Chapter 7
Demographic Processes: Mortality

Abstract The study of mortality is a major endeavor among demographers with the analysis of mortality patterns being central to applied demography. An examination of deaths and death rates allows the demographer to understand patterns of mortality within a population. This chapter considers the factors that contribute to mortality and the variation that exists in mortality risk among various groups in society.

7.1 Introduction

Mortality refers to the level of death characterizing a population, and the study of it involves research on the who, how, why, and when issues related to dying. Demographers have contributed greatly to our understanding of mortality both in terms of the development of mortality measures and the identification of patterns within the population. Applied mortality analyses can inform efforts to reduce overall mortality within the population as well as mortality attributed to specific causes.

The study of mortality has historically been important to population scientists for several reasons. As one of the three primary demographic processes its analysis is considered critical to an understanding of population growth and change. Mortality serves as a limiting factor vis-à-vis population growth, and a society's pattern of mortality is reflected in its population composition. A preponderance of seniors (and, conversely, the relative dearth of youth) reflects the decreased mortality and increased longevity characterizing the U.S. population. Similarly, the "Arab spring" that occurred around 2010 in several Middle Eastern countries was a manifestation of a precipitous decline in infant mortality. For the first time in history a preponderance of infants survived to young adulthood in certain Middle Eastern countries, resulting in a demographic "bulge" in the young adult age cohort.

The impact of mortality on contemporary U.S. society is not as significant as it has been in the past. The mortality rate has dropped to the point that death is a relatively rare event (even though the number of annual deaths continues to edge

up). As a component of population change, mortality has become less important than fertility and both have become less important than migration in the U.S. today. Further, the correspondence between mortality and morbidity has become less clear. Because of the preponderance of chronic disease within the U.S. population, determining the "true" cause of death has become increasingly challenging. This is not to say that mortality analysis cannot provide insights into a society's health status and morbidity patterns, but that the situation is more complicated today and requires a better understanding of disease processes and the vagaries of death certificates than in the past.

7.2   Concepts and Measures

7.2.1   Concepts

Mortality refers to the level of death within a population as measured by the number of deaths and the death rates characterizing that population during a particular time period. *Death* is defined as the complete cessation of life after a live birth has taken place. Deaths that occur prior to a live birth–fetal deaths—are allocated to a separate category of mortality study. Though the words "cessation of life" may seem to comprise a simple, straightforward definition, medical advances are making the interpretation of death more complex. The definition of death is constantly being rewritten in the light of medical and technological advances, although that issue is beyond the scope of this book.

Although deaths are counted and rates calculated for the general populations as a first step in mortality analysis, infant deaths represent a special category. *Infant mortality* refers to the level of death characterizing babies under one year of age. The infant mortality rate (IMR) is considered a useful indicator for comparing the health and well-being of groups across and within populations. The rate of infant mortality is considered a measure of not only health status but of the social, economic and environmental conditions characterizing a population, thereby providing insights that extend beyond a simple recounting of infant deaths.

The IMR can be divided into *neonatal* and *postneonatal* components, with the former referring to deaths during the first 28 days of life and the latter reflecting deaths occurring from 29 days to one year. Deaths occurring prior to delivery are considered *fetal* deaths. Deaths during the first month of life are most often a result of congenital abnormalities, low birth weight and birth complications, respiratory distress syndrome, and maternal complications of pregnancy. Deaths during the remainder of the first year are primarily due to environmental factors. Sudden infant death (SIDS) is a major factor in post-neonatal deaths, accounting for some 30% of deaths during this period.

The *causes of death* affecting a population are a major factor in determining the level of mortality characterizing a population. Populations in different times and

places are subject to different threats to health which, in turn, determine the conditions from which most people die. These causes of death are subject to change over time, and the United States population has undergone significant transformation of its primary causes of death since the early part of the 20th century. From an applied perspective, this aspect requires particular attention, since there are major correlations between demographic attributes and mortality rates resulting in significant disparities in mortality among different population groups within contemporary U.S. society.

7.2.2   Measures

The most basic way to measure mortality is simply to count the number of deaths that occur within a population during a specific period of time. Such counts are usually based on a one-year period and may be reported for the nation as a whole, states, metropolitan areas or smaller geographic areas. Virtually every death in the U.S. is recorded, and as a result our death data are of very high quality. Compiling death counts over a period of years allows demographers to identify trends with regard to increases or decreases in mortality. Insights into mortality can be gained by cross-classifying deaths by the medical, social, and economic characteristics of the deceased (e.g., cause of death and age at death).

Using a simple count of deaths in the analysis of mortality has several shortcomings. As in the case of fertility analysis, a comparison of deaths among geographic areas or over time is generally not very useful, given the various sizes of the populations reporting these deaths. It would not be meaningful, for example, to compare the number of deaths in Community X (population 10,000) with the number of deaths in Community Y (population 100,000). Because of the need to compare mortality levels for different populations and over time, demographers have developed a number of rates for this purpose. Exhibit 7.1 presents the calculations used to generate commonly used measures of mortality. (Note that the method for calculating age-adjusted death rates is not included here but is dealt with in Exhibit 7.2.)

> *The crude death rate is frequently used due to its ease of calculation. However, being "crude" it may not provide the most accurate measure of mortality, and demographers frequently adjust this rate to take age structure and other factors into consideration when measuring mortality.*

The simplest measure used is the *crude death rate* (CDR). Like the crude birth rate discussed in Chap. 6, this rate expresses mortality as the number of deaths per 1000 population during a particular year (e.g., 6.5 deaths per 1000 people in 2010). The number of deaths, particularly for small populations, may fluctuate widely from

year to year, and researchers may calculate a 3-year average to account for this. Crude death rates are frequently cited due to their ease of calculation. However, just as it is not very useful to compare numbers of deaths for various communities, comparisons based on crude death rates can be misleading.

Exhibit 7.1: Calculation of Mortality Rates
The calculation of mortality rates is relatively straightforward and the requisite data are usually readily available. Death data (numerators) are available from vital statistics registries, and population figures (denominators) can be drawn from Census Bureau data, state demographic centers or commercial data vendors.

$$\text{Crude death rate (CDR)} = \frac{\text{Number of deaths in year } X}{\text{Midyear population in year } X} \times 1000$$

$$\text{Age-specific death rate (ASDR)} = \frac{\text{Deaths to persons age } X \text{ to age } X+5 \text{ in year } Y}{\text{Number of persons age } X \text{ to age } X+5 \text{ in year } Y} \times 1000$$

$$\text{Infant mortality rate (IMR)} = \frac{\begin{array}{c}\text{Number of deaths to persons} \\ \text{under 1 year of age in year } X\end{array}}{\text{Live births in year } X} \times 1000$$

$$\text{Neonatal mortality rate (NMR)} = \frac{\begin{array}{c}\text{Number of deaths to persons} \\ \text{1 to 28 days of age in year } X\end{array}}{\text{Live births in year } X} \times 1000$$

$$\text{Post-neonatal mortality rate (PNMR)} = \frac{\begin{array}{c}\text{Number of deaths to persons} \\ \text{29 days to 1 year of age in year } X\end{array}}{\text{Live births in year } X} \times 1000$$

$$\text{Cause-specific death rate (CSDR)} = \frac{\begin{array}{c}\text{Number of deaths from} \\ \text{a specific cause in year } X\end{array}}{\text{Midyear population in year } X} \times 1000$$

$$\text{Maternal mortality rate (MMR)} = \frac{\begin{array}{c}\text{Number of women dying} \\ \text{during childbirth in year } X\end{array}}{\text{Live births in year } X} \times 1000$$

The section below provides examples of the calculation of the most important indicators described above:

$$\text{Crude death rate (CDR)} = \frac{100 \text{ deaths in 2010}}{10{,}000 \text{ residents in 2010}} \times 1000 = 10/1000$$

$$\text{Age-specific death rate (ASDR)} = \frac{10 \text{ deaths of } 45{-}49 \text{ year-olds in 2010}}{500 \ 45{-}49 \text{ year-old residents in 2010}}$$
$$\times \ 1000$$
$$= 20/1000$$

$$\text{Infant mortality rate (IMR)} = \frac{3 \text{ infant deaths in 2010}}{200 \text{ births in 2010}} \times 1000$$
$$= 15/1000 \text{ live births}$$

$$\text{Cause-specific death rate (CSDR)} = \frac{20 \text{ heart disease deaths in 2010}}{10{,}000 \text{ residents in 2010}} \times 1000$$
$$= 2/1000$$

$$\text{Maternal mortality rate (MMR)} = \frac{2 \text{ maternal deaths in 2010}}{200 \text{ births in 2010}} \times 1000$$
$$= 10/1000*$$

*Maternal mortality rates are typically presented per 10,000 live births

Just as everyone in a population is not at risk of pregnancy, not everyone in a population is at equal risk of death at a particular point in time. Death rates are driven to a certain extent by the biological characteristics of the population but, like birth rates, exhibit some level of elasticity. Death rates may rise or fall as a result of economic developments, social trends, wars and natural disasters, and other non-biological factors. Death rates are also influenced by developments in medicine and technology. Death rates exhibit a correlation with demographic attributes such as age, sex, race, income, education and other factors (as described below).

The age structure is a major determinant of death rates in contemporary U.S. society. Because of the effect of age distribution on death rates, demographers refine the crude death rate by adjusting it for the age distribution of the population under study. This involves using a "standard" population to convert the crude death rate to a more meaningful measure by removing the influence of age structure. The age-adjusted death rate thereby provides a basis for cross-population comparisons.

Another way in which to refine the crude death rate is through the calculation of *age-specific death* rates (ASDRs). By calculating the death rate for each age cohort,

it becomes possible to determine which portions of the age distribution account for the mortality observed. ASDRs are usually calculated for 5-year age intervals, though 3- or even 1-year intervals may be used for more detailed analyses.

> *In contemporary U.S. society each age cohort has its unique death rate, and demographers typically generate age-specific rates in order to better understand patterns of mortality.*

The infant mortality rate (IMR) represents a special case of age-specific death rates. The IMR is expressed as a 1-year rate and is examined separately because of the relatively high probability of dying during the first year of life. Persons under age 1, for example, are 20 times more likely to die in a given year than those in the 1–4 year-old cohort.

The fetal death rate is calculated to determine the extent to which babies are "stillborn." This includes miscarriages that occur after 28 weeks of gestation. The perinatal mortality rate combines late fetal and early infant mortality into one rate. This figure is used to assess the quality of antenatal and perinatal medical care. It is calculated by adding the later fetal deaths (usually after 28 weeks of gestation) to early infant deaths (usually during the first 7 days after birth but sometimes the first 28 days—i.e., neonatal period—after birth) for a given year and then dividing by the denominator (i.e., live births for that year).

One note of caution with regard to the use of rates should be offered. Rates can be considered "averages" in that they summarize the characteristics for a particular population. The use of rates assumes that the rate reasonably accurately describes the population under study. However, depending on the level of geography for which data are obtained, a rate may be misleading. In fact, there are many situations in which no one in the population is "average". A case in point might be a county that recorded an infant mortality rate of 10/1000 live births. Further examination, however, determines that half of the population exhibits a rate of 5/1000 while the other have exhibits a rate of 15/1000. Without decomposing the population into subgroups this information would be lost and a misleading perception of the population's status with regard to infant mortality would be presented. Unfortunately, public health data are seldom available to analysts below the county level. This represents a challenge for those performing epidemiological analyses. Wherever possible the study population should be decomposed in order to generate rates that reflect the actual conditions characterizing that population.

Our understanding of mortality patterns can be significantly advanced by examining the cause of death. The cause-specific death rate (CSDR) reflect the health status of the population, social factors that contribute to mortality and the effectiveness of the healthcare delivery system. The method for calculating cause-specific death rates is similar to other death rates, with the numerator being the number of deaths from a particular cause. The at-risk population (the

denominator) is typically the total population unless it is a condition restricted to a particular sex.

There are, however, a number of issues related to the specification of cause of death. Given today's morbidity patterns, it is increasingly difficult to specify the ultimate cause of death. With a preponderance of chronic diseases, it is often the case that death can and should be attributed to a factor other than the underlying cause of death. For example, patients with AIDS do not typically die as a direct result of AIDS but due to system failure as a result of AIDS. Similarly, individuals affected by diabetes are often said to die from "complications of diabetes".

While the death certificate provides space for the recording of contributing conditions, the complexity of chronic disease often makes it difficult to determine the exact cause of death. Today, obesity, while not an immediate cause of death, is increasingly being listed as a contributing factor. We have in fact developed a better appreciation of the role of obesity in a variety of health problems through the analysis of death certificates.

Life expectancy is a measure that represents the "average" number of years that members of a population live. For still-living populations, the calculation of life expectancy involves assumptions with regard to future age-specific death rates (ASDRs). Life expectancy projections may be adjusted to reflect anticipated age-specific death rates.

A population's mortality patterns are the primary determinant of life expectancy. The fact that life expectancy for the U.S. population has continued to increase over the past century is a function of a reduction in overall mortality rates and particularly a reduction in infant mortality, child mortality and maternal mortality. Life expectancy, like mortality rates, is somewhat elastic in that this metric does not simply reflect biological health but the range of social, economic and political factors that influence mortality rates. Recently observed declines in life expectancy within the U.S. population reflect these types of non-biological influences.

> *A population's mortality patterns are a primary determinant of life expectancy. The increase in life expectancy for the U.S. population experienced during the 20th century was a function of declining rates of infant mortality, child mortality and maternal mortality.*

For many measures of mortality, the rates generated may be misleading if the population under study is not a "standard" population. When comparing two communities in terms of their mortality profiles, the various rates discussed above are useful if their population composition is similar. However, in many cases, distinctly different populations may affect the rates and result in misleading comparisons. For example, the crude death rate for Florida in 2009 was 9.2 per 1000 population, a figure much higher than the CDR of 7.2 for Nevada in that same year. This would suggest (counter-intuitively) that Nevada is a healthier state than Florida. However, when the death rate is standardized to take into account

differences in age structure, the age-adjusted death rate is 6.7 for Florida and 7.9 for Nevada. In addition to age standardization, it is possible to adjust mortality rates by other demographic characteristics such as sex and race. Exhibit 7.2 describes the process of data standardization used by demographers.

Exhibit 7.2: Standardization of Data

Standardization is a method for adjusting mortality rates or other measures of vital processes for compositional factors that have an effect on those rates. For example, the number of deaths occurring in any year is a function of three components: health status, population size and demographic attributes (e.g., age). Since mortality rates are frequently used as indicators of health conditions, it is important to hold population size and age structure (and perhaps other attributes) constant when mortality rates are being constructed.

The calculation of rates addresses concerns over differences in population size and allows the analyst to compare the health status of two populations that are different demographically. The crude death rate (CDR) may be used to compare the mortality experience of two populations. However, the CDR may be misleading since it is influenced by differences in the age structures. That is, areas with relatively young populations (and hence less risk of dying) are likely to report low death rates, while areas with relatively old populations (and greater risk of dying) are likely to report high death rates independent of the size of the respective populations.

It is possible to adjust or standardize rates in order to control for age structure and, often, other factors (e.g., race). One method for accomplishing this is to select a "standard" age structure (e.g., the age structure for the United States), apply the ASDRs from two different populations to the standard age distribution, and then compare the number of deaths and age-adjusted death rates that result. This process generates the number of deaths for the respective populations *as if* their age structures were the same. The revised number of deaths (the numerator) can then be divided by the population size and an age-adjusted death rate generated.

The same principles of standardization can be used to adjust rates for other factors, such as education, race, and ethnicity. For example, the death rates for a predominantly white population and a predominantly African-American population might be recalculated using a standardized method that assumes that the populations have comparable racial characteristics.

The following calculations illustrate the process of data standardization. If the crude death rates for the populations of Mexico and the United States are compared, we find that the death rate for the U.S. (8.5/1000) is considerably higher than that for Mexico (4.7/1000). Knowing what we do about the two countries a higher death rate for the U.S. does not appear realistic. In order to develop more accurate figures for comparison purposes the rates can be adjusted using a standard age distribution (in this case that for the U.S.).

Age	Standard population	Age-specific mortality rate per 100,000 population		Expected number of deaths	
		Mexico	United States	Mexico	United States
<1	2400	1693.2	737.8	41	18
1–4	9600	112.5	38.5	11	4
5–14	19,000	36.2	21.7	7	4
15–24	17,000	102.9	90.3	17	15
25–44	26,000	209.6	176.4	55	46
45–64	19,000	841.1	702.3	160	133
65+	7000	4967.4	5062.6	348	354
Total	100,000			639	574

When a standard age structure is employed and death rates recalculated as above, we find that the age-adjusted mortality rate for Mexico is 6.4/1000 (compared to the crude rate of 4.7/1000) and the age-adjusted mortality rate for the United States is 5.7/1000 (compared to the crude rate of 8.5/1000). Thus, age-adjusted death rates for these two countries indicate that the health status of the U.S. population (at least as measured by the mortality rate) is more favorable than that of Mexico.

7.2.3   Life Tables

Life tables describe the probability of death over the life cycle for a population and thus represent a valuable tool for mortality analysis. Life tables provide health planners, demographers, insurance companies, and risk managers with a great deal of useful information. Age-specific mortality rates are calculated and combined in such a way as to generate a measure of life expectancy. Life tables are a mechanism for combining death data and rates into a summary measure of mortality.

The construction of a life table begins with a hypothetical population of 100,000 and commences to "age" that population over the life cycle. For each age cohort the probability of dying is presented for the year(s) in question. The surviving population in each age cohort can then be calculated. The table also presents the number of person-years lived to date for each cohort along with the expected remaining person-years for the surviving population. Finally, life expectancy for each age cohort is calculated.

The life table is an invaluable resource for analyzing the mortality experience of a defined population and projecting future longevity levels for that population.

Life tables reflect the social, economic, and political conditions characterizing a population. Comparative life table analysis can yield information on life expectancy differentials by sex and race for any age. Comparing life tables for blacks and whites reveals that two very different populations exist vis-à-vis mortality risk. For example, out of 100,000 white females born in a specific year over 85,000 will be alive at age 65. For black males, only 57,000 will be alive at that same age, or only about two-thirds of the white female population.

Cause-specific life tables allow the measurement of the effect of the hypothetical removal of certain causes of death on overall life expectancy. It is not unusual to find life table calculations assuming that heart disease or cancer is eliminated as a cause of death. Clinical researchers and healthcare administrators rely on information on the survival ratios of patients on whom various procedures are performed. Exhibit 7.3 presents an example of a life table for the U.S. population.

Exhibit 7.3: Abridged Life Table: United States 2003

Age	Probability of dying between ages x and x + 1	Number surviving to age x	Number dying between ages x and x + 1	Person-years lived between ages x to age x + 1	Total number person-years lived above age x	Expectancy of life at age x
0–1	0.006879	100,000	688	99,398	7,784,998	77.8
1–5	0.001174	99,312	117	396,970	7,685,600	77.4
5–10	0.000727	99,196	72	495,784	7,288,630	73.5
10–15	0.000898	99,124	89	495,452	6,792,846	68.5
15–20	0.003251	99,035	322	494,460	6,297,395	63.6
20–25	0.004869	98,713	481	492,387	5,802,935	58.8
25–30	0.004865	98,232	478	489,966	5,310,547	54.1
30–35	0.005551	97,754	543	487,457	4,820,581	49.3
35–40	0.007433	97,211	723	484,370	4,333,124	44.6
40–45	0.011588	96,489	1118	479,837	3,848,755	39.9
45–50	0.017540	95,371	1673	472,927	3,368,918	35.3
50–55	0.025802	93,698	2418	462,770	2,895,990	30.9
55–60	0.036299	91,280	3313	448,575	2433,221	26.7
60–65	0.055819	87,967	4910	428,282	1,984,646	22.6
65–70	0.082066	83,057	6816	399,173	1,556,364	18.7
70–75	0.125036	76,241	9533	358,595	1,157,191	15.2
75–80	0.188740	66,708	12,590	303,365	798,596	12.0
80–85	0.288884	54,117	15,634	232,350	495,231	9.2

(continued)

(continued)

Age	Probability of dying between ages x and x + 1	Number surviving to age x	Number dying between ages x and x + 1	Person-years lived between ages x to age x + 1	Total number person-years lived above age x	Expectancy of life at age x
85–90	0.420212	38,484	16,171	151,473	262,881	6.8
90–95	0.575974	22,312	12,851	77,357	111,408	5.0
95–100	0.733375	9461	6938	27,543	34,051	3.6
100 and over	1.000000	2523	2523	6508	6508	2.6

Source National Center for Health Statistics (2006)

7.3   Demographic Correlates of Mortality

The relationship between various demographic variables and mortality rates has become a major consideration for health demographers. Two or three generations ago, the U.S. population did not exhibit the morbidity and mortality patterns that are observed today. The ascendancy of chronic disease has been the primary contributor to this development.

Overall, there is a direct and positive relationship between age and mortality in contemporary U.S. society, with the probability of dying being different for each age cohort. The risk of death is particularly high during the first year of life but drops dramatically for children and teenagers. The likelihood of death increases slowly for each subsequent age cohort with death rates beginning to accelerate when the population reaches "middle age". Not surprisingly, the greatest risk of death is exhibited by the oldest age cohorts.

It should be noted that the observed pattern of mortality by age is relevant for the U.S. population at a particular point in time. In fact, significant differences in mortality by age is a relatively modern phenomenon. Traditional societies and U.S. society for much of its history exhibited a much different age-specific configuration, one that reflected a predominance of acute conditions rather than the chronic conditions accounting for most deaths today. If the major killers are health threats such as epidemics, infectious and parasitic diseases, and injuries, then virtually everyone is at the same risk of death.

The 2014 age-specific mortality rate of 11.5/1000 for those aged 5–9, the cohort with the lowest death rate, increases gradually up through age 50. From the mid-fifties on the increase in the mortality rate is dramatic (Kochanek, Murphey, Xu, et al., 2016). This mortality configuration reflects conditions in contemporary U.S. society and has been maintained for the past two or three decades.

Historically, there was little difference in mortality rates for various age cohorts (the very young and very old excepted) for the U.S. population but, with the emergence of chronic disease as the major cause of death, each cohort exhibits an age-specific mortality rate.

For example, the leading causes of death for infants (under 1 year) are birth defects, respiratory conditions, and infectious diseases. The leading causes for young adults are accidents and suicide; for young adult African-Americans homicide is added to the list. The elderly are more likely to fall victim to the major killers: heart disease, cancer and stroke. Ultimately, each age cohort has its own peculiar cause-of-death configuration, and to a certain extent these differences in mortality patterns reflect differences in morbidity patterns. However, the emergence of chronic diseases has complicated the relationship between morbidity and mortality in that chronic diseases are not necessarily the direct cause of death.

The differences in mortality between males and females is particularly noteworthy (Kochanek et al., 2016). Overall, males exhibit a higher mortality rate than females. In 2014 the crude death rate was 8.5/1000 for males and 8.0/1000 for females. As illustrated by Exhibit 7.4, males record a higher mortality rate for every age cohort. The differences in sex-specific mortality rates are small up until age 14, but widen with increasing speed thereafter. For all conditions except those restricted to females, males exhibit a higher mortality rate.

Exhibit 7.4: Age-Specific Mortality Rates by Sex: United States 2014
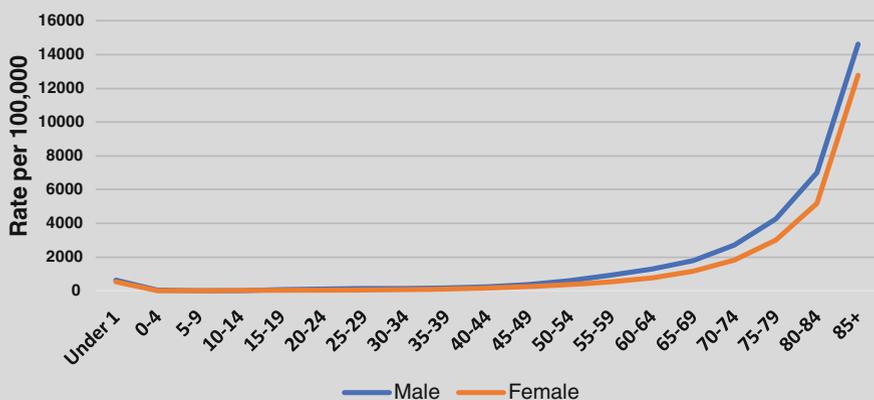
Source National Center for Health Statistics

Significant differences in mortality are found between various racial and ethnic groups with current trends representing a substantial departure from past experience (Kochanek et al., 2016). As recently as 15 years ago the non-Hispanic white population held a distinctive mortality advantage over other racial and ethnic minorities. Today that advantage has essentially evaporated. Based on the crude death rate it appears that whites bear the greatest risk of mortality of any observed racial or ethnic group. The white mortality advantage still appears to have dissipated, with only African-Americans exhibiting a higher age-adjusted mortality rate.

> *Until recent years, the non-Hispanic white population in the U.S. maintained a clear mortality advantage. However, today all major racial and ethnic groups other than African-Americans exhibit lower death rates than the white population.*

Whites in the United States are more likely to die from chronic conditions, especially those associated with aging. Blacks and members of certain ethnic groups are relatively more likely to die from acute conditions. Further, nonwhites are more likely to be affected by environmentally caused health problems and life-threatening problems associated with lifestyles (such as homicide, HIV/AIDS, and accidents). Consequently, the dominant causes of death among the white population are heart disease, cancer, and stroke. African-Americans, on the other hand, are more likely to die as a result of infectious conditions, respiratory and digestive systems conditions, and the lifestyle-associated problems noted above.

Much of the mortality advantage characterizing Asian-Americans and Hispanics has been attributed to the foreign-born among these populations. While first generation immigrants are on average healthier than native-born Americans, subsequent generations of Asian-Americans and Hispanics, it seems, do not fare as well in comparative mortality analyses. Interestingly, Native Americans have made the greatest gains of any group in reducing mortality in recent years (National Center for Health Statistics, 2010).

> *A number of demographic attributes exhibit an association with mortality, and the demographic composition of a defined population can serve as a predictor of its mortality rate.*

A particularly important cause of death for the African-American population is infant mortality. Although infant mortality was dramatically reduced as a cause of death in the United States during the last century, it continues to be a serious health threat for nonwhites. The infant mortality rate for African-Americans in 2014 was more than twice that for whites, 11.3 per 1000 live births versus 4.8 (Kochanek

et al., 2016). The African-American population has not benefited from improvement in mortality to the extent that other racial and ethnic groups have.

Mortality outcomes for married persons are better than for unmarried persons. These findings suggest that marriage provides a buffer with regard to adverse health outcomes (Robards, Evandrou, Falkingham, et al., 2012). It has also been suggested that a committed non-marital relationship may serve the same function of mitigating mortality for those in such relationships.

Cross-national analyses have found that the mortality advantage of married persons continues up to the oldest age groups (85–89) and that, the largest absolute differentials in mortality levels between marital statuses are at higher ages. This same research found that over the 1990s the advantage of married people increased for almost all the countries studied. An increasing body of work has used long-term marital history to account for current mortality (Robards et al., 2012). There is a long history of findings of adverse mortality outcomes for single men relative to women.

The U.S. population exhibits noteworthy disparities in mortality related to income. The mortality rate for the lowest income group is considerably higher than that of the most affluent, even after adjusting for age (National Center for Health Statistics, 2016). The CDR for the segment of the U.S. population with the lowest income is more than twice that for the highest income category. Virtually all infant mortality in the United States today is accounted for by the lowest income groups, and maternal mortality (which has been virtually eliminated society-wide), is disturbingly common among the poor and appears to be increasing.

The pattern with regard to mortality and education resembles that exhibited for mortality and education. The death rate for the poorly educated is much higher than for those with higher educational achievement (National Center for Health Statistics, 2010). Infant mortality, once a leading cause of death, has been virtually eliminated from the groups with the highest educational levels. The poorly educated as it turns out account for the bulk of infant deaths. The correlation between educational level and infant mortality rates is reflected in differences in low birth weight babies and premature births.

> *The unexpected and unprecedented uptick in mortality rates for certain segments of the U.S. population is being attributed to the "diseases of despair"—addictions, suicide depression and other conditions–that plague the poorly educated white population.*

Mortality rates and longevity vary directly with occupational status. Mortality rates for professionals are significantly lower than those for unskilled laborers, for example. A study in Sweden and Germany found a link between mortality and occupational status, with the risk of death for the lowest occupational group

(unskilled laborers) being nearly twice that of the highest (professionals). The authors note that income and education are confounding factors (Geyer, Hemstrom, Peter, et al., 2006). The causes of death for those lower in terms of occupational status are similar to those for the poor and uneducated.

It is found that certain occupations tend to be characterized by inordinately high levels of both. It is also found that certain industries tend to be characterized by inordinately high levels of both morbidity and mortality. Among the standard industrial categories utilized by the U.S. Department of Labor the industry recording the highest death rates in 2008 was farming/fishing/forestry with 30.4 deaths per 100,000 employed workers. This compares to finance and insurance with 0.3 deaths per 100,000 workers (National Center for Health Statistics, 2010).

Hummer, Rogers, Nam, et al. (1999) found a clear relationship between church attendance and mortality rates. People who never attend church services exhibit a risk of death 1.87 times that for those who attend services two or more times per week. This calculates out to a 7-year difference in life expectancy (at age 20) between non-attenders and frequent attenders. Koenig, McCullough, Larsen's (2001) review of previous studies found that those who were deemed to be religious experienced fewer suicides than the non-religious (Koenig et al., 2001).

7.4   Mortality Trends in the U.S.

Like fertility, mortality is a dynamic process, influenced by a number of demographic factors and subject to significant fluctuations. The total number of annual deaths in the United States, as indicated in Exhibit 7.5, increased steadily during the twentieth century. However, by 2005 this trend had moderated and the number of annual deaths stabilized at around 2.4 million per year, or around one million more deaths annually compared with 1935. By 2014, however, the number of deaths had increased to over 2.6 million, no doubt reflecting the long-awaited impact of aging baby boomers.

More significant than the number of deaths, however, is the mortality rate since it is adjusted for population size. The crude death rate in 1900 was 17.2 per 1000. This figure declined dramatically during the first one-half of the twentieth century, with a rate of 10.8 recorded in 1940. The death rate continued to decline during the century, recording a modern-day low of 8.0 in 2010. The most recent NCHS data, however, indicate an unexpected increase to 8.5 in 2015. This figure represents an uptick in mortality unprecedented in recent years (Kochanek et al., 2016). Exhibit 7.5 presents combined data for deaths and crude death rates.

**Exhibit 7.5: Deaths and Death Rates: United States 1935–2015**

Year	Deaths[a]	Crude Death Rate
2015	2713	8.5
2010	2468	8.0
2005	2448	8.3
2000	2403	8.5
1995	2312	8.7
1990	2146	8.6
1985	2084	8.8
1980	1990	8.8
1975	1893	8.8
1970	1921	9.5
1965	1828	9.3
1960	1712	9.0
1955	1529	9.4
1950	1452	9.5
1945	1402	10.1
1940	1417	10.8
1935	1393	11.0

Source National Center for Health Statistics
[a]Deaths in thousands

At the beginning of the twentieth century life expectancy was about 49 years, with women outliving men by around three years. Significant improvement was seen in life expectancy during the first half of the 20th century, and since WWII life expectancy has continue to increase but at a steadily declining rate. Viewed over time, life expectancy increased dramatically to over 59 years in 1930, 68 years in 1970 and over 75 years in 1990. By 2015 life expectancy in the U.S. had increased to 79 years. Between 1930 and 1970 the male/female differential in life expectancy widened, reaching seven years by 1970. The seven-year margin continued until 1990, followed by a gradual narrowing of the difference. Today, U.S. women outlive men by five years on the average. Exhibit 7.6 graphically displays trends in deaths, crude death rates and age-adjusted death rates.

Exhibit 7.6: Deaths, Crude Death Rates, and Age-Adjusted Death Rates: United States: 1935–2010
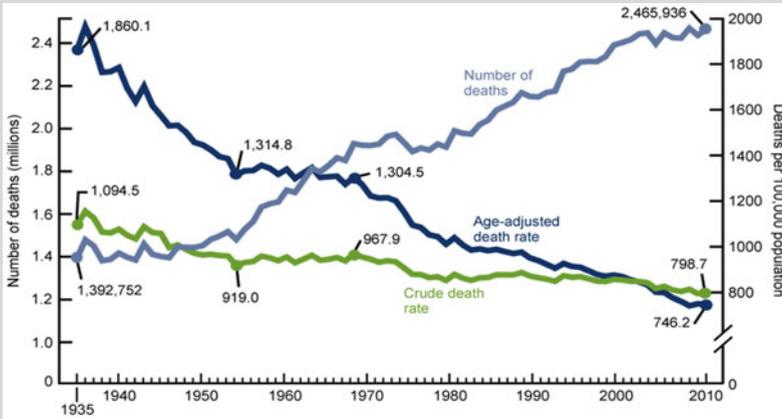
Notes 2010 data are preliminary. Crude death rates on an annual basis are per 100,000 population; age-adjusted rates are per 100,000 U.S. standard population. Rates for 2001–2009 are revised and may differ from rates previously published. *Source* CDC/NCHS, National Vital Statistics System, Mortality.

An interesting twist has arisen with regard to life expectancy in some geographic areas of the United States. For certain subsets of the U.S. population, life expectancy is currently decreasing (Kindig & Cheng, 2013), with the trend toward greater longevity being reversed for the populations in a number of U.S. counties (i.e., 4% of U.S. men and 16% of U.S. women experiencing *declining* life expectancy) (Ezzati, Freedman, Kulkarni, et al., 2008). While the most adverse trends in longevity have been limited to a small segment of the population, the decline was found to be relatively widespread among females. The fact that any segment of the U.S. population is demonstrating a decline is life expectancy is worthy of note.

Exhibit 7.7: Life Expectancy at Birth by Sex in the United States 1900–2015

Year	Total	Males	Females
2015	78.8	76.5	81.3
2010	78.7	76.2	81.0
2005	77.4	74.9	79.9
2000	76.8	74.1	79.3

(continued)

(continued)

Year	Total	Males	Females
1990	75.4	71.8	78.8
1980	73.7	70.0	77.5
1970	70.8	67.1	74.8
1960	69.7	66.6	73.1
1950	68.2	65.6	71.1
1940	62.9	60.8	65.2
1930	59.7	58.1	61.6
1920	54.1	53.6	54.6
1910	50.0	48.4	51.8
1900	47.3	46.3	48.3

Source National Center for Health Statistics

One of the significant developments during the twentieth century in the U.S. was the dramatic reduction in infant mortality. As can be seen in Exhibit 7.8, early in that century infant mortality was a leading cause of death and contributed to a relatively short average life expectancy. Between 1920 and 1940 the IMR was cut essentially in half and by 1970 it was halved again. Overall, a rate of 85 infant deaths per 1000 live births in 1920 was cut to 7 per 1000 by 2000. A similar but even more dramatic trend was recorded for maternal deaths, a leading cause of death for females at the beginning of the twentieth century. The maternal death rate of around 80 per 10,000 births was reduced to only 1 per 10,000 by the end of the 20th century. The improvements in infant and maternal mortality rates can be attributed to a number of factors in addition to better medical care, including improved public health conditions and changes in demographic characteristics such as education and income. Moreover, the sharp reduction in the maternal mortality rate was directly responsible for the rapid increase in female life expectancy that took place in the middle part of the 20th century.

Current trends in maternal mortality in the U.S. display a pattern that suggests a reversal of historic trends. The century-long decline in the maternal mortality rate began to reverse itself after 1980 with maternal mortality rates actually increasing moving into the 21st century.

Current trends in maternal mortality in the U.S. display a pattern that suggests a reversal of historic trends. The century-long decline in the maternal mortality rate began to reverse itself after 1980, stagnating during the 80s and 90s and actually increased moving into the 21st century. The rate of less than 1.2 maternal deaths per 10,000 live births in the 1980s increased to a modern high of 2.5 deaths per 10,000

live births in 2014, making the U.S. the only developed country for which the maternal mortality rate is increasing (Kassenbaum, 2014).

The disappointing progress the U.S. has made in reducing infant mortality is to a great extent a function of disparities in access to healthcare that exist between various groups within the population. The relatively large infant mortality disparity between African-Americans and whites, for example, reflects differences in life chances between the two groups. The racial difference in infant mortality can be partially attributed to dissimilarities in the cause of death. African-American infants exhibit a greater likelihood of dying from complications associated with low birth weight, pneumonia, and respiratory distress syndrome. Exhibit 7.8 presents trends in infant and maternal mortality for the U.S.

Exhibit 7.8: Infant and Maternal Mortality Rates in the United States 1920–2014

Year	Infant mortality[a]	Maternal mortality[b]
2014	5.8	2.5
2010	6.1	1.3
2005	6.9	1.0
2000	6.9	1.0
1990	9.2	0.8
1980	12.6	0.9
1970	20.0	2.2
1960	26.0	3.7
1950	29.2	8.3
1940	47.0	37.3
1930	64.6	67.3
1920	85.8	79.9

Source National Center for Health Statistics
[a]Deaths per 1000 live births
[b]Deaths per 10,000 live births

Significant changes have occurred with regard to the major causes of death affecting U.S. society. The dominant causes of death early in the 20th century have waned in importance due to improvements in disease prevention and treatment. In 1900 acute conditions—particularly infectious and communicable diseases—were the leading causes of death. "Diseases of civilization", while not unknown, accounted for only a small fraction of the deaths and by 2009 heart-related conditions and cancer, although minor threats a century ago, accounted for about 48% of all mortality. Other conditions related to environmental threats and lifestyles had also become prominent. In 1900 it could be argued that death was a result of what disease did to the population, but by 2009 it had become clear that deaths were due to what the population was doing to itself. Exhibit 7.9 presents the leading causes of

death in 1900 and 2009. Case Study 7.1 describes the extent to which a disease can affect different demographic groups disproportionately.

Exhibit 7.9: Proportion of Deaths Attributed to Leading Causes 1900 and 2009

	1900	2009
Heart disease	8.0%	25.0%
Cancer	3.7%	22.9%
Tuberculosis	11.3%	*
Diarrhea	8.1%	*
Chronic lower respiratory diseases	*	5.7%
Stroke	4.5%	5.4%
Liver disease	5.2%	*
Accidents	5.1%	4.9%
Alzheimer's disease	*	3.3%
Diabetes	*	2.9%
Pneumonia/influenza	10.2%	2.3%
Nephritis and related	*	2.0%
Suicide	*	1.5%

Source National Center for Health Statistics
*Negligible proportion

Case Study 7.1: Understanding the Epidemiology of HIV/AIDS
Many diseases currently affecting the U.S. population exhibit a clear distribution pattern based on demographics. One of the conditions that was linked to demographic subsets of the population almost since its identification is acquired immunodeficiency syndrome (AIDS). In fact, the history of the HIV/AIDS epidemic is really a history of shifting demographic correlates.

AIDS was first recognized as a new disease in the United States when clinicians in New York, Los Angeles, and San Francisco began to see young, white homosexual men with a certain type of pneumonia (PCP) and Kaposi's sarcoma (KS), both unusual diseases for young adults. A similar syndrome was reported for injecting drug users. Then, in mid-1982, the Centers for Disease Control and Prevention (CDC) published a report of 34 cases of KS and opportunistic infections in Haitians living in several different states in the United States, none of whom reported homosexual behavior. Shortly thereafter, the CDC reported cases of PCP among persons with hemophilia.

Before HIV was identified as the virus that causes AIDS, tracking the course of the epidemic depended on the reporting of AIDS diagnoses to public health departments. However, throughout the 1980s most of the states

with the largest numbers of AIDS cases did not report HIV test results. This began to change in the 1990s when attempts to monitor the course of the epidemic were augmented. The observed incidence of HIV cases continued to increase into the 1990s, with the peak incidence of deaths (50,877) reached in 1995. A rapid decline of deaths in 1996 and thereafter was a result of both the peak in AIDS incidence and the effectiveness of multidrug therapy which became widely available in 1996.

The characteristics of the first 50,352 cases, reported between 1981 and 1987 to CDC, differ significantly from the characteristics of the 69,151 cases reported a decade later in 1996 and then even later in 2015. During the 1990s and into the 21st century, the epidemic became increasingly an epidemic of non-white populations, women, heterosexuals and injecting drug users. While only 8% of the earlier cases were female that proportion rose to 21% of the 1996 cases, 23% in 1999 and 26% in 2001. Since then the proportion of cases attributed to females has dropped to 21% in 2015.

The distribution of new cases by race/ethnicity also changed greatly during the first twenty years of the epidemic. The proportion of new cases in non-Hispanic whites dropped from 60% in 1981 to 43% in 1996 and to 28% in 2001. The proportion of new cases in African-Americans rose from 25% in 1981 to 50% in 2001, and the proportion of Hispanics rose from 14% to 20%. Today African-Americans are represented among AIDS cases at 4 times their proportion in the U.S. population, and Hispanics at nearly twice their population percentage. In 2015 the proportion of new cases attributed to whites was 26%, blacks 44% and Hispanics 24%.

Although the proportion of cases who were "men who have sex with men" (MSM) declined from 71% in 1983 to 44% in 1996 (of whom 4% also reported injecting drug use) that proportion has held steady for several years and, contrary to some predictions in the early 1990s of a precipitous decline, increased to 67% in 2015. (Users of CDC data on reported cases should note, however, that the risk groups in which cases are initially reported are skewed toward a high proportion in the "risk not reported/identified" category, the majority of which are eventually reclassified as MSM cases.)

By 1993, AIDS had become the leading cause of death among persons 25–44 years old and eighth overall among all causes of death, accounting for 2% of the total. Over 40,000 U.S. residents died of AIDS in 1994 and 50,000 in 1995. The number of AIDS deaths had dropped to 6721 by 2014. In 1994, AIDS accounted for 23% of all deaths among men and 32% of all deaths among African-American men. It was third overall among causes of death for women 25–44 years of age (11% of deaths), but first among African American women (22% of deaths). (These data probably underestimate of the impact of AIDS on mortality in young adults, because studies have found that using HIV as the underlying cause of death on the death certificate captures only two-thirds to three-fourths of deaths attributable to HIV infection.)

Since the mid-1990s when AIDS was a leading cause of death for those 25–44 it has dropped in significance to the point that it accounts for only a fraction of one percent of deaths. The majority of this decline is probably attributable to the effectiveness of the multidrug treatment regimens that became widespread beginning in 1996, although it is also due in part to the peaking of infection incidence rates in the mid-1980s. The reported increase in transmission by MSMs is thought to be linked to a new generation that did not experience the tragedy of the 1990s.

Perhaps more than any other disease HIV/AIDS is a product of social behavior, with the behavior patterns and lifestyles characterizing various demographic segments of U.S. society being primary factors in the distribution of HIV infections and AIDS deaths. An understanding of the distribution of the disease within the population and the changing demographic correlates of its incidence provide invaluable information to those seeking to reduce the burden of HIV/AIDS on U.S. society.

7.5 Sources of Mortality Data

The primary source of mortality data in the United States is the government death registry maintained by the National Center for Health Statistics. This registry is compiled from death certificates filed at the local level (i.e., county health department) which are processed at the state level and forwarded to NCHS for compilation and analysis. In the U.S. highly accurate data are available for mortality and relatively timely information on deaths and death rates. Death rates are generally provided for the total population although it is not uncommon to present death rates for subsets of the population or to adjust death rates for standardization purposes. Mortality data are generally reported based on the place of residence of the deceased, although data are also collected on the place of occurrence of this vital event.

The data collected on the standard death certificate include primary cause of death, contributing causes, and individual demographic and socioeconomic characteristics such as sex, race, ethnicity, last occupation, place of residence, and place of death. Using these data, demographers can study the relationship between the cause of death and a variety of demographic variables. Exhibit 7.10 describes the data available through the standard death certificate.

Exhibit 7.10: Relevant Items: Standard Certificate of Death

Sex	Location of death
Age at death	Date of death
Location of residence	Hospital/facility name
Marital status	
Education	
Race	
Cause of death (3)	
Manner of death	
Contribution of tobacco	
Occupation	
Industry	

There are several potential problems related to data compiled from death certificates. While identifying the cause of death may seem relatively easy to a layperson, in practice it is often difficult to determine the precise cause of death, potentially resulting in the incorrect assignment of cause. Some deaths are complicated in that more than one condition is present (e.g., cancer and pneumonia) with several bodily systems affected (e.g., heart and lungs). Further, it is often difficult to distinguish between and among the primary and contributing causes, especially since the proximate cause of death may not represent the ultimate factor in the death. For example, few people die as a direct result of diabetes or AIDS since some derivative condition (e.g., pneumonia) or associated system failure (e.g., kidney failure) is likely to be the proximate cause of death. This situation is further complicated by the fact that the cause of death in many jurisdictions may not be assigned by a physician but a medically untrained coroner.

Exercise 7.1: Data Standardization
Using the data supplied below, calculate the age-adjusted death rate for this community in Florida:

Age category	Original population	Crude		Adjusted	
		Death rate	Deaths	Population	Deaths
0–15	1000	2/1000	_____	1500	_____
15–29	1000	1/1000	_____	1500	_____
30–44	1000	3/1000	_____	1500	_____
45–59	2000	5/1000	_____	1500	_____
60–74	2000	15/1000	_____	1000	_____
75+	1000	30/1000	_____	500	_____
Total	8000		_____	8000	_____

Crude death rate: deaths per 1000 persons = _____
Age-adjusted death rate: deaths per 1000 persons = _____

Exercise 7.2: Life Table Calculations

The partial life table presented below has some blank spaces left in the columns. For this exercise students will fill in the missing data.

Age	Probability of dying between ages x to x + 1	Number surviving to age x	Number dying between ages x to x + 1	Person-years lived between ages x to x + 1	Total number of person-years lived above age x	Expectation of life at age x
	q(x)	l(x)	d(x)	L(x)	T(x)	e(x)
0–1	0.006123	100,000	612	99,465	7,866,027	78.7
1–2	0.000428	99,388	43	99,366	7,766,561	78.1
2–3	0.000275	99,345	27	99,331	7,667,195	77.2
3–4	0.000211	99,318	21	99,307	7,567,864	76.2
4–5	0.000158	99,287	16	83,283	7,468,556	75.2
5–6	0.000145	99,281	14	99,274	7,369,267	74.2
6–7	0.000128	99,267	13	99,260	7,269,993	73.2
7–8	0.000114	99,254	11	99,249	7,170,733	72.2
8–9	0.000100	99,243	10	99,238	7,071,484	71.3
9–10	0.000087	99,233	9	99,229	6,972,246	70.3
10–11	0.000079	99,224	8	99,220	6,873,017	69.3
11–12	0.000086	99,216	9	99,212	6,773,797	68.3
12–13	0.000116	99,208	12	99,202	6,674,585	67.3
13–14	0.000175	99,196	17	99,188	6,575,383	66.3
14–15	0.000252	99,179	25	99,167	6,476,195	65.3
15–16	0.000333	99,154	33	99,138	6,377,028	64.3
16–17	0.000412	99,121	41	99,101	6,277,891	63.3
17–18	0.000492	99,080	49	99,056	6,178,790	62.4
18–19	0.000573	99,032	57	99,003	6,079,734	61.4
19–20	0.000655	98,975	65	98,942	5,980,731	60.4

(continued)

(continued)

Age	Probability of dying between ages x to x + 1	Number surviving to age x	Number dying between ages x to x + 1	Person-years lived between ages x to x + 1	Total number of person-years lived above age x	Expectation of life at age x
	q(x)	l(x)	d(x)	L(x)	T(x)	e(x)
20–21	0.000744	98,910	74	98,873	5,881,789	59.5
21–22	0.000829	98,836	82	98,795	5,782,916	58.5
22–23	0.000892	98,754	88	98,710	5,684,120	57.6
23–24	0.000925	98,666	91	98,621	5,585,410	56.6
24–25	0.000934	98,575	92	98,529	5,486,789	55.7
25–26	0.000936	98,483	92	98,437	5,388,260	54.7
26–27	0.000943	98,391	93	98,344	5,289,824	53.8
27–28	0.000953	98,298	94	98,251	5,191,479	52.8
28–29	0.000971	98,204	95	98,157	5,093,228	51.9
29–30		98,109	98	98,060	4,995,071	50.9
30–31	0.001029	98,011	101	97,961	4,897,011	50.0
31–32	0.001063	97,910	104	97,858	4,799,051	49.0
32–33	0.001099	97,806	108	97,752	4,701,193	48.1
33–34	0.001137	97,699	111	97,643	4,603,440	47.1
34–35	0.001180	97,587	115	97,530	4,505,797	46.2
35–36	0.001235	97,472	120	97,412	4,408,267	45.2
36–37	0.001302	97,352	127	97,289	4,310,855	44.3
37–38	0.001377	97,225	134	97,158	4,213,567	43.3
38–39	0.001461		142	97,020	4,116,408	42.4
39–40	0.001557	96,949	151	96,874	4,019,388	41.5
40–41	0.001663	96,798	161	96,718	3,922,514	40.5
41–42	0.001793	96,637	173	96,551	3,825,796	39.6

(continued)

(continued)

Age	Probability of dying between ages x to x + 1	Number surviving to age x	Number dying between ages x to x + 1	Person-years lived between ages x to x + 1	Total number of person-years lived above age x	Expectation of life at age x
	q(x)	l(x)	d(x)	L(x)	T(x)	e(x)
42–43	0.001962	96,464	189	96,370	3,729,245	38.7
43–44	0.002177	96,275	210	96,170	3,632,875	37.7
44–45	0.002423	96,065	233	95,949	3,536,705	36.8
45–46	0.002676	95,833	256	95,704	3,440,756	35.9
46–47	0.002931	95,576	280	95,436	3,345,052	35.0
47–48	0.003205	95,296		95,143	3,249,616	34.1
48–49	0.003505	94,990	333	94,824	3,154,473	33.2
49–50	0.003830	94,658	363	94,476	3,059,649	32.3
50–51	0.004177	94,295	394	94,098	2,965,173	31.4
51–52	0.004535	93,901	426	93,688	2,871,075	30.6
52–53	0.004903	93,475	458	93,246	2,777,386	29.7
53–54	0.005284	93,017	491	92,771	2,684,140	28.9
54–55	0.005684	92,526	526	92,263	2,591,369	28.0
55–56	0.006117	92,000	563	91,718	2,499,106	27.2
56–57	0.006589	91,437	603	91,136	2,407,388	26.3
57–58	0.007095	90,834	644	90,512	2,316,253	25.5
58–59	0.007626	90,190	688	89,846	2,225,741	24.7
59–60	0.008180	89,502	732	89,136	2,135,895	23.9
60–61	0.008767	88,770	778	88,381	2,046,759	23.1
61–62	0.009397	87,992	827	87,578	1,958,378	22.3

Spreadsheet version available from: ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Publications/NVSR/63_07/Table01.xlsx

References

Case, A, & Deaton, A. (2017). *Mortality and morbidity in the 21st century*. Downloaded from URL: https://www.brookings.edu/wp-content/uploads/2017/03/casedeaton_sp17_finaldraft.pdf.

Ezzati, M., Friedman, A.B., Kulkarni, S.C., & Murray, C. J. L. (2008). The reversal of fortunes: Trends in county mortality and cross-county mortality disparities in the United States. *PloS Medicine* (April). Downloaded from URL: http://www.plosmedicine.org/article/info:doi/10.1371/journal.pmed.0050066.

Geyer, S., Hemstrom, O., Peter, R., et al. (2006). Education, income, and occupational class cannot be used interchangeably in social epidemiology. Empirical evidence against a common practice. *Journal of Epidemiology and Community Health, 60*(9), 804–810.

Hummer, R. A., Rogers, R. G., Nam, C. B., et al. (1999). Religious involvement and U.S. adult mortality. *Demography, 36*(2), 273–285.

Kassenbaum, N. J. (Ed.). (2014). Global, regional, and national levels and causes of maternal mortality during 1990–2013: A systematic analysis for the global burden of disease study 2013. *Lancet* (May 2). Downloaded from URL: http://download.thelancet.com/flatcontentassets/pdfs/S0140673614604979.pdf.

Kindig, D. A., & Cheng, E. R. (2013). Even as mortality fell in most US counties, female mortality nonetheless rose in 42.8 percent of counties from 1992 to 2006. *Health Affairs, 32*(3), 3451–3458.

Kochanek, K. D., Murphy, B. S., Xu, J., et al. (2016). Deaths: Final data for 2014. *National Vital Statistics Reports, 65*(4). Downloaded from URL: https://www.cdc.gov/nchs/data/nvsr/nvsr65/nvsr65_04.pdf.

Koenig, H. G., McCullough, M. L., & Larsen, D. B. (2001). *Handbook of religion and health*. New York: Oxford University Press.

National Center for Health Statistics. (2006). United States life tables, 2003. *National Vital Statistics Reports, 54*(14).

National Center for Health Statistics. (2010). *Health United States: 2010*. Bethesda, MD: National Center for Health Statistics.

National Center for Health Statistics. (2016). *Health United States: 2015*. Bethesda, MD: National Center for Health Statistics.

Robards, R., Evandrou, M., Falkingham, J., et al. (2012). Marital status, health and mortality. *Maturitas, 73*(4), 295–299.

Rogers, R. G., Hummer, R. A., & Nam, C. B. (2000). *Living and dying in the USA: Behavioral, health and social differentials of adult mortality*. New York: Academic Press.

Additional Resources

Anson, J., & Luy, M. (Eds.). (2014). *Mortality in international perspective*. New York: Springer.

National Center for Health Statistics. (2012). United States life tables, 2009. *National Vital Statistics Reports, 61*(3).

Pressat, R. (2008). *Demographic analysis: Projections on natality, fertility and replacement*. New York: Springer.

Shyrock, H. (2013). *The methods and materials of demography* (Vol. 2). Memphis, TN: General Books.