CHAPTER 3

Survival, Mortality, and Cause of Death

INTRODUCTION

A most significant demographic change has been the significant improvement in life expectancy. As noted in Chapter 1, this improvement has been achieved among people in every age group. In the early 1900s, the most dramatic improvement was achieved by infants and by women in their childbearing years. Today, the improvement has been realized by older people, especially among those who have reached the age of 65.

Despite the overall aging of the society, there is considerable variation in the extent of life expectancy within populations, and, as we shall see, among people who have already reached the age of 65. Some people, indeed, some populations, survive longer than others. Life expectancy is greater for women than men, and greater for non-Hispanic whites and Asian-Americans than for African-Americans and Hispanic whites. The level of difference in life expectancy among gender, race, and ethnic groups also has been found to vary across different geographic areas. Recognition of these demographic and geographic patterns in life expectancy has stimulated considerable research in epidemiology to understand the biologic, behavioral, social, and environmental reasons for these broad patterns within and among populations. Research in these areas is based on the premise that explanations for these population patterns will contribute significantly to our understanding of human aging and longevity. It is further assumed that this research will lead to public health strategies to improve the life chances of those at risk for premature death.

In this chapter, we will review the epidemiology of aging, survival, and mortality. Research in this area is extensive and varied, including the independent and joint effects of biologic, behavioral, social, and environmental factors. The ecological model presented in Chapter 2, underscores the point that in the epidemiology of aging, as in life, all paths lead to the question of survival and, ultimately, mortality.

VITAL STATUS AND CAUSE OF DEATH

Studies of survival and mortality depend on the quality of information on vital status, defined to mean whether the person is alive or dead. It would appear at first glance that this information is not only reasonably accurate, but also readily available. Although it is true that data on vital status is perhaps the most widely available population health indicator, ensuring the quality of this information represents an important public health challenge.

Cause-specific mortality statistics serve as the basic source of data for many epidemiological studies on aging. A mortality rate is the number of deaths in a given time period divided by the number of person-years lived in that time period by those at risk for death. For cause-specific rates, the deaths are restricted to those in which a particular condition or disease is listed as the *underlying* cause of death on the death certificate.

The death certificate is a legal document that is used as proof for insurance, to obtain a burial permit, and to determine cause of death in court. The death certificate consists of two parts (See Figure 3–1). Part 1 consists of a listing of the causal conditions leading to death: the *immediate* cause of death is entered first; following by one or more *intermediate* conditions; and, finally, the *underlying* cause of death. The underlying cause of death is that disease or condition that initiated the chain of events that led to death. The premise is that without that disease or condition, the particular death could not have occurred. Part 2 includes the addition of other significant conditions that contributed, but were not directly related, to the death. For example, septicemia, a systemic infection, may be listed as the immediate cause of death, followed by pneumonia as an intermediate condition, with lung cancer listed as the underlying cause of death. Diabetes may be listed as a contributory cause. This particular decedent case would be included in the numerator as part of a calculation of a lung cancer mortality rate. Figure 3–1 displays a sample of a death certificate from the State of Michigan.

TYPE/PRINT IN PERMANENT BLACK INK

LF _____
CF _____

STATE OF MICHIGAN
DEPARTMENT OF COMMUNITY HEALTH
CERTIFICATE OF DEATH

STATE FILE NUMBER _____

DECENDENT

1. DECENDENT'S NAME *(First, Middle, Last)*
2. DATE OF BIRTH *(Month, Day, Year)*
3. SEX
4. DATE OF DEATH *(Month, Day, Year)*
5. NAME AT BIRTH OR OTHER NAME USED FOR PERSONAL BUSINESS *(include AKA if any)*
6a. AGE - Last Birthday *(*
6b. UNDER 1 YEAR: MONTHS, DAYS
6C. UNDER 1 DAY: HOURS, MINUTES
7a. LOCATION OF DEATH *(Give place officially pronounced dead* HOSPITAL OR OTHER INSTITUTION - Name *(if not in either give name and number and zip code)*
7b. CITY, VILLAGE, OR TOWNSHIP OF DEATH
7c. COUNTY OF DEATH
8a. CURRENT RESIDENCE - STATE
8b. COUNTY
8c. LOCALITY *(check which best describes the location)* ☐ City or Village ☐ Township ☐ Place
8d. STREET AND NUMBER Include Apt. No. *(If applicable)*
9a. ZIP CODE
9b. BIRTHPLACE *(City and State)*
10. SOCIAL SECURITY NUMBER
11. DECEDENT'S EDUCATION - What is the highest grade or level of school completed at the time of death?

NAME OF DECENDENT
For use by physician or institution

12. RACE - American Indian, White, Black, *(If Asian, give i.e., Chinese, Filipino,*
13a. ANCESTRY - Mexican, Cuban, Asian, African, French, Dutch, etc. *(all that apply)* If American Indian race, enter tribe
13b. HISPANIC ORIGIN *(Yes or No)*
14. WAS DECENDENT EVER IN THE U.S. ARMED FORCES? *(Yes or No)*
15. USUAL OCCUPATION Give list of *during most of working life. Do*
16. KIND OF BUSINESS OR INDUSTRY
17. MARITAL STATUS - Married, Never Married, Widowed, Divorced *(Specific)*
18. NAME OF SURVIVING SPOUSE *wife give name before*

PARENTS

19. FATHER'S NAME *(First, Middle, Last)*
20. MOTHER'S NAME BEFORE FIRST MARRIAGE *(First, Middle, Last)*

INFORMANT

21a. INFORMANT'S NAME *(Type/Print)*
21b. RELATIONSHIP TO DECEDENT
21c. MAILING ADDRESS *(City or Village, State, Zip Code)*

DISPOSITION

22. METHOD OF DISPOSITION Burial, Cremation, , Donation, Removal, Storage *(Specify)*
23a. PLACE OF DISPOSITION *(Name of Cemetery, Crematory or other*
23b. LOCATION - City or Village, State
24. SIGNATURE OF MORTUARY SCIENCE LICENSEE
25. LICENSE NUMBER *(of licensee)*
26. NAME AND ADDRESS OF FUNERAL FACILITY

CERTIFICATION

27a. CERTIFIER *(Check only one)*
☐ Certifying Physician - To the best of any knowledge,
☐ MedicaL Examiner -
Signature and Title _____
28a. ACTUAL OR PRESUMED TIME OF DEATH
28b. PRONOUNCED DEAD ON *(Mo., Day, Yr.)*
28c. TIME PRONOUNCED DEAD
29. MEDICAL EXAMINER CONTACTED? *(Yes or No)*
30. PLACE OF DEATH (Home, Nursing Home, Hospital, Ambulance) *(Specify)*
31. IN HOSPITAL Emergency Room, DOA *(Specify)*
27b. DATE SIGNED
27c. NUMBER
32. MEDICAL EXAMINER'S CASE NUMBER *(if applicable)*
33. NAME OF ATTENDING PHYSICIAN IF OTHER THAN CERTIFIER *(Type or Print)*
34. NAME AND ADDRESS OF ATTENDING PHYSICIAN *(Type or Print)*
35a. REGISTRAR'S SIGNATURE
35b. DATE FILED *(Month, Day, Year)*

CAUSE OF DEATH

36. PART I. Enter the chain of events, diseases, injuries, or complications - that directly caused the death. DO NOT write such as cardiac arrest, respiratory irreg., or vestibular fibrillation without knowing the . Enter only one reason on a line.

