed world. Instead, chronic non-communicable and degenerative diseases such as cancer, diabetes, liver, cardiovascular, or neurological diseases have replaced infectious diseases as the leading cause of death in the developed world. As the incidences of disease and premature death were reduced, individuals were able to enjoy longer life expectancies.

Countries occupy different stages in this transition and progress through it at different rates. Unlike in the developed world, where socioeconomic improvements resulted in declining mortality over a span of decades, most developing countries have moved quickly through the epidemiological transition, directly benefiting from the transfer of public health knowledge and medical technology and medicines from the developed world. This has meant that the developing world has experienced a much more rapid decline in mortality levels than that experienced in the developed world.

DIFFERENCES IN MORTALITY

The past one hundred years have seen remarkable improvements in life expectancy and infant mortality. Reductions were particularly dramatic in developing countries when countries gained the ability to treat or eradicate infectious diseases such as malaria, smallpox, and yellow fever and where improvements in basic health status had immediate effects. Despite improvements in indicators such as life expectancy or infant mortality, mortality rates vary across the globe and by age, sex, sociodemographic status, race, ethnicity, and location, with the developed world characterized by lower death rates than elsewhere. Yet, in summarizing worldwide variations in mortality measures, we tend to make two assumptions. First, we assume that health indicators will constantly improve. We have come to expect improvements in life expectancy as medical science continues to make discoveries and as the population is increasingly taught to make positive lifestyle choices (i.e., maintaining physical fitness or not smoking) that will extend or protect life. Second, we generally assume that poor indicators of health are only found in the developing world. In other words, we assume that the Western, developed world has the advantage of an accessible

and developed health system that ensures population health. Yet, neither of these assumptions is correct, as the following two examples illustrate. These health and mortality differentials are particularly problematic, not because they represent populations that require large-scale intervention and have little access to health care, but for the exact opposite reasons. That is, in the presence of a large health care infrastructure, poor mortality experiences within segments of the population seem to be a paradox, yet they are common.

Race and Ethnicity: The Case of the United States

Americans have access to some of the best health care in the world, and their health care system consumes a significantly higher proportion of America's gross domestic product (GDP) than other developed countries.[8] A casual observer might, therefore, expect the United States to have the lowest infant mortality rate or the highest life expectancy. In fact, with a 2005 infant mortality rate of 6.86[9] and a life expectancy of seventy-eight years from birth, health indicators within the United States are rather poor by Western standards. In some cases, health indicators are more akin to those found in the developing world than the developed world, with the US infant mortality rate higher than that found in twenty-eight countries, including Cuba and Hungary, placing American indicators closer to the bottom of the developed world's list than the top.

In large part, the poor performance of American mortality indicators reflects the poor health status and mortality conditions of its minority populations,[10] with large differences by race and ethnicity.[11] Non-Hispanic black, American Indian, Alaska Native, and Puerto Rican women have the highest rates of infant mortality, while Asian and Pacific Islanders, Central and South Americans, Mexicans, and Cubans have the lowest.[12] Disparities are particularly noticeable between African Americans and whites. The 2005 IMR for non-Hispanic whites was 5.76. In comparison, the IMR for non-Hispanic blacks was 13.63. For Puerto Ricans, it was 8.3. In part, increases in preterm birth and preterm-related causes of death are major factors associated with the high IMR in the country.

Similarly, despite dramatic improvements in life expectancies since 1900 (from approximately 33 years to 73.2 years in 2005), black life expectancies remain shorter than those of white Americans, who average 78.3 years of life,[13] with the gap in life expectancy between blacks and whites growing over the past fifty years.[14] African American mortality rates are higher than those observed within the white population at every age except the very oldest, and African Americans have higher rates of death relative to whites from almost every major cause, especially for heart disease, cancer, HIV/AIDS, and homicide. The increased risk of death is magnified among young African American males,

where homicide is the leading cause of death, while white men are more likely to die in accidents (table 5.1). Young blacks are also several times more likely to die from AIDS than whites.

Smaller geographic scales show these same racial disparities. Infant mortality rates amongst blacks are more than two times those observed amongst whites, with some of the highest rates observed in the Southern states.[15] Within the state of Illinois, the 2004 IMR (7.2) was worse than the national average. This value, however, reflects a white (2004) IMR of just 5.9, and an IMR of 15.5 among African Americans,[16] a rate that is higher than Sri Lanka (11)! At an even smaller geographic scale, the 2002 IMR within the City of Chicago was 14.8 among African Americans, but just 5.1 among whites.

While the disparities in mortality experiences of black and white Americans are startling, they reflect the continued marginalization of blacks within American society, measured by inequalities in education, economic status, or occupation. Despite improvements in their overall economic and social status from the 1930s onward and legislation that has reduced the social and economic gulf between the two groups, the gap remains substantial. For instance, median household income in 2006 was $48,201, yet for blacks, the median income was only $31,969.[17] Minority children suffer disproportionately from economic deprivation, with the proportion of children in poverty among blacks approximately three times that of white children in 2006.[18] Differences in mortality by race remain even after comparing individuals with similar levels of income and education.

The prevalence of poor mortality outcomes is also linked to the structure of the American health care system. The lower socioeconomic position of blacks makes the affordability of private medical insurance less likely. While public health programs such as Medicare or Medicaid are available for the poor or elderly, these programs are limited and means-tested. For the remainder, it has become too expensive to pay for private health insurance, and an estimated 47 million Americans had no insurance in 2006.[19] Amongst blacks, over 20 percent did not have health insurance, compared to 14.5 percent amongst whites, and rates of noninsurance for black children were double those observed for white children in 2006. Regardless of race, lack of health insurance typically means that individuals forgo medical treatment, rely upon social service agencies for assistance, or utilize emergency room services, where the cost of medical attention is significantly greater.

Concurrently, the health system provides fewer services and clinics in poor areas.[20] Physicians, clinics, and institutions locate in areas with higher financial returns, and inner-city areas have fewer services. The number of public hospitals that provided care for the poor declined from 1,778 in 1980 to 1,197 in 1999, victims of hospital closures, acquisitions, or mergers.[21] Inner-city areas

Table 5.1. Leading Causes of Death: Black and White Males Aged 25–34 in the United States, 2006

	Black males			*White males*		
Rank	*Cause of death*[a]	*Number*	*Rate*	*Cause of death*	*Number*	*Rate*
—	All causes	6,684	252.3	All causes	20,581	127.0
1	Assault (homicide)	2,163	81.6	Accidents (unintentional injuries)	8,180	50.5
2	Accidents (unintentional injuries)	1,333	50.3	Intentional self-harm (suicide)	3,526	21.8
3	Diseases of the heart	597	22.5	Assault (homicide)	1,501	9.3
4	HIV disease	508	19.2	Diseases of the heart	1,431	8.8
5	Intentional self-harm (suicide)	429	16.2	Malignant neoplasms	1,401	8.6
6	Malignant neoplasms	265	10.0	HIV disease	392	2.4
7	Diabetes mellitus	104	3.9	Diabetes mellitus	227	1.4
8	Cerebrovascular diseases	77	2.9	Cerebrovascular diseases	198	1.2
9	Anemias	71	2.7	Congenital malformations, deformations, and chromosomal abnormalities	189	1.2
10	Chronic lower respiratory diseases	66	2.5	Chronic liver disease and cirrhosis	182	1.1
—	All other causes	1,071	40.4	All other causes	3,357	20.7

Source: United States, *National Vital Statistics Report* 56, no. 5 (2007).

[a] Based on International Classification of Diseases, Tenth Revision.

have difficulty in recruiting doctors and frequently depend upon federal programs such as the National Health Services Corps, created in 1970 to provide basic care to inner-city neighborhoods. Not surprisingly, therefore, where people live matters in terms of health, reflective of the "context-composition" discussion found within the health geography literature.[22] African Americans are, for instance, more likely to live in areas that have poor or limited health care services, and are therefore more likely to experience poor health.[23]

Mortality in Russia: Reductions in Mortality Improvements

Despite the mortality transition and its expected improvements, it is not necessarily a one-way street. That is, mortality can, in some cases, increase, reversing decades of improvement, with Russia providing an example.[24] As recently as 1900, Russian life expectancy was only slightly greater than thirty years, reduced by infant mortality rates that most likely reached three hundred per one thousand and a child mortality rate of up to 50 percent.[25] Within a relatively short period of time, the former Soviet Union had successfully reduced mortality and increased life expectancy within its population, with rates in the early 1960s comparable to those found in the United States and elsewhere in the developed world. Despite these dramatic improvements in health in the postrevolutionary period, the Soviet Union could not keep pace with the West with respect to basic health outcomes from the 1960s onward. As life expectancy and infant mortality continued to improve in the West, they deteriorated in the former Soviet Union. By the 1990s, observers of Russia's demographic system noted that male life expectancy had dropped from sixty-five years in 1987 to fifty-seven in 1994. Similarly, female life expectancy dropped by more than three years to an average of seventy-one years.[26] Although there is some disagreement about what caused the declines in mortality, most placed this decline within the context of the breakup of the Soviet Union in 1989 and the corresponding economic and social turmoil, along with inadequate health services, lack of prescription medicine, alcohol abuse, and high smoking prevalence.

Russia's mortality experiences run counter to typical expectations, demonstrating that mortality decline and the epidemiological transition are not unidirectional. While the exact causes of the deterioration of health outcomes are unknown and debated, they reflect a much longer process dating back over thirty years to the Soviet era. Infant mortality in the Soviet Union was always relatively high, but research in the 1970s by Davis and Feshbach noted infant mortality rates had started to diverge from Western experiences.[27] While infant mortality rates continued to decline in the West, rates in the former Soviet Union stabilized at approximately twenty-five, and then increased to over thirty by the mid-1970s. At about the same time, the Soviet Union stopped publishing

detailed mortality statistics, a point that speaks for itself.[28] Davis and Feshbach attribute the increase in the infant mortality rate to social, economic, and medical reasons, including increased smoking and drinking among mothers, poor maternal nutrition and health, inadequate health care during pregnancy, and unsanitary conditions in hospitals. They also noticed strong regional differences in mortality, with the rise in infant mortality led by Central Asian republics, including Uzbekistan and Kazakhstan, along with the Caucasian republics of Georgia and Armenia.

The declining life expectancy among Russian men in the 1990s was not new either, but instead reflected longer-term trends, with Soviet indices worsening relative to the West as early as the 1970s. After a temporary improvement in life expectancies in the 1980s, which was attributed to an aggressive anti-alcohol campaign under then-president Mikhail Gorbachev, the gap between the Soviet Union and the West continued to grow through the 1990s. As with infant mortality, a portion of the widening gap was the result of increasing life expectancy in the West. But the gap also reflected deeper institutional problems within the Soviet Union itself, including inadequate health services and the general neglect of the Soviet and Russian health care system. Alcohol abuse and high rates of cardiovascular disease and injury also contributed to declining life expectancy.

Although male life expectancy had rebounded to sixty-six years by 2001, it dipped again in subsequent years, and was just sixty-one years in 2009. Russia's infant mortality rate has continued to drop, moving from sixteen in 2001 to nine in 2009. Still, it remains to be seen whether these measures will improve in the near future. The democratically nascent Russia continues to grapple with economic and social reform, and its health care system remains in a state of crisis. Russia must first catch up to the levels of infant mortality and life expectancy that were observed in the 1960s before approaching Western levels. In the meantime, political uncertainty and stalled economic reforms mean that its health institutions remain underfunded and social and economic conditions remain poor, neither of which is conducive for improvements to life expectancy.

INFECTIOUS AND PARASITIC DISEASES (IPDs)

Infectious and parasitic diseases encompass a range of diseases, including cholera, HIV/AIDS, and tuberculosis, to name a few. With the advent and widespread use of powerful antibiotics in the mid-twentieth century, science and the medical community thought that many IPDs were controllable, and ultimately could be eliminated as serious causes of death. The control of measles,

mumps, polio, and other common childhood diseases further solidified the impression that modern medicine would overcome diseases that had been a scourge to humans for centuries.

In the postwar era, huge financial resources were committed to the eradication of infectious and parasitic diseases. Most notable among these programs was the eradication of smallpox, an infectious disease that had mortality rates in excess of thirty percent and was the leading cause of death in Europe in the 1800s. Its successful defeat in the 1970s through a global immunization program seemed to confirm that infectious diseases could be controlled through large-scale public health initiatives. Another major program targeted malaria, a health problem that has plagued humanity throughout history. The drainage of swamps and the control of mosquitoes, the "vectors" that carry malaria, through the application of the pesticide dichlorodiphenyltrichloroethane (DDT), resulted in dramatic reductions in the number of new cases.

The (Re)emergence of Infectious and Parasitic Diseases

Successes, such as the eradication of smallpox, proved to be temporary, and the past two decades have seen a reemergence of IPDs as major threats to societal health.[29] After 1963, commitment to malaria programs waned and the disease returned, worse than before. Long-term use of DDT had given birth to DDT-resistant mosquitoes, not to mention DDT's own deadly legacy linked to cancer and environmental effects. Concurrently, inadequate treatment regimes, poor drug supplies, and the misuse of drugs contributed to the rise of drug-resistant malaria.[30] Despite worldwide attempts to control malaria, the disease is as prevalent today as it was at the start of the campaign.[31] Similarly, and despite the success of inoculation programs, many children remain at risk for other infectious diseases, and IPDs remain the leading cause of death in the developing world. Measles remains one of the five leading causes of death in children under five years.[32] Although the prevalence of measles has been reduced remarkably within the past five years, it continues to account for a large number of preventable deaths (an estimated 197,000 deaths worldwide in 2007, including 177,000 deaths among children).[33] Worldwide, IPDs represent upwards of 54 percent of all deaths among children, while over 60 percent of deaths in Africa can be attributed to IPDs.

The reemergence of malaria should have served as a warning that complacency in the fight against infectious diseases was not an option and indicated that diseases could emerge or reemerge as the causal microbe evolved into a more infectious form or as new pathways to infection appeared. The rise of new IPDs, including Ebola, a usually deadly disease for which there is no known cure; multidrug-resistant tuberculosis, malaria, and meningitis; and new forms

of cholera, has further shaken our complacency in science's ability to control infectious disease.

A variety of factors have been responsible for the reemergence of IPDs. One reason that infectious diseases cause a larger percentage of deaths in areas such as sub-Saharan Africa is purely demographic. The proportion of the population surviving into older ages, where the risk of death from chronic degenerative diseases is greater, is small in many parts of the developing world. Instead, young populations, widespread poverty, malnutrition, and inadequate public health care systems contribute to the high death toll, even though a majority of existing IPDs can be prevented through immunization, safe drinking water, proper food storage, safe-sex practices, and personal hygiene. Changes to the natural environment have also contributed to IPDs' reemergence. Human-induced changes can cause genetic changes in organisms or the vectors that transmit diseases (e.g., as in the case of DDT-resistant mosquitoes). Further, the misuse of antibiotics has contributed to the rise of drug-resistant forms of malaria and tuberculosis, and HIV/AIDS has resulted in an increase in tuberculosis and pneumonia. Agricultural practices affect the environment within which microbes live and spread, and social, economic, and political conditions have facilitated their return and spread. Population movement has long been an important avenue for the spread of disease. Historically, the bubonic plague was brought to Europe from Asia, and European explorers brought smallpox to North America and Oceania, decimating the indigenous populations, who had no resistance to the disease. Settlement and urbanization have concentrated populations and allowed the sustained presence of diseases that were formerly epidemic in small areas or for short periods. Cholera, nearly nonexistent in rural areas, quickly rose to epidemic proportions with urbanization as people were brought together and the risk of contagion was escalated in crowded and unsanitary conditions. Today, rapid urbanization in the developing world repeats this process as migrants settle in crowded and inadequate conditions.

The twenty-first century brings with it new challenges in the control of IPDs. For instance, the surge in IPDs has been due to a breakdown in the provision of public health, with civil strife a prime cause, as it disrupts the distribution of needed drugs and food. Rapid population growth and urbanization have meant that governments have not been able to provide adequate or basic health care or infrastructure such as clean water. Perhaps more worrisome is the speed and ease of transference of disease. The rapidity of movement across countries through jet travel poses additional challenges to the control of IPDs, with airplanes offering a highly effective means of transportation for disease, with the potential to spread illness and disease across the world in a matter of hours.

Additionally, there are an increasing number of cases in which individuals or societies reject immunization. In North America and elsewhere in the devel-

oped world, rejection may be based upon religious grounds and/or (unfounded) fears that immunization is linked to increased incidence of childhood autism.[34] Elsewhere, the failure to immunize and thus protect children from preventable IPDs is based on religious grounds. In Nigeria, for example, the government in the northern state of Kano stopped immunizing children against polio in 2004 amidst fears and claims by religious leaders that the vaccine made girls infertile.[35] Polio is a disease that is spread through human feces and can result in paralysis in one in two hundred people. Instead of hoping to eradicate polio, the World Health Organization was fighting to contain the virus, which had spread quickly to countries including Sudan, Benin, Botswana, Chad, Ghana, Togo, the Ivory Coast, Cameroon, and the Central African Republic. In these cases, the spread of the virus was likely due to the relatively porous borders in the region, while air travel has likely resulted in its spread to countries including Afghanistan, Indonesia, Egypt, Niger, Nigeria, and Pakistan.

HIV/AIDS

The human immunodeficiency virus (HIV), the virus that causes AIDS (acquired immunodeficiency syndrome), has altered mortality patterns and life expectancies globally, and perhaps best summarizes the potential for the emergence of new infectious diseases and their devastating effects. Although new research has pushed back the biological origins of the disease to between 1884 and 1924,[36] with evidence of HIV found in tissue samples from 1959,[37] it only attracted attention in 1981 when it was identified among gay men in the United States. Commonly thought to have emerged somewhere in central Africa and present-day Congo, the scientific community is still at a loss to explain exactly where it came from, although the most plausible theory is that the virus somehow moved from monkeys into humans, perhaps through hunting or religious or cultural ceremonies. With little interaction and population mobility, it potentially survived for decades within the human population, albeit at very low levels and within a spatially confined area. Civil war in the Congo in the early 1960s likely facilitated its movement into the larger population, carried by soldiers and aided by refugee movements and famine. It would emerge as a major public health concern and a leading cause of death throughout the world within a generation.

HIV/AIDS has resulted in an epidemic that is far more extensive than was initially forecasted. In 2007, 2.7 million were newly infected with the virus, 2 million people worldwide died of AIDS, and 33 million people were living with HIV/AIDS. Most HIV cases (95 percent) are found in the developing world, where the scale of the epidemic has profound economic, social, demographic,

and political implications. It is just as important, however, to realize that the epidemic is far from over, with the Centers for Disease Control and Prevention (CDC) reporting in 2008 that HIV/AIDS was spreading faster in the United States than had been thought, with over 56,000 people newly infected with HIV. African Americans were disproportionately more likely to be infected, with black women nearly fifteen times as likely to be infected as white women and Hispanic women four times as likely to be infected as white women. At the same time, black men are six times more likely to be infected than white men, and approximately three times more likely than Hispanic men.[38]

Spatial Variations in HIV/AIDS in Africa

The challenges posed by HIV/AIDS vary from place to place, but are perhaps felt most acutely within sub-Saharan Africa, where AIDS remains the leading cause of death (table 5.2). In 2007, the region recorded an adult (aged fifteen to forty-nine) infection rate of 5.0 percent, with 22.5 million infected. Sub-Saharan Africa represents over 67 percent of the world's cases.[39] Although infection rates are high in the region, the prevalence of HIV/AIDS is unequal, meaning it is inaccurate to speak of a single, African epidemic. While initially centered in the countries of central and eastern Africa, the epidemic has exploded in southern Africa, while prevalence rates remain steady at five percent or less in many West African states, and East Africa has seen some modest declines in HIV prevalence among pregnant women in urban areas (figure 5.2).[40]

The epidemic peaks in southern Africa, where 26.1 percent of all adults (aged fifteen to forty-nine) in Swaziland are infected, and 23.9 percent of adults in Botswana are infected. Growing from just 1 percent in the early 1990s, the prevalence rate in South Africa is now 18.1 percent among adults, giving the country the dubious distinction of having more people infected with HIV than any other country. National adult HIV prevalence also exceeded 15 percent in Lesotho, Namibia, Zambia, and Zimbabwe.

These spatial variations in HIV/AIDS prevalence are likely rooted in a complex web of behavioral, social, and biological factors that interact with the continent's varied economic, social, and political systems.[41] The exact reasons for the spatial variation remain unclear, however, and a number of theories have been advanced.[42] One possibility lies in the patterns of sexual activity or networking within sub-Saharan Africa that promote heterosexual infection. Premarital and extramarital intercourse, age at first intercourse, number of partners, polygamy, the low status of women, wife inheritance, and use/frequency of contact with prostitutes have been implicated as practices that increase the risk of infection. While there are elements of truth to the networking theory, it is important to place it within the proper social, cultural, and

Table 5.2. Regional HIV/AIDS Statistics and Features, 2008

Region	*Epidemic started*	*People living with HIV/AIDS*	*New infections, 2007*	*Adult prevalence rate*[a] *(%)*	*% of HIV positive adults who are women*	*Main mode(s) of transmission*[b]
Sub-Saharan Africa	Late 70s–Early 80s	22 million	1.9 million	5.0	57	Hetero
North Africa and Middle East	Late 80s	380,000	40,000	0.3	48	Hetero IDU
South and Southeast Asia	Late 80s	4.2 million	330,000	0.3	28	Hetero IDU
East Asia	Late 80s	740,000	52,000	0.1	22	IDU Hetero MSM
Latin America	Late 70s–Early 80s	1.7 million	140,000	0.5	35	MSM IDU Hetero
Caribbean	Late 70s–Early 80s	230,000	20,000	1.1	49	Hetero MSM

Table 5.2. (Continued)

Region	*Epidemic started*	*People living With HIV/AIDS*	*New infections, 2007*	*Adult prevalence rate*[a] *(%)*	*% of HIV positive adults who are women*	*Main mode(s) of transmission*[b]
Eastern Europe and Central Asia	Early 90s	1.5 million	110,000	0.8	34	IDU
Western and Central Europe	Late 70s Early 80s	730,000	27,000	0.3	26	MSM IDU
North America	Late 70s–Early 80s	1.2 million	54,000	0.6	25	MSM IDU Hetero
Oceania	Late 70s–Early 80s	74,000	13,000	0.4	20	MSM
Total		33 million	2.7 million	0.8	48	

Source: Based on data derived from the United Nations Program on HIV/AIDS (UNAIDS), www.unaids.org.

[a] The percentage of adults (fifteen to forty-nine years of age) living with HIV/AIDS in 2008.

[b] Hetero (heterosexual transmission), IDU (transmission through injecting drug use), and MSM (sexual transmission among men who have sex with men).

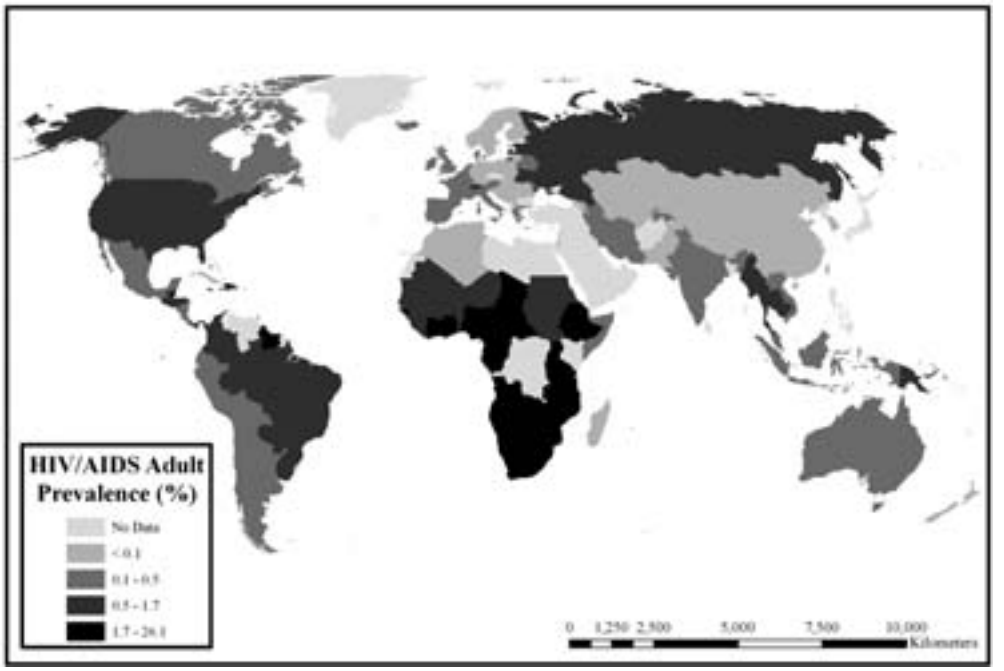

Figure 5.2 HIV Prevalence Rates, 2007.

Source: Data derived from UNAIDS, www.unaids.org.

political context of sub-Saharan Africa, rather than creating an ethnocentric version that portrays African societies as sexually promiscuous.[43] A second theory relates to the increased prevalence of other sexually transmitted diseases in sub-Saharan Africa, with sexually transmitted diseases resulting in lesions to the skin, allowing easier infection. A third suggests that the presence of other infections such as malaria or tuberculosis can increase the amount of HIV in the blood, thereby increasing the ability to infect a partner.

While there are successful models for controlling HIV/AIDS within the African continent and reductions in prevalence rates have been noted, many sub-Saharan countries were slow to adopt HIV/AIDS-awareness programs or to simply recognize the existence of the virus. The discussion of sex or sexuality was taboo in many societies, and HIV/AIDS carried a stigma that governments and individuals alike tried to avoid, denying it as a problem and failing to invest in public education. Countries lost time in introducing measures to contain HIV because the disease and its significance were not fully understood, or governments denied that it was occurring. The Kenyan government, along with other governments in the region, denied that AIDS existed in the early and mid-1980s and rejected condom use. As recently as 1999, the South African president Thabo Mbeki questioned whether HIV causes AIDS.[44] For years afterward, the

country lagged the world in dealing with HIV/AIDS by not providing antiretroviral medicines to its population, with one study estimating that the government could have prevented the premature deaths of some 365,000 people if it had provided the necessary drugs.[45] Although South Africa slowly recognized the significance of the disease and moved to provide AIDS drugs to its population, progress was slow. Economic disparities, poor health systems, and drug shortages further hamper HIV/AIDS control.[46] In many countries, access to condoms, anti-AIDS drugs, and health care facilities were (or still are) limited for economic, political, or cultural reasons, and many countries continue to lack sufficient screening facilities, drugs, and health care workers. Throughout the developing world, only a small proportion of pregnant women are given drugs that would prevent the transmission of the virus to their child, meaning that approximately nine hundred children are born each day with the AIDS virus.[47] Many unknowingly carry the virus and infect others, with one estimate suggesting that upward of 90 percent of the infected population are unknowing carriers.[48]

Demographic, Economic, and Social Implications of the AIDS Crisis in Africa

Sub-Saharan Africa is a region coping with the cumulative impact of HIV/AIDS, where the disease has probably lasted longer than elsewhere in the developing world since it is thought to have originated there. Here, HIV threatens to destroy decades of progress measured by health and economic indicators, as well as generating personal suffering and hardship. In 2007, it was estimated that 1.7 million sub-Saharans were newly infected with HIV, although this represents a significant drop from 3.8 million new infections in 2000.

Demographic Effects

The most obvious effect of the HIV/AIDS epidemic is the increase in mortality rates.[49] Already high relative to the developed world, mortality rates have risen higher in countries that are affected by AIDS than they would have without AIDS. In South Africa, for example, mortality is projected to climb from 16 per one thousand (in 2005) to 25 per thousand in 2025, before declining somewhat by 2050 (figure 5.3).[50] In countries with high HIV prevalence, life expectancy at birth has also fallen. In southern Africa, average life expectancy at birth is estimated to have declined to 1950 levels, or approximately 50 years. In Zimbabwe, AIDS is expected to reduce life expectancy (from birth) from its 1997 level of 51 years to 39 years in 2010, with further reductions expected by 2025. As of 2009, life expectancy at birth was only 40 years.[51] Without HIV/AIDS, it is estimated that life expectancy would increase to 69.5 years within the next ten

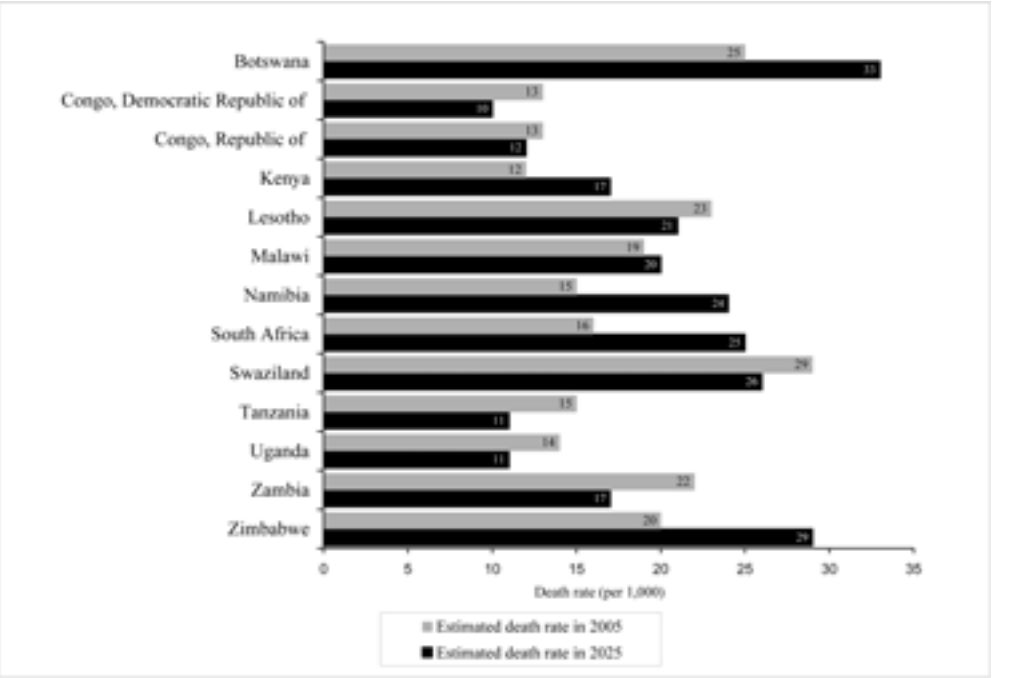

Figure 5.3 Estimated Death Rates in Selected African Countries: 2005 and 2025.

Source: Data derived from IDB, www.census.gov/ipc/www/idb/.

years. For children born in some countries, including Lesotho and Zambia, life expectancies are also below 40 years. In South Africa, fifteen-year-olds have a greater than 50 percent chance of dying from HIV-related causes.[52]

Given higher mortality rates, the AIDS epidemic can also alter population growth rates. Projections by the US Census Bureau, for example, suggest that several African countries, including Botswana, South Africa, and Zimbabwe, will experience negative rates of natural increase by 2025. Several other sub-Saharan countries will see their growth rates approach zero within the next twenty-five years, declines that are far faster than would be expected without AIDS, and significantly different from 2005 rates (figure 5.4).

AIDS deaths are premature deaths, and consequently alter the age structure of the population as well as life expectancy. We would typically expect to see increasing life expectancy associated with improvements to diet and health. AIDS, however, changes the equation. Turning once again to those countries hardest hit by HIV/AIDS, life expectancy is likely to decline in multiple countries before recovering somewhat by 2025 (figure 5.5). In Botswana, for instance, life expectancies peaked at approximately sixty-four years in the early 1990s before declining to less than forty-seven years in 2000–2005. Conse-

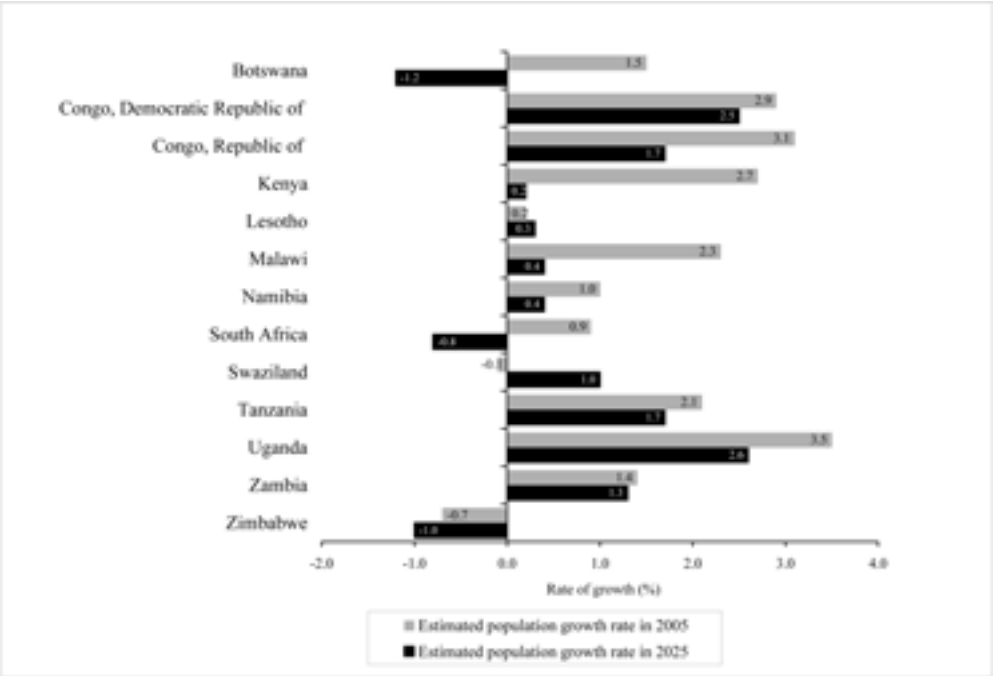

Figure 5.4 Estimated Population Growth Rates in Selected African Countries: 2005 and 2025.

Source: Data derived from IDB, www.census.gov/ipc/www/idb.

quently, the traditional population pyramid, with a wide base of young and tapering with increasing age, is being restructured and characterized as a population "chimney" in countries that have high HIV prevalence rates, as AIDS "hollows out" the young adult population, generating a base that is less broad and with fewer young children. With fewer women reaching and surpassing their childbearing years and with women having fewer children, the most dramatic changes occur when young adults who were infected in their adolescence die, substantially shrinking the adult population, particularly those in their twenties and thirties.

Social Implications

The effect of HIV/AIDS reaches into almost every corner of daily life and affects individuals, family units, and societies. In countries worst affected by the epidemic, HIV occurs against a backdrop of deteriorating public services, poor employment, and poverty, all of which work to reduce coping ability. Existing evidence suggests that households bear a large part of the burden, with differences in the ability to cope based upon wealth and income.[53] In poor

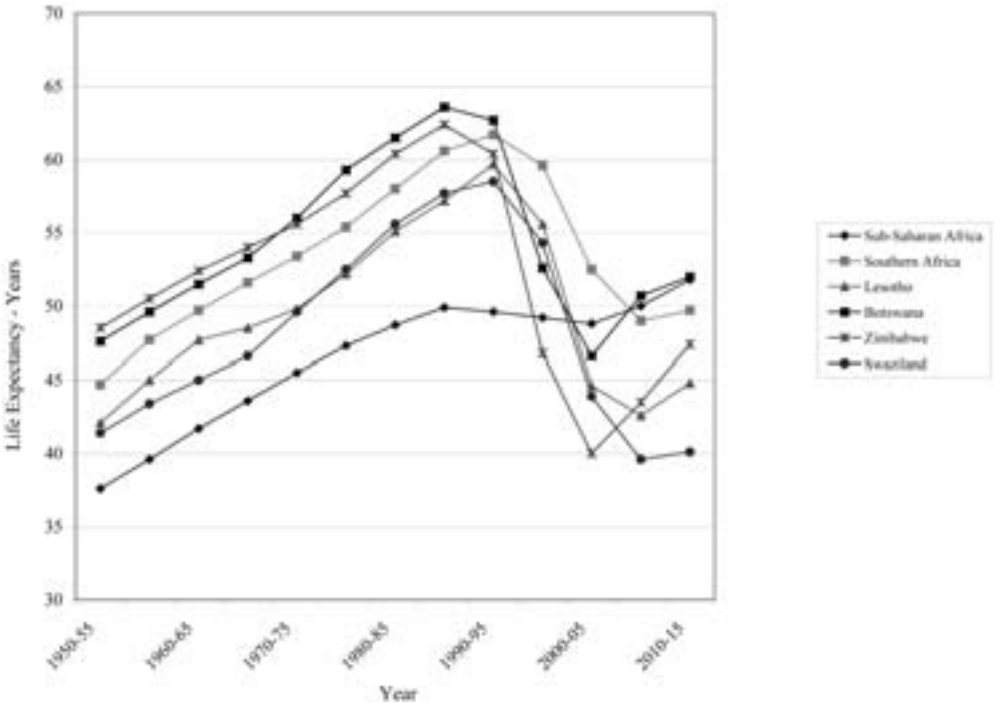

Figure 5.5 Life Expectancy and the Impact of HIV/AIDS in Selected Regions and Countries: 1950/1955–2010/2015.

Source: Data derived from Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, *World Population Prospects: The 2006 Revision*, esa.un.org/unpp.

households, the death of an adult member reduces money for food, with poor households receiving little financial help from family and friends. Many other households are unable to cope with the death of a family member or the burden of care that is associated with either sickness or death. Socially, fear and shame are still frequently associated with the disease, hindering prevention and care while potentially exposing others to the virus. Death of just one parent also disrupts life and economic abilities. Even if they are not infected, the responsibility for care of children lies with women. With widows lacking property and inheritance rights in many African countries, the epidemic compounds the burden placed upon AIDS widows, who are faced with the loss of their economic livelihood. Oftentimes, children are left with a future that only reflects what the streets can offer.

Although AIDS tends to kill proportionately more young or middle-aged persons who were infected in adolescence, its effect on the very young is startling, and has created a cohort of AIDS orphans. In sub-Saharan Africa, it is estimated that nearly twelve million children are AIDS orphans.[54] Orphaned children face a variety of social and economic challenges. Economically, the large

number of orphans increases the burden of communities and governments to provide food, shelter, health care, or schooling. Young orphans are rarely able to cope with agricultural tasks, leading to crop failure and the death of livestock. Socially, AIDS orphans may be burdened by the psychological damage of seeing a parent die. Immediately relevant is the question of who raises the orphaned child. Grandparents or extended family members are frequently called upon to raise him or her, but this occurs at the same time that they had expected to have a reduced role in the family. Instead, they are forced into the parenting role once again, including the need to provide economic security. However, the increased number of orphans has altered the ability and willingness of families and communities to help, and the task threatens to outstrip the capacity of the extended-family system. For those lacking an extended family, street gangs provide an alternate "family," but one that exposes them to violence and anti-social behavior, as well as sexually transmitted infections (STIs) or HIV as they exchange sex for food and money. Although the number of orphans is large, this represents only a portion of the children who are affected by HIV. Millions more are living with parents who are ill, becoming primary caregivers for their parents or siblings.[55] Like orphans, they are more likely to drop out of school, more likely to suffer from malnutrition, and may be compelled to work.

Economic Implications

HIV/AIDS also threatens the economic stability of countries through a variety of routes by straining already fragile health care systems, decreasing the quality and quantity of labor, reducing economic output, and decreasing the amount of disposable income. The epidemic has increased the demand for health care, along with the costs of providing care and drugs and maintaining and improving infrastructure. In order to deal with the epidemic, countries have generally placed a larger share of domestic spending on HIV/AIDS, but this tends to draw expenditures away from other needs. Training and the staffing of health centers pose additional hardships, particularly because of AIDS-related illnesses or the death of health care workers from AIDS. Concurrently, non-AIDS patients are frequently crowded out of health care facilities, and tuberculosis is emerging as the leading cause of death among those infected with HIV.[56]

From an educational standpoint, the epidemic threatens the coverage and quality of education. As teachers die from AIDS, African countries will be faced with a teacher shortage, class sizes are likely to increase, and governments are faced with the costs of training replacement teachers over the longer term. Failure to do so or to meet the demand for teachers will result in a population that lacks the skills needed to fully participate within the economy. Moreover, education may not be reaching those who need it the most. This includes orphaned children, who may be forced to drop out of school to earn a wage or work on the family farm or because they can no longer afford school fees. In

turn, there is an increased likelihood of infection, with Joint United Nations Programme on HIV/AIDS (UNAIDS) studies demonstrating that those with lower levels of education were more likely to engage in casual, unprotected sex.[57] On a larger scale, HIV/AIDS is stripping the ability of sub-Saharan countries to build for the future, robbing them of the ability to generate and supply what Homer-Dixon calls "ingenuity," and threatening their very survival.[58]

The impact of AIDS is also felt within the labor force, where it reduces the number of workers and degrades the quality or productivity of work at the same time that it undermines education and the ability of the system to provide the needed skills. Responsible for a large burden of sickness, HIV/AIDS leads to increased absenteeism from work, medical costs, and higher costs for training of new workers. Faced with high prevalence rates and lower productivity, companies may outsource their labor requirements. Alternatively, companies may reduce their investment in areas with high HIV prevalence. Either way, the cost of caring for sick workers is shifted from the company to households or governments and undermines the economic security of workers.

While it is difficult to measure the economic impact of HIV/AIDS, there is growing evidence that as HIV prevalence increases, the growth of national income, measured by GDP, falls.[59] Among countries with prevalence rates greater than 20 percent, GDP growth may be reduced by as much as 2 percent per year. In South Africa, UNAIDS estimates that the overall economic growth in the coming decade may be 0.3 to 0.4 percent per year lower than it would be without AIDS. What this means is that household income will be reduced at the same time that countries spend more on the care of AIDS patients or orphans, and AIDS will alter the distribution of income, with the number of households in poverty expected to increase while poor households will see a drop in income. In South Africa and Zambia, it is estimated that household income is reduced by 60 to 80 percent in AIDS-affected households, most of which were already poor households, due to coping with AIDS-related illnesses. While the large pool of unemployed may replace unskilled workers, the impact of HIV/AIDS on the education of future workers will likely mean a shortage of skilled workers. Investment, which promotes long-term economic growth, will suffer as money is diverted into health care expenditures.

CONCLUSION: THE FUTURE OF MORTALITY

Changes to the mortality experiences of populations were one of the most significant events of the twentieth century. Unlike the previous century, the twenty-first century will likely see less dramatic changes to life expectancy within the developed world. Similarly, the developing world will likely see some

change, although the degree of change and direction is unclear. It is, in fact, likely that life expectancy will *decrease* in parts of the developing world as infectious diseases, including HIV/AIDS, continue to take their toll. As we look ahead over the coming decades, five nonexclusive issues relating to the mortality and morbidity experiences of populations can be raised, including the implications associated with aging societies, the threats to mortality gains posed by urbanization, the renewed threat of infectious and parasitic diseases, and the provision of health services and other programs to improve population health.

First, the twentieth century has witnessed remarkable improvements in life expectancy, with a concurrent increase in life expectancy after age sixty-five. Advances in medical technology have meant that an increasing number are surviving into old age, but it is amongst the "old elderly," variously referred to as those greater than seventy-five, eighty, or even eighty-five years, that the largest increases in morbidity (sickness) are observed. Therefore, are improvements to life expectancy a double-edged sword? For example, what are the implications of aging Western societies in terms of increased morbidity, service provision, and support of a growing elderly population? Has this increase come at the expense of an increasing number of years of morbidity? Readers can consult PRB's online discussion (http://discuss.prb.org/content/interview/detail/3581/).

Second, emerging health concerns may place many urban residents at a disadvantage with respect to mortality experiences in the near future. Urban health advantages hide the huge disparity between the urban poor and their wealthy counterparts, particularly in the developing world, where mortality experiences are frequently far worse in poor urban areas as compared to rural areas.[60] In one study in Bangladesh, for example, infant death rates varied from 95 to 152 per 1000 in urban areas, higher than both middle-class urban areas (32) and rural Bangladesh.[61] Continued in-migration from rural areas and increasing population density may push mortality and morbidity higher in urban areas. Many cities in the developing world have also grown faster than their infrastructure, leaving large proportions of their populations without adequate and safe water or sanitation, allowing diseases associated with poverty to increase in urban areas. Given these trends, the traditional advantage of urban areas is likely to be diminished in the future.

Third, infectious and parasitic diseases remain a threat to health. In the developed world, there is a need for action to avoid epidemics associated with the importation of disease. Despite safety nets that are designed to prevent diseases from entry, such as the health screening of immigrants, the system is not foolproof, and infectious diseases can spread quickly, as witnessed by the rapid and global spread of the swine flu virus (H1N1) in 2009. Systems and procedures must be in place if epidemics are to be avoided. The developing

world faces its own set of problems. Among these, the poor living conditions associated with rapid urbanization and poverty in many developing-world cities create an ideal breeding ground for disease. Throughout 2008 and 2009, Zimbabwe faced a cholera epidemic, a preventable water-borne bacterial illness that causes severe diarrhea, vomiting, and dehydration and can lead to death in a matter of days if not treated. Attributed to the collapse of its health system and the breakdown of its water treatment system following years of economic crisis and government mismanagement, it was estimated that at least 3,623 people died in a six-month span, and over 76,000 were infected.[62] All of these deaths were preventable.

Fourth, some commentators have openly wondered if increasing obesity levels that are widely observed in the United States and elsewhere will ultimately mean that the current generation of youth will actually have shorter life spans than their parents. With obesity closely linked to increased cardiovascular disease, diabetes, and other health complications, this remains a real possibility.

Finally, improvements in life expectancy and infant mortality can hardly be removed from the provision of health care and related services. While some authors[63] have called for a medically driven response to the problems of IPDs and other health threats via the development of new vaccines, antibiotics, and improved laboratories, these methods carry a high price and may be years in research and development, and their applicability in the developing world is limited if drug companies do not make the drugs available. If expensive medical programs and intervention cannot provide the assurance of basic population health, other directions must instead be pursued. As a starting point, improvements to life expectancy must be achieved through a renewed commitment to public health programs and basic health care, providing a frontline defense against IPDs, maternal health problems, and other health concerns.

The provision of basic health care to meet the needs of the population is only one piece of the health puzzle, being insufficient on its own to ameliorate or remove inequalities in morbidity or mortality. Instead, it is increasingly realized that the broader determinants of health, including education, sanitation and nutrition, lifestyle options (i.e., smoking, drinking, and drug use behavior), housing conditions, and personal power, impact directly upon health and mortality experiences.[64] Despite the importance of these factors and their contribution to health, governments have been relatively slow to address disparities.[65] Clearly, however, investments in public infrastructure to provide clean drinking water, sanitation, appropriate housing, public education, or other programs, let alone the provision of basic health care services within the developing world, are limited. While needed, such a broad response to health conditions and mortality experiences is likely to be constrained by budgets and inadequate resources. Attempts at broad responses are further constrained by population growth and political agendas that shape economic assistance, with growth fre-

quently slowing the attainment of these goals in low-income countries and creating a young population that places large demands upon costly educational, social, and health services. Solutions will not come easily or inexpensively.

FOCUS: MORTALITY DIFFERENCES—THE UNITED STATES, MEXICO, AND ZIMBABWE

Although we all must die, differences in mortality rates are found in numerous places and for different reasons. The mortality transition can be illustrated by a comparison of mortality data across countries. In this case, we will contrast Mexico, Zimbabwe, and the United States. Graphing the age-specific death rates of males and females (figure 5F.1), the observed J-shaped function is a characteristic that is found in all countries and populations. The standard age pattern is characterized by differences between males and females and by death rates that are comparatively high in the first year of life, decline through childhood and adolescence, and then increase into old age. Among women, lower death rates are shown from birth onwards. This sex differential is typically greatest for young adults, with the death rates of fifteen- to twenty-four-year-old males approximately three times that of females in the same age group, a difference that is largely attributed to the increased risk of HIV/AIDS, suicide,

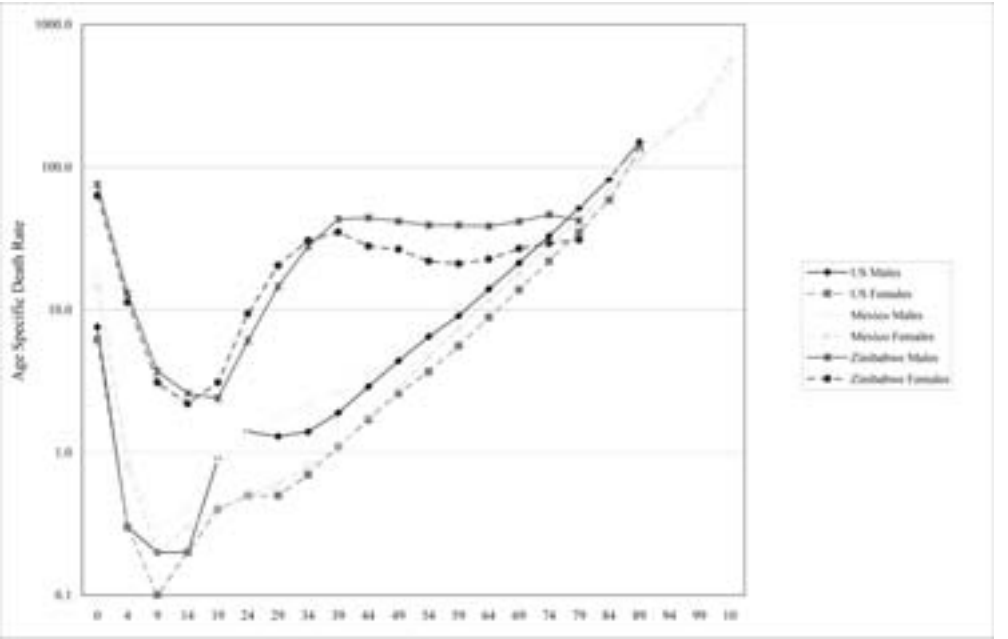

Figure 5F.1 Age-Specific Death Rates, US, Mexico, and Zimbabwe, 2005.

Source: Data derived from WHO, www.who.int/countries/en/#M.

accidents, or homicides among young males. Moreover, despite overall gains in life expectancy over the past thirty years, fifteen- to twenty-four-year-old males have actually experienced increasing mortality,[1] even though most deaths in this group are preventable.

Across all the ages, observed mortality rates in Zimbabwe exceed those found in Mexico or the United States, while the United States has a slight advantage (in terms of lower mortality rates) over Mexico. Differences in cause-specific mortality regimes are illustrated in table 5F.1. Values in this table represent the age-standardized death rates (per 100,000) by cause, with age standardization enabling comparison of the importance of death rates across countries while accounting for different population structures. With the lowest all-cause age-standardized death rate (543.5), the United States has clearly passed through the epidemiological transition. Major causes of death include cancers, including breast, colon, and lung cancers, as well as heart or cerebrovascular diseases and road traffic accidents.

With a high all-cause death rate (1,950) and HIV/AIDS as the leading cause of death, Zimbabwe represents a counterexample to that of the United States, and has yet to enter the mortality transition. Reflective of many countries in the developing world, infectious and parasitic diseases including diarrhea, tuberculosis, and measles rank within the top ten causes of death. A lack of health care providers, impoverished health care systems, and war are responsible for the high mortality rates. Clearly, many of these causes of death are easily preventable. In many ways, after years of economic erosion and the decimation of its health care system, Zimbabwe is worse off as compared to other developing countries.

Mexico is in the midst of its mortality transition: mortality rates have fallen over the past four decades, but the age-specific death rate remains higher than observed in the United States. Missing are infectious or parasitic diseases. Instead, mortality is increasingly characterized by the growth of noncommunicable diseases such as heart and cerebrovascular diseases, diabetes, and high blood pressure and accident rates. However, socioeconomic inequalities in Mexican society have led to inequities in access to basic health services. The poorer southern states have the highest disease prevalence and mortality rates for preventable causes and have the highest concentration of rural and indigenous populations.

While death rates give a quick illustration of an individual's risk of dying, demographers typically prefer the complementary measures of life expectancy (the average duration of life beyond age x) or the IMR (the number of deaths of infants less than one year of age divided by the number of births). Both measures provide descriptions of the mortality experiences of a population and a society's quality of life. In 2009, the US IMR was 6.6, and individuals could expect to live seventy-eight years. In Zimbabwe, the IMR was 60, and individuals could expect to live forty-one years from birth. Finally, the IMR in Mexico was 19, with a life expectancy of seventy-five.

Table 5F.1. Top Ten All Ages Causes of Death: United States, Mexico, and Zimbabwe, 2002

	# (thousands)	%	ASDR[a]
	United States		
All causes	2,420	100	543.5
Ischemic heart disease	514	21	105.8
Cerebrovascular disease	163	7	31.9
Trachea, bronchus, lung cancers	157	7	39.0
Chronic obstructive pulmonary disease	128	5	27.2
Alzheimer's and other dementias	93	4	15.4
Diabetes mellitus	76	3	17.5
Colon and rectum cancers	64	3	14.8
Lower respiratory infections	59	3	11.3
Breast cancer	45	2	11.2
Road traffic accidents	45	2	15.0
	Mexico		
All causes	469	100	646.1
Diabetes mellitus	55	12	86.8
Ischemic heart disease	52	11	81.6
Cerebrovascular disease	26	6	41.7
Perinatal conditions	26	6	21.6
Chronic obstructive pulmonary disease	24	5	26.8
Cirrhosis of the liver	16	3	35.7
Lower respiratory infection	15	3	19.4
Congenital anomalies	12	3	10.5
Road traffic accidents	12	3	13.2
Hypertensive heart disease	10	2	16.7
	Zimbabwe		
All causes	270	100	3,314.8
HIV/AIDS	180	67	1,950.2
Lower respiratory infections	10	4	138.2
Tuberculosis	7	3	84.4
Perinatal conditions	6	2	30.3
Cerebrovascular disease	6	2	119.4
Diarrheal diseases	6	2	42.0
Ischemic heart disease	5	2	110.4
Protein-energy malnutrition	3	1	16.3
War	2	1	33.8
Measles	2	1	11.5

Source: Based on World Health Organization (WHO) data, www.who.int/countries/en/.

[a] Age-specific death rate.

In 2005, a total of 2,448,017 deaths were registered in the United States, translating to a crude death rate of 825.9 deaths per 100,000 and an age-adjusted death rate of 798.8 deaths per 100,000.[1] What do these different measures mean and which is a better representation of mortality in a society? As with fertility, a number of different measures may be used to describe mortality. As before, the quantity and quality of information available determine the detail and accuracy of mortality measures, with data compiled as vital statistics measures. The simplest measure, largely given the limited information required and the ease of calculation, is the *crude death rate* (CDR):

$$CDR = \left(\frac{D}{P}\right)*1{,}000$$

where D is the total number of deaths recorded in a year, and P is the population at risk of dying. Typically, the midyear population is used for the denominator.

Like the crude birth rate, however, the main problem is that it does not take account of the age and sex structure of a population in the likelihood of death. This means that a comparison of the CDR across countries is problematic given different age distributions and variations in mortality between genders. Therefore, if we were to contrast two equal-sized populations, but with one having a larger proportion of older individuals, its crude death rate would be higher, but is not necessarily indicative of a greater risk of death.

We therefore turn to the *age-specific death rate* (ASDR), which accounts for age and sex composition of the population:

$$ASDR = \left(\frac{D_{t,t+5}}{P_{t,t+5}}\right)*100{,}000$$

The ASDR measures the number of deaths for people in a specific age group (usually measured in five-year age groups, t to $t + 5$) divided by the average number of people in that same age group. This measure assumes that death is recorded by age and gender and that accurate knowledge of the population by age and gender is also known.

Measures of infant mortality are also commonly used to describe death rates in the first years of life. Given that a large number of deaths within the first year of life are directly associated with childbirth, the infant mortality rate (IMR) is defined as:

$$IMR = \left(\frac{D}{B}\right)*1{,}000$$

or the number of deaths to infants aged less than one year relative to 1,000 live births. As discussed elsewhere in this book, there is considerable variation in infant mortality throughout the world. A comparable measure defines mortality within the first five years of life. Known as the *child mortality rate* (CMR), it reflects the impact of undernourishment, war, or early childhood disease, and is defined as the number of deaths to children under five relative to the population aged five and less that is at risk of dying. Even now, approximately 40 percent of deaths in the developing world occur among children less than five years old.

The *standardized mortality rate* (SMR) is the ratio of the number of deaths observed in a specified population to the number that

would be expected if that population had the same mortality rate as the standard population, where the standard population is arbitrarily chosen (i.e., a specific region or time period). The SMR is often used to compare outcomes in two or more groups.

The *cause-specific death rate* is the rate of death from specific causes, such as cancer, heart attack, or stroke. Like the measures presented so far, cause-specific death rates would contrast the number of deaths due to a particular outcome (i.e., lung cancer) relative to the population at risk of dying, and should also be adjusted for age and gender differences. However, accuracy can be a problem in some situations, particularly where cause of death is not accurately recorded or determined.

Finally, we may sometimes express mortality differences in terms of *life expectancy*, or the average number of years beyond age *x* an individual can expect to live under current mortality levels. Life expectancy is usually referenced from birth, but as we saw in the discussion of life tables in chapter 3, it can be expressed from any age. *Life span* also refers to the longest period over which a person may live.