Approximate Interval Between Onset and Death

IMMEDIATE CAUSE (Final disease or condition resulting in death)

a. _____
DUE TO (OR AS A CONSEQUENCE OF)
b. _____
DUE TO (OR AS A CONSEQUENCE OF)
c. _____
DUE TO (OR AS A CONSEQUENCE OF)

UNDERLYING CAUSE (disease or injury that initiated the resulting in death) LAST

d. _____

continues

FIGURE 3–1 Sample Death Certificate, State of Michigan

FIGURE 3–1 continued

PART II. OTHER SIGNIFICANT CONDITIONS contributing to direct but not resulting in the underlying care given in Part I.

37. DID TOBACCO USE CONTRIBUTE TO DEATH?
☐ Yes ☐ Probably
☐ No

38. IF FEMALE:
☐ Not pregnant within past year
☐ Pregnant at time of death
☐ Not pregnant, but within 42 days of death
☐ Not pregnant, but 43 days before death
☐ Unknown if pregnant within the past year

39. MANNER OF DEATH - Accident, Suicide, Homicide, Natural, Indeterminate or Pending *(Specify)*

40a. WAS AN AUTOPSY PERFORMED? *(Yes or No)*

40b. WERE AUTOPSY FINDINGS AVAILABLE PRIOR TO COMPLETION OF CAUSE OF DEATH? *(Yes or No)*

SAMPLE COPY

MEDICAL EXAMINER

41a. DATE OF INJURY *(Mo., Day, Yr.)*

41b. TIME OF INJURY

41c. DESCRIBE HOW INJURY OCCURRED

41d. INJURY AT WORK *(Yes or No)*

41e. PLACE OF INJURY - At home, farm, , construction site, wooded area, etc. *(Specify)*

41f. IF TRANSPORTATION INJURY - Driver/Operator, Passenger,

41g. LOCATION - Street or RFD No. City, Village or Twp. State

DCH-0000-0000

The death certificate also contains demographic information about the decedent, such as age, race, gender, residence, occupation, and the location of the death. Information is also maintained on the certifier of the death, in most cases the physician of record, and on the burial or other method of handling the remains of the deceased.

The classification of the cause of death is based on 17 general categories of diseases that are grouped by system (such as diseases of the circulatory system and diseases of respiratory system), or by type of disease (such as infectious and parasitic diseases, and neoplasms). Although the certifier of death, a physician, determines the underlying and intermediate causes of death, a medical coder or nosologist processing the certificate may change data within certain guidelines established by the World Health Organization. Local health departments in the United States submit this data to their state health departments, which, in turn, transmit the data to the National Center for Health Statistics (NCHS) in Washington, DC. Once the data reach NCHS, further reclassification may occur. Automated Classification of Medical Entities (ACME) is a computerized algorithm that programmatically reviews and evaluates the data and assigns causes of death based on established criteria. The results of this programmatic review are used, in turn, to generate national statistics on cause-specific mortality rates by age, gender, race, and geographic area.

In 2001, the leading causes of death in the U.S. for those aged 65 and over include diseases of the heart (1,632 deaths per 100,000 people), malignant neoplasms (cancer) (1,100 per 100,000), cerebrovascular diseases (stroke) (404 per 100,000), chronic lower respiratory diseases (301

per 100,000), influenza and pneumonia (155 per 100,000), and diabetes mellitus (151 per 100,000) (Federal Interagency Forum on Aging-Related Statistics, 2005).

The validity of data on cause of death has been a subject of concern both for studies of the general population and for studies of older populations in particular. With regard to older populations, there is concern that it may be difficult to identify a definitive cause of death, as older people are very likely to have multiple, concurrent health conditions (comorbidity). As Sherwin Nuland writes (1993, p. 78) in his book, How We Die: Reflections on Life's Final Chapter:

> Every group of lethal diseases of the elderly consists predominantly of the usual suspects. Of hundreds of known diseases and their predisposing characteristics, some 85% of our aging population will succumb to the complications of one of only seven major entities: atherosclerosis, hypertension, adult-onset diabetes, obesity, mentally depressing states such as Alzheimer's and other dementias, cancer, and decreased resistance to infection. Many of those elderly who die will have several of them; and not only that, the personnel of any large hospital's intensive care unit can confirm the everyday observation that terminally ill people are not infrequently victims of all seven. The seven make up the posse that hunts down and kills the elderly among us. For the vast majority of those of us who live beyond middle age, they are the horsemen of death.

In keeping with Nuland's observations, results from the National Health Interview Survey indicate that the percentage of people aged 60 years and greater that reported having two or more of the nine most common conditions increased steadily with age (Guralnik et al., 1989). Specifically, the percentage of women who reported two or more conditions increased from 45% among those aged 60 to 69 years, to 61% for those aged 70 to 79 years, and to 70% for those aged 80 years and over. Among men, the percentages were 35%, 47%, and 53% respectively. Compared to cancer patients without comorbid conditions, those with comorbid conditions are more likely to die with an underlying cause of death other than the index cancer (Satariano & Ragland, 1994). In a national study of mortality patterns, Manton and colleagues (1991) reported that cancer is often found on death certificates as contributing to the risk of noncancer causes of death. The occurrence of cancer as a nonunderlying cause of death increased with age and was highest for treatable and slowly growing tumor types. Breast cancer patients from the Detroit metropolitan area who had three or more of seven selected comorbid conditions had a 20-fold higher rate of mortal-

ity from causes other than breast cancer and a 4-fold higher rate of all-cause mortality when compared with patients who had no comorbid conditions (Satariano & Ragland, 1994). In a recent study of the cause of death among men diagnosed with prostatic cancer in Kaiser hospitals in the San Francisco Bay Area, increasing age and comorbidity, in particular, cardiovascular comorbidity, were independently associated with death due to a cause other than prostate cancer (Satariano et al., 1998a).

In view of the potential difficulties associated with the study of mortality statistics for the elderly, it has been recommended that research focus on multiple causes of death, based on data that include all of the causes of death listed on the death certificate, not just the underlying cause. The National Center for Health Statistics now generates public use data tapes, which include two different coding schemes for all the cause-of-death information on the death certificate as well as the single underlying cause. Mortality statistics based on multiple causes of death have a number of advantages, including opportunities to study disease combinations associated with high mortality; to understand more about the contribution of less lethal diseases to death; and to monitor increases and declines in causes of death in a more accurate way. With increasing age of the decedent, a greater number of associated conditions are listed on the death certificate. It is also reported that diabetes is more likely to be included as an associated or contributing cause of death than it is to be listed as an underlying cause of death. In addition, examinations of multiple causes of death over time by age and gender suggest that as the incidence of coronary heart disease declines, different forms of cancer are likely to become the leading underlying causes of death, especially among the elderly (Manton et al., 1991). Despite the importance of data regarding multiple causes of death, there are limitations. In particular, it is impossible to establish from the death certificate either the timing or sequence of multiple health conditions, or the relative severity of those conditions. To complement studies of comorbidity from death certificates, other studies are being conducted based on data from medical records and personal interviews. This work will be discussed later in Chapter 8.

STUDIES OF SURVIVAL

There are generally two types of survival studies. First, there are studies of survival based on general population surveys. The objective is to describe

and explain patterns of survival in a specific population. Baseline assessments of subjects are conducted and then followed for particular periods of time, coupled with regular assessments of vital status. In addition to vital studies, these studies also may entail periodic assessments of other, hypothesized predictor variables. With this type of study, there is an opportunity to determine whether patterns of survival are associated with not only the independent and joint effects of independent variables, but also the association of survival with *changes* in those independent variables. This type of study is ideally suited for the investigation of aging and longevity. Examples of such longitudinal studies include the National Institute on Aging (NIA) Established Populations for Epidemiologic Studies (EPESE) (Cornoni-Huntley, Brock, Ostfeld, Taylor, & Wallace, 1986) and the NIA-funded Study of Physical Performance and Age-Related Changes in Sonomans (SPPARCS) (Satariano et al., 1998b). Second, there are longitudinal studies based on older people recently diagnosed with a particular health condition. In this case, identification and recruitment is not based solely on the residence of subjects in a particular geographic area, but rather a particular diagnosis among people of a particular age and geographic area. It is also possible, as with the previous types of study, to monitor the levels and changes in hypothesized independent variables. Examples of this type of study include the NIA/NCI Cancer in the Elderly Study, a population-based study of older cancer patients recruited from selected areas in the United States (Yancik et al., 1996), and the Cardiovascular Health Study, a study of heart disease in older populations (ref).

The quality of the results from longitudinal studies of this kind depends on the extent to which members of the study cohort are actively followed. Losing members of the study cohort over time, termed, "loss to follow-up," may result in biased results. Although in most cases a decedent subject can be located through the U.S. National Death Index, it is more difficult to obtain information about a subject who is not known to be dead. Moreover, if the loss of contact is not random, but rather associated with one or more of the hypothesized independent variables, the study results may be biased. Even in situations in which contact is maintained with cohort members, bias may be introduced because of the differential survival rate. Without taking into account the timing of the death of the decedents and the characteristics of those decedents, an incorrect estimation of the association between independent variables,

such as physical activity, and survival may result. With this brief introduction to the measurement of vital status and survival, we now turn to a consideration of some of the basic epidemiological patterns in this area.

DEMOGRAPHIC PATTERNS

Age

There is a strong association between chronological age and the risk of death. However, the relationship between age and the risk of death varies by other demographic and socioeconomic factors. Moreover, the strength of the association between chronological age and the risk of death varies by the cause of death. This is most evident in the area of cancer. Among men, the strongest association between age and cancer is found for prostatic cancer, less so for cancer of the colon and rectum. As we will see, the most important question has to do with the reasons for this association with age.

In addition to age, the variables of gender, race, ethnicity, and socioeconomic status are strongly associated with the length of survival and risk of death in most human populations. What is of interest is the manner in which chronological age seems to moderate the association between the other demographic factors, socioeconomic status, and vital status. In general, among adults, the extent of the difference by gender, race, ethnicity, and socioeconomic status is greatest among people in their middle years (approximately, age 40 to 60). With increasing age, the extent of the difference becomes less pronounced. It is also interesting to determine the reasons for these differences and whether those reasons vary over the life course. Put differently, are the reasons for gender or racial differences in mortality among people in their middle years the same reasons for those differences among people in their senior years? These questions are among the most central to an understanding of the epidemiology of aging and longevity.

Gender

It is well known that women live longer than men (Hazard, 1986; 1989). Today, a women has an excellent chance of surviving well into her 80s and among women who survive to age 85, they can expect to live another 6

years on average. At each point in the life course, females have a greater life expectancy than men. As William Hazzard (1986) has written:

> It would appear that the only clear point of advantage occurring to the male over the female of the human species is at the point of fertilization: various estimates have placed the male:female sex ratio at conception to be as high as 170:100. In the first trimester of pregnancy, the point at which the earliest secure estimates of sex ratios can be ascertained, the sex ratio has already diminished to almost 130:100, with a decline throughout fetal life to a sex ratio at birth of 106:100. Before adulthood the greater mortality of male infants and children than girls of comparable age is largely attributable to infections and accidents. Parity in numbers between the sexes is accomplished at the time of adolescence, the gap thereafter to favor female over male survival throughout the remainder of the human life span.

The extent of gender difference varies globally. Based on the Epidemiologic Transition Theory described in Chapter 1, Newman and Brach (2001) report that gender differences in longevity are related to the stage of economic and social development. As noted earlier, the relatively high maternal mortality rate limits life expectancy among women in developing countries. With improvements in maternal and infant mortality, often used as a health indicator of economic development, life expectancy improves significantly, especially for women. Newman and Brach (2001, p. 343) hypothesized that in the latest stage of development, "Life expectancy for women is so high that it may be near its maximum." Moreover, subsequent improvements are found for elderly men, even though the percentage of older women still far exceeds the percentage of older men (Newman and Brach, 2001, p. 343):

> Thus, in developed countries such as the United States, Canada, and the countries of Western Europe the gender gap in longevity is now decreasing between men and women. However, the larger number of women surviving at every age has resulted in a much larger number of older women than of men. In the United States, there are about 20 million [women] over age 65 years compared with 14 million men. The ratio of women to men at age 65 is about 120 women for every 100 men, and by age 85, it is 250 women to 100 men. Because of these trends, the majority of older patients in the health care system are women. Of those over age 65 years, about 60% are women, and more than 70% of those over 85 years are women.

Males are more likely to develop and to die from the leading chronic health conditions, including coronary heart disease, stroke, cancer (most notably, lung, colorectal, and, of course, prostate cancers), diabetes, as well as motor vehicle accidents and occupation-related injuries. It is generally hypothesized that gender differences in longevity are due to a variety of factors, or as Newman and Bach (2001, p. 343) describe them, "a complex interaction of environmental, behavioral, and biologic factors." No doubt, the nature of that complex interaction will vary geographically as well as over time. One leading hypothesis is that the gender difference in sex hormone levels gives rise to the gender differential in lipoprotein metabolism. Among men, testosterone raises low-density lipoproteins and lowers high-density lipoproteins. Among females, estrogen has the opposite effect. Over time, this leads to a gender differential in arteriosclerosis, which, in turn, leads to a gender difference in longevity, given that coronary heart disease is the leading cause of death. Support for this hypothesis is based on the fact that gender differences in longevity vary by age. It is reported that the male–female coronary risk ratio is greater than 1.0 at all ages, though it narrows progressively with age; and the median female LDL/HDL cholesterol ratios are greater than 1.0 at all ages beyond puberty, but also narrows progressively with age, most notably after menopause. Despite this change, males remain at higher risk than females for coronary heart disease.

Differences in socialization and health behaviors are offered as contributing to gender differences in longevity. Most recently, Berrigan and colleagues (2003) reported on the patterns of health behavior among U.S. adults. They noted that with the exception of physical activity, men are more likely than women to engage in behaviors that elevate the risk of major chronic health conditions. These behaviors include tobacco exposure, excessive alcohol consumption, poor dietary and nutritional practices, and other "risky behaviors." In the Berrigan (2003) study, men were reported to be 2.6 times more likely than women to report they did not adhere to any of the five national recommendations on physical activity, tobacco use, alcohol consumption, fruit and vegetable consumption, and dietary fat intake. In contrast, women were approximately 60% more likely than men to report that they adhered to all five healthful behaviors (Berrigan et al., 2003).

As noted in the previous chapter, the International Longevity Institute (2004) recently convened a conference to examine men's health issues. In

addition to noting differences in health behaviors, conference participants identified other factors that may account for differences in health and longevity between men and women. For example, men are reported to be more likely than women to underestimate the risk associated with particular behaviors, such as reckless driving and exposure to the sun. Compared to women, men also are reported to be less knowledgeable about basic health information and less likely to obtain preventive health services or seek care following the onset of particular symptoms. While these are important points, it is still unclear to what extent these gender differences vary by geographic area as well as by race, ethnicity, socioeconomic status, and, of course, age.

Even though differences in health behaviors and access to health services may help to explain gender differences in longevity, it is important to report the findings of one community study as a caution against assuming that we completely understand the reasons for these differences. Based on a random sample of 6928 adult residents of Alameda County, California, researchers examined gender differences in mortality over the following nine years (Seeman, Kaplan, Knudsen, Cohen, & Guralnik, 1987). The unadjusted relative mortality risk for men compared to women was 1.5, that is, the mortality risk was 50% greater for men than for women. An attempt was made to explain the gender difference by a systematic adjustment for 16 demographic and behavioral risk factors. These factors included age, race, socioeconomic status, occupation, physical health status, use of health services, smoking, alcohol consumption, physical activity, weight, sleeping patterns, marital status, social contacts, church and group membership, and life satisfaction. Adjustment for some of the factors, such as smoking and alcohol consumption, reduced the gender difference, suggesting that the excess risk of death found for men may be due, at least in part, to the fact that males are more likely than females to have a history of smoking and alcohol consumption. Interestingly, adjustment for other factors, such as physical activity, physical health status, and marital status, actually increased the gender difference. This means that women were more likely than men to be physically sedentary, report poorer health status, and less likely to be married—all factors associated with an elevated risk of death. Therefore, when those factors were held constant between men and women, the elevated risk of death for men increased. Overall, adjustment for 16 factors slightly increased the relative risk of death from 1.5 to 1.7. It was concluded that

in general these demographic, social, and behavioral factors do not completely explain the gender difference in longevity. Moreover, it was recommended that a more fruitful course would be to examine the possible interaction of biologic and behavioral risk factors.

Race and Ethnicity

Racial and ethnic minorities have poorer survival than non-Hispanic whites, across the life course. Most research has focused on differences between non-Hispanic whites, African-Americans, and Hispanic whites. Considerably less attention has been directed to the different Asian-American groups, one of the fastest growing populations in the United States. In general, African-American males have poorer life expectancy than Asian-American, Hispanic white, or non-Hispanic white males. Although the racial and ethnic differences in longevity are also evident for females, it is much less pronounced. Not only are racial and ethnic minorities at elevated risk for acute and chronic conditions, but also they tend to be diagnosed at a more advanced stage and have less access to care and rehabilitation services. These factors contribute significantly to an elevated risk of death. It is interesting to note, however, that the extent of that racial difference is considerably reduced among those aged 75 years and older (Hummer, Benjamin, & Rogers, 2004) (see Figure 3–2).

Double-Jeopardy Hypothesis

Research has focused on the extent to which race and ethnic patterns of health, disease, and longevity vary by age. The double-jeopardy hypothesis, an early characterization of the interplay of race, age, and health, states that the association between chronological age and a decline in health outcomes occurs more precipitously for minorities than others (Dowd and Bengston, 1974). Put differently, the hypothesis suggests that aging has greater negative consequences for members of minority groups who must face the burdens and difficulties associated with growing old, as well as the burdens and difficulties associated with their minority status. Racial and ethnic memberships serve to modify, therefore, the association between age and health outcomes. Although there is some evidence to support the double-jeopardy hypothesis, primarily studies based on self-reports of general health between African-American and non-Hispanic white populations, there have been very few direct tests of the hypothesis. Moreover, the tests that have been conducted have been based on cross-sectional data.

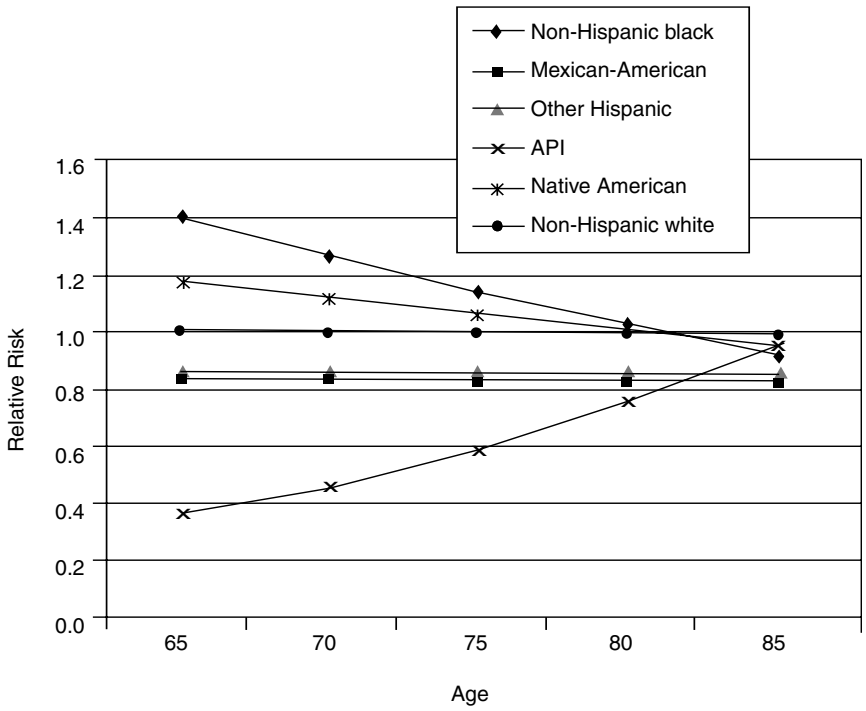

FIGURE 3–2 Predicted Racial/Ethnic Mortality Disparities by Age, United States, 1989–1997

Although cross-sectional data provide a snapshot of racial differences in health by age and by gender, a true test of the hypothesis requires a longitudinal investigation. Such data are necessary to determine whether and to what extent there are differences in health status based on a variety of indicators between members of a minority group and members of the majority, in most cases, non-Hispanic whites, as they age. Although the results of the test seem to depend on the type of health outcome, most research to date, from both cross-sectional and a limited number of longitudinal studies, seems to support the converse of double jeopardy—a decline in health differences with age (Ferraro & Farmer, 1996). While there may be health differences across the life course, those differences, in fact, are most pronounced at earlier points in life, in particular, during the middle years.

Selective survival, associated with racial and ethnic differences in life expectancy, seems to account for the decline in health differences in the later years. The selective survival hypothesis argues that higher early mortality in disadvantaged populations leads to greater survival of biological

robust members of minority populations at advanced ages. The middle years, therefore, may represent a watershed. The accumulation of insults associated with minority status, coupled with reduced physiological resistance, may make the middle years critical for determining who subsequently survives and who does not. Moreover, the health status of minorities who survive their middle years may be somewhat more akin to the health status of their non-Hispanic white age peers. In fact, there is considerable evidence to indicate that there is a black–white mortality crossover in the later years, meaning the age-specific mortality rate for whites aged 75 and older and 85 and older may exceed that found for the age-specific mortality rate for African Americans of the same age. In the end, the double-jeopardy hypothesis may be conceptually flawed. It ignores the presence of subgroups within the racial and ethnic groups. Second, it ignores latency, i.e., early-life susceptibilities and exposures may only become manifest later in life. The double-jeopardy hypothesis is based on the assumption that negative health outcomes that occur in the later years are due primarily to factors that occur at that time.

Black–White Mortality Crossover

US national vital statistics show that black mortality rates at advanced ages converge with and then drop below white mortality rates (see Figure 3–2). Although some argue that the crossover is due, at least in part, to methodological difficulties, for example, an undercount of the middle-aged minority population, there is general consensus that the black/white mortality crossover is real and due, in a greater extent, to the premature death of subpopulations of blacks, primarily black males.

The most compelling evidence for the mortality crossover comes from epidemiological research. Evidence from the Charleston Heart Study and Evans County Study indicate that part of the black–white differential in the early and middle years seems to be attributed to specific groups in the black population with multiple risk-factor exposures, especially high rates of alcohol consumption, cigarette smoking, and violence (Keil et al., 1993, 1995). These factors, together with differences in sexual and reproductive behavior, nutritional and dietary differences, hypertension and obesity, elevate the risk of infant mortality, heart disease, accidents, and homicide. In terms of premature or excess deaths, the greatest impact is found for chronic conditions between the ages of 45 and 70. Two recent epidemiological studies confirm the black/white mortality crossover

(Ny-Mak, Dohrenwend, Abraido-Lanza, & Turner, 1999; Corti et al., 1999). Mortality hazard ratios between African-Americans and non-Hispanic whites during nine years of follow-up were estimated from the National Longitudinal Mortality Study (Ny-Mak et al., 1999). Black persons younger than 65 years were at higher risk than others for all-cause and cardiovascular mortality. The excess mortality was greatest for African-Americans aged 25 to 44. Similar results were reported for a study of African-Americans and non-Hispanic white residents of North Carolina as part of the NIA Established Populations for Epidemiologic Studies of the Elderly (EPESE). A total of 4136 men and women living in North Carolina were interviewed in 1986 and followed until 1994 to examine differences in subsequent mortality. Black persons had higher mortality rates than whites at young old age (65–80 years) but had significantly lower mortality rates after age 80. Black persons age 80 or older had a significantly lower risk of all-cause mortality and of coronary heart disease (CHD) mortality (hazard ratio of blacks vs. whites = 0.75 and 0.44 respectively). It is important to note that these race and age patterns were not found for other causes of death. The authors conclude that the results were due either to differences in the selective survival of the healthiest oldest African-Americans or to other biomedical factors affecting longevity after age 80. The authors also conclude that as the crossover was observed only for deaths due to coronary heart disease, it was unlikely that the results could be explained by the overreporting of age by older African-Americans (Corti et al., 1998).

Despite these results, there are reports of similar race and age patterns for deaths due to stroke as well as ischemic heart disease. Recent trends in ischemic heart disease and stroke mortality were compared in California among six major gender-racial or gender-ethnic groups (Karter et al., 1998). Rates of age-specific and age-adjusted mortality were calculated for persons aged 35 and older during the years 1985 to 1991. Between 1985 and 1991, mortality rates for ischemic heart disease and stroke were generally highest for African-Americans, intermediate for non-Hispanic whites, and lowest for Hispanics. In keeping with the crossover effect, African-Americans had excess ischemic heart disease mortality relative to non-Hispanic whites until later in life, whereas stroke mortality in non-Hispanic white was higher at older ages. In general, similar results were reported from a national study of stroke mortality. Data were obtained from among participants age 45 and older in the National Longitudinal

Mortality Study. The hazard ratios for African-American men and women (relative to non-Hispanic whites) were nearly identical, at > 4.0 at age 45, but marginally significant < 1.0 by age 85. For both Hispanic men and women, the hazard ratios (relative to non-Hispanic whites) were approximately 1.0 at age 45 but were marginally significant < 1.0 at older ages. The ethnic differences in stroke death rates reveal differences in age distributions of fatal strokes between these groups. Approximately 6% of fatal strokes for non-Hispanic whites occurred before age 60, whereas $> 15\%$ occurred in both Hispanic whites and blacks. In conclusion, the results indicate that for Hispanics, stroke risk is similar to that for non-Hispanic whites at younger ages but is marginally lower at older ages, the excess stroke mortality in blacks mainly occurs at younger ages (between 45 and 55 years), and the relationship between stroke risk for blacks and Hispanics relative to whites is similar by gender. Most important, proportionally more strokes occur at older ages in non-Hispanic whites than in either African-Americans or Hispanic whites.

There is also evidence of race by age interactions in population-based studies of prostate and female breast cancers (Austin & Convery, 1993; Simon & Severson, 1997). A retrospective analysis was made of men diagnosed with prostate cancer, based on data from the National Cancer Institute's SEER program. A total of 12,907 men diagnosed from 1973 to 1987 were included in the study. The results indicated that African-American men had poorer survival than white men for all stages of prostate cancer when the cancer was diagnosed at younger ages. However, these differences in survival were not demonstrated for men diagnosed with prostate cancer after age 70 (Austin & Convery, 1993). In a study of racial differences in breast cancer survival in metropolitan Detroit, 10,502 invasive breast cancer cases were included (Simon & Severson, 1997). African-American women were more likely than white women to have more advanced disease, a higher tumor grade, and a tumor that was estrogen-receptor negative. After controlling for age, tumor size, stage, histological grade, census-derived socioeconomic status, and the presence of a residency training program at the treatment hospital, the relative risk of dying for African-Americans compared with whites was 1.68 for women less than 50 years of age, and 1.33 for women older than 50 years of age. In a separate study of breast cancer patients in Wisconsin and in the nation at large, the results indicate that the black:white gap in mortality increased

among women of all ages, but especially among under the age of 55 (Russell, Langlois, Johnson, Trentham-Dietz, & Remington, 1999).

Racial differences in mortality are affected by age at death (Berkman, Singer, & Manton, 1989). African-Americans, especially African-American men, are at elevated risk of premature death from coronary heart disease, stroke, and prostate cancer. African-American women, in turn, have poorer survival than white women following early-onset breast cancer. In contrast, there is little if any racial difference in survival following late-onset disease or when death occurs later in life, either after ages 65 or 75, depending on the disease in question. In fact, there is evidence of a black/white crossover in late-age mortality from deaths due primarily to coronary heart disease.

As part of the recent report on racial and ethnic differences in health in later life published by the National Academy of Sciences, Robert A. Hummer and colleagues (2004, p. 55) nicely summarize the research in this area:

> Although researchers for many years have documented such a mortality crossover using a number of different data sets and have concluded that it appears to be real, others have been more skeptical because of the data quality concerns. The most recent, carefully produced evidence by a research team from the latter group continues to find a racial mortality crossover occurring at ages 90 to 94 for females and 95+ for males (Hill, Preston, & Rosenwaike, 2000). Although the crossover is identified at an older age than a number of other researchers have found, the weight of the evidence, using a number of nationally based U.S. data sources, is strong that a black-white crossover exists.

Socioeconomic Status

Socioeconomic status (SES) has been found to be associated with a variety of health outcomes, including survival and mortality, in older populations. Socioeconomic status has been assessed in terms of both the characteristics of the individual as well as characteristics of the place of residence, across the life course. Just as we found for gender, race, and ethnicity, the strength of the association between socioeconomic status and mortality is affected by age, such that the most pronounced difference is noted for people in their middle years and much less difference is found among the elderly (Kaplan et al., 1987; House et al., 1990; Sorlie, Baclund, & Keller, 1995). Based on the data from the NIA EPESE study, Bassuk and colleagues

(2002) examined whether specific indicators of SES, including education, family income, and occupational history, were differentially associated with all-cause mortality among populations of people aged 65 and older. In addition, this analysis addressed whether the strength of the association varied by age and gender as well as place by focusing on the following locales and regions: East Boston, Massachusetts; New Haven, Connecticut; east-central Iowa; and the Piedmont region of North Carolina. The results confirm the association between SES and all-cause mortality, with overall family income being the strongest predictor among men and women and across the geographic areas. In addition, adjustment for social and behavioral factors reduced but did not extinguish the association. Although these findings suggest that social and behavioral factors are on the causal pathway between socioeconomic status and mortality, there are clearly other factors as well. The strength of the association also varied by place. Specifically, the relationship between socioeconomic status and mortality was more pronounced among elders in New Haven and North Carolina than among elders in East Boston and Iowa. Bassuk and colleagues (2002, p. 530) explained this difference in terms of the "relative deprivation hypothesis":

> A low income may be more deleterious in communities where the majority of the population is wealthy than in poorer communities, either because of invidious social comparison processes or because of economic barriers to purchasing goods and services at prices geared toward more affluent residents.

Bassuk and colleagues (2002) conclude that future research should address the extent to which community factors serve to affect the association between socioeconomic factors and mortality. In addition, it would be valuable in the future to obtain more information about the significance of socioeconomic factors across the life course.

In a separate study, lower levels of educational attainment were shown to be associated with higher rates of mortality, based on data from the National Longitudinal Mortality Survey (Elo and Preston, 1996). The authors argue that educational attainment is an ideal indicator of socioeconomic status. First, it can be obtained for most individuals and it is readily quantifiable. Second, unlike occupational status and family income, it is less likely to be affected by adult health status. Although moderated among those aged 65 and older, there is evidence that educational attainment is

associated with subsequent longevity. The researchers also conclude that the findings suggest that levels of health and functioning should improve in future cohorts of seniors (Elo and Preston, 1996, p. 56):

> The responsiveness of mortality to years of schooling at ages 65 and above give support to the view that older age mortality will continue to decline in the United States in the coming decades as better-educated cohorts replace those currently aged 65+.

This is an interesting hypothesis that would seem to depend on the extent to which the causal mechanism between educational attainment and longevity for the current cohort of seniors will remain constant for future generations of seniors. This will be discussed in greater detail in Chapter 12.

The effect of socioeconomic status over the life course is a critical issue and will require detailed investigation. There is some interesting preliminary work in this area. For example, the risk of death associated with socioeconomic status at different points in the life course and by place was assessed in a study in Great Britain (Breeze, Sloggett, & Fletcher, 1999). The study was based on the Longitudinal Study, a 1% sample of the populations of England and Wales. These data include a linkage of successive censuses since 1971 with routinely collected vital registration data from the National Health Service Central Register. The purpose of the study was to examine the association between socioeconomic and demographic factors and mortality over a 21-year period. The specific objective was to assess whether circumstances occurring in the first 10 years of life affected subsequent mortality and institutionalization. The results indicated that socioeconomic status (assessed here in terms of access to a car and type of housing) during middle age predicted subsequent mortality twenty years later. This was found for both men and women.

There is also evidence that elevated mortality is associated with geographic indicators of socioeconomic status. Although census tract data in the United States are often used as proxy measures for the individual's socioeconomic status, other studies suggest that census data may capture more global, ecological effects on mortality. For example, Mary Haan and colleagues (1987) reported that residents of a federally designated poverty area experienced higher age-, race-, and sex-adjusted mortality rates than residents of nonpoverty areas over a 9-year follow-up period (Relative Risk = 1.71), independently of a variety of individual characteristics,

including race, income, and employment status. There is also evidence from a separate study of 276 metropolitan areas in the United States that a measure of income segregation, i.e., the extent to which people with different levels of income live in separate census tracts, was associated with mortality (Lobmayer & Wilkinson, 2002). Although neither study focused on age differences in mortality or the elderly in particular, the results suggest that both *compositional* factors (characteristics of the people) and *contextual* factors (characteristics of the place) may contribute to longevity. For example, based on data from the National Longitudinal Study, it is reported that residents of rural areas aged 55 and older have lower mortality rates than those in urban areas, following adjustment for age, gender, race/ethnicity, education, income, and marital status (Smith, Anderson, Bradham, & Longino, 1995). The extent of the rural-urban difference was increasingly reduced with increasing age. These overall results were confirmed in a separate study that indicated that older residents of rural areas of the United States have lower rates of mortality than those who reside in urban areas, even though those in urban areas have greater socioeconomic resources and greater access to health services (Hayward, Pienta, & McLaughlin, 1997). It is hypothesized that the lower rate of mortality may be associated with an apparently more equitable distribution of life chances across different socioeconomic positions. In the Alameda County study, Haan and colleagues (1987) concluded that properties of the sociophysical environment might contribute to the relationship between low socioeconomic status and excess mortality, independently of individual behaviors.

Physical Environment

Environmental factors include both chemical and toxic exposures as well as characteristics of the built environment. There is evidence that environmental exposures such as air pollution and lead exposures elevate the risk of illness and death across the life course (Committee on Chemical Toxicity and Aging, 1987). As noted earlier, there is a recent initiative to examine effects of environmental exposure on health and longevity of older people. Segments of the older population may be at elevated risk because of combinations of exposures over the life course, coupled with reduced immunological resistance later in life.

There is also evidence that characteristics of the built environment, e.g., land use patterns, are associated with mortality. In a longitudinal

study of senior residents of Tokyo born in 1903, 1908, 1913, and 1918, it was determined that environmental area characteristics in the place of residence was associated with survival (Takano, Nakamura, & Watanabe, 2002). Specifically, it was determined that those who live in areas with walkable streets and spaces had better survival than those who did not, after adjustment of the residents' age, sex, marital status, and socioeconomic status. While this is one of the few studies to examine a hypothesized association between the built environment and mortality, it is very suggestive for future projects in this area. In the future, it will be necessary to determine whether length of residence in the area or area characteristics at other points in the life course affect the strength of this association. As noted earlier, in studies of this kind, it is important to understand whether the elevated risk of death is due to compositional or contextual factors. This too will be examined in more detail in Chapter 12.

There are also a number of studies that have examined the association between residential characteristics and the risk of accidental death in older populations. In addition to research on the environmental correlates of falls and injuries, which we will examine later in the chapter, there are a number of recent studies that have examined fire- and heat-related deaths in older populations. Although deaths associated with fatal fires may seem rather capricious, some people are at greater risk than others (Marshall, Runyan, Bangdiwala, Linzer, Sacks, & Butts, 1998). In a study of fire-related deaths in North Carolina, Marshall and colleagues (1998) determined that people at greatest risk for death include those under the age of 5 years and those over age 64, those suffering with a physical or cognitive disability, and those who were impaired by alcohol or other drugs. There are also studies of older people at risk for heat-related deaths. Kilbourne and colleagues (1982) reported that those most likely to die of heatstroke in St. Louis, Missouri, were those who were elderly, ill, poor, and socially isolated. These results were confirmed in a subsequent study of St. Louis health-related mortality (Smoyer, 1998), in which it was also determined that health-related deaths were more likely to occur in the "warmer, less stable, and most socioeconomically disadvantaged areas" of the city (Smoyer, 1998, p. 1821). Finally, Eric Klinenberg's (2002) chronicle of the 1995 Chicago heat wave, Heat Wave: A Social Autopsy of Disaster in Chicago, provides further confirmation of the results reported first in St. Louis. In the Chicago study, Klinenberg called attention to the general fear and isolation that characterized many of the city's seniors, in particular,

those seniors who lived in the poorest parts of the city. These are the areas, like those in St. Louis, with the fewest resources and highest rates of crime (Sampson, Raudenbush, & Earls, 1997). Although Chicago had made "cooling stations" available throughout the city, many seniors were apprehensive about leaving their apartments and houses to travel to those stations. Moreover, the seniors who lived alone and who were most isolated were either least likely to be aware of the service or lacked the resources, in most cases, a friend or relative, to accompany them to a station. This illustrates that places can either enhance opportunities for social connection or not. As Klienberg (2002, p. 103) writes,

> Old people in all parts of Chicago complain about the difficulties of navigating across broken sidewalks, rickety stairways, and forbidding open spaces left dark by burned-out street lamps. The fear of falling is a real concern of senior citizens, who know all too well that a stumble from which they once would have recovered could cripple or kill them when their bodies become frail. In North Lawndale, where the city government has done little to repair streets, sidewalks, alleys, and empty lots in the area and poverty prevented many residents from making major repairs on their homes, porches, and stairways, the condition of the physical environment contributes to the local seniors' sense of precariousness and increases the risks of leaving home. The social costs of fear in and of the streets made a brutal appearance during the heat wave, when the barriers North Lawndale residents established to keep themselves safe became the sources of their demise.

Social Capital

In keeping with these observations, it is often reported that place provides a context for social interaction. Along these lines, researchers have addressed the topic of social capital. As noted in Chapter 2, social capital refers to the quality of social relationships and community life. Following from research and commentary in sociology and political science (Coleman, 1988; Putnam, 1995), social capital has been defined in terms of social and community relationships characterized by trust and reciprocity (Kawachi & Kennedy, 1997; Lochner et al., 2001, 2003). It is important to emphasize again that social capital is a term used to characterize populations and communities rather than individuals. Research indicates that communities (both at the level of the state and the neighborhood) characterized by high social capital have lower rates of mortality than communities with lower levels of social capital, following adjustment for indi-

vidual and population characteristics (Kawachi et al., 1997; Lochner et al., 2003). To my knowledge, the relationship between social capital and mortality has not been examined by age or length of residence in the area.

LIVING ARRANGEMENTS, SOCIAL NETWORKS, AND SOCIAL SUPPORT

One of the most persistent findings in social epidemiology is the association between social contacts and health outcomes (Berkman and Kawachi, 2000). In general, those people with regular contacts with friends and relatives and those who reported regular sources of social support have the best health outcomes. In fact, one of the earliest studies in this area demonstrated that residents of Alameda County, California, with the most developed social network index (a composite measure of personal and group relationships) in 1965 had the lowest age-adjusted mortality rate in 1974, following adjustment for baseline health status and health behaviors (Berkman & Syme, 1979). In a subsequent examination of the Alameda County cohort, this relationship was also found for seniors (Seeman et al., 1987). In addition to confirming the association between a general social network index and subsequent 17-year mortality among residents aged 70 years and older, research indicated that the strength of the association varied among specific measures of social networks and mortality by age. Specifically, the relationship between marital status and mortality was strongest for those less than 60 years of age at baseline. In contrast, the relationship between ties with close friends and relatives and mortality was most pronounced for those over the age of 60. In a subsequent study of social ties and mortality based on data from three geographic areas of the NIA EPESE, the strength of the association was affected by the geographic area and by gender (Seeman et al., 1993). The age-adjusted analysis revealed that those with the least developed social network were at elevated risk of death between 1982 and 1987 for both men and women (relative hazard ranged from 1.97 to 3.06 across the three areas). After adjustment for measures of health, functioning, and health practices, social ties was associated with subsequent mortality only in New Haven, Connecticut, and among men in Iowa. No significant association was demonstrated for men and women in East Boston. The results suggest that the relationship between social ties and mortality may operate through other factors, in particular situations, and for certain

groups of people. The variation in results across the different geographic areas also underscores yet again that compositional and contextual characteristics of place may help to account for differences in health outcomes.

In a separate study based on data from the New Haven component of the NIA EPESE, social and productive activities, even those that do not involve physical activity, are associated with survival over a 13-year period (Glass et al., 1999). Those elderly who engaged in those activities had better survival than those who did not, following adjustment for a variety of factors including age, gender, race/ethnicity, marital status, income, body mass index, smoking, functional disability, and history of cancer, diabetes, stroke, and myocardial infarction.

Particular types of social relationships seem to be especially important. For example, there is a growing body of evidence that older people who engage in religious activities and belong to religious organizations have lower rates of mortality and higher survival rates than those who do not (Omran and Reed, 1998; Helm, Hays, Flint, Koenig, & Blazer, 2000). It has been hypothesized that religious affiliation is important for at least two reasons. First, as with membership in other organizations, it provides fellowship with others and potential sources of social support. Second, participation in this organization may provide meaning and "a sense of coherence," to use Aaron Antonovsky's (1979, p. 123) term, to cope with the issues of everyday life as well as more profound existential issues.

Marital status has been shown to be associated with health outcomes (Mendes de Leon, Kasl, & Jacobs, 1993). In general, those who are married are in better health than those who are not, especially among those who are divorced and separated. The health of those who are never married seems to depend on gender as well as their contacts with friends and relatives. As we shall see, those who have lost a spouse are at elevated risk of death, but this is associated with the timing and circumstances of the loss and gender of the surviving spouse.

Results from the National Longitudinal Mortality Study indicate that divorced and separated men had a higher mortality rate, especially for deaths due to suicide, than those who were married (Kposowa, 2000). Being single or widowed had no significant defect on suicide risk. As is true of other findings, the relationship between marital status and the risk of death was reduced among older people (Johnson, Backlund, Sorlie, & Loveless, 2000).

The loss of a spouse to death is also associated with a subsequent risk of death among the surviving spouse. A critical review of this literature was conducted by the Osterweis, Solomon, & Green (1984). It was determined that there was a relationship between a loss of a spouse and a subsequent risk of death, especially among middle-aged men. In addition, the risk of death was most pronounced with the first year following the loss of the spouse. Subsequent studies have continued to identify this relationship. For example, in a study of 12,522 spouse pairs belonging to a prepaid health care plan in northern California, it was determined that there was an elevated risk of death among the surviving spouse, most notably within the first seven months, but continuing for as long as two years (Schaefer, Quesenberry, & Wi, 1995). Among surviving women, the risk was 1.9 between 7–12 months following the death of the spouse. Among surviving men, the risk was associated with the level of preexisting health conditions. The risk for men with no preexisting health conditions was 2.12, and for those with preexisting conditions, it was only 1.5. It is unknown whether the timing and circumstances of the spouse's death affected the subsequent risk of death. This is an intriguing issue, as there is research indicating that stressful caregiving can have a negative effect on the health of the caregiving spouse. Another important issue is homicide and elder abuse (Schiamberg and Gans, 2000). Some commentators have speculated that stressful caregiving may be one of the factors that contribute to abuse, and in some cases, elder homicide (Schiamberg and Gans, 2000).

HEALTH BEHAVIORS

It is well known that specific types of behavior are associated with subsequent risk of death. In general, this is evident across the life course, but it is less pronounced among those aged 65 and older.

Tobacco Exposure

A history of cigarette smoking is associated with the risk of death from all of the leading causes of death, including coronary heart disease, stroke, chronic obstructive lung disease, and a number of different forms of cancer, such as cancers of the lung and bronchus, head and neck, stomach, and esophagus, as well as infections (Arcavi & Benowitz, 2004; Burns,

2000; Rivara, Ebel, Garrison, Christakis, Wiehe, & Levy, 2004). The quantity of tobacco consumed and length of time one has smoked are associated with the subsequent risk of death. As Burns (2000, p. 357) writes, "Disease consequences of smoking occurs disproportionately among the elderly because of long duration of cumulative injury or change that underlies the bulk of tobacco-caused disease." There is also evidence that older smokers are more likely than younger smokers to develop lung cancer, a cancer with a relatively long latency. On the other hand, younger smokers are at elevated risk for the development of cardiovascular disease.

Alcohol Consumption

Heavy and sustained consumption of alcohol is associated with an elevated risk of death (Camacho, Kaplan, & Cohen, 1987). Unlike tobacco exposure, there is evidence that moderate consumption of alcohol may be associated with reduced risk of coronary heart disease. Heavy consumption, however, is associated with an elevated risk of death associated with conditions such as cancer of the head and neck, liver cancer, cirrhosis, suicide, and deaths due to accidents and injuries. An elevated risk of death is also associated with alcohol consumption, even moderate consumption, in combination with multiple medications and comorbidites (Reid et al., 2002).

Physical Activity

There is considerable research indicating that older people who engage in physical activity have a reduced risk of death. In contrast, those who are sedentary are at elevated risk for many of the leading causes of death, including coronary heart disease, stroke, and specific forms of cancer, most notably colorectal cancer (Rakowski & Mor, 1992; Rosengren & Wilhelmsen, 1997). A reduction of risk is noted for people who engage in a variety of forms of physical activity, both weight-bearing exercise as well as aerobic forms of activity. The reasons for this reduction of risk include increased lung capacity, increased lean muscle mass, and increase in antioxidant activity.

Diet and Nutrition

Research also indicates that diet and nutrition are associated with a reduction in the risk of premature mortality (Pirlich and Lochs, 2001; Meyyazhagan and Palmer, 2002). Although there is considerable debate

about the types of foods that should be consumed, there is general consensus that moderate consumption of food is healthful. In terms of specific foods, there is general agreement that a low-fat diet coupled with consumption of fruits and vegetables are associated with reduced risk of premature death. Ironically, the twin problems facing older populations that are associated with diet and nutrition are obesity on the one hand and undernutrition on the other. Obesity is associated with increased intake of food, coupled with sedentary activity. Undernutrition is associated with inadequate consumption of nutritious foods, a condition that many researchers consider to be the primary source of nutrition-related mortality in older populations. This may be associated with poor oral health, reduction in sense of smell and olfaction, as well as comorbid conditions of cognitive dysfunction and depression.

SENSE OF CONTROL, COHERENCE, AND SELF-EFFICACY

There is evidence that particular types of psychosocial factors, such as self-efficacy and a sense of control, are associated with vital status. Those people who lack control and a sense of confidence do not do as well as those who have those characteristics. One of the earliest studies to examine this issue, and in many ways still the most profound and the most compelling, was an intervention study to investigate the health effects of providing seniors with responsibility. Seniors in a nursing home were randomly assigned to two groups. Members of one group were given a potted plant and told that they were responsible for its care and well-being. Members of the second group also were given a plant but told that members of the staff would be responsible for its care. After 18 months, there was a mortality difference between the two groups. Those who were told that members of the staff would care for their plants had a higher mortality rate than those who were told that they were responsible. While some commentators have since criticized the study's small sample size and other elements of its design and interpretation, the results were quite startling and stimulated other researchers to examine the issue of control in more detail. As indicated in Chapter 2, Leonard Syme (1998) and Aaron Antonovsky (1979) contributed significantly to this area of research. Both Syme and Antonovsky argue that this concept (either a sense of control or a sense of coherence) help to explain the connection between many of the social and behavioral factors and health out-

comes, not the least of which, is survival and mortality. Also, as noted previously, Albert Bandura (1997) introduced the concept of self-efficacy, which describes a person's level of confidence in being able to complete a particular task. In keeping with Syme's and Antonovsky's observations, Bandura argued that the successful completion of a task depends in large part in one's confidence that it can be done. As we will see in subsequent chapters, in particular, Chapter 11, self-efficacy is a core concept in public health and epidemiology and the basis of a new generation of public health interventions for populations in general as well as interventions that are focused on the elderly. A sense of control, a sense of coherence, and self-efficacy all seem to be pointing to an underlying factor that includes a sense of competence, confidence, well-being, and optimism about the future (Penninx, van Tilbrug, Kriesgsman, Deeg, Boeke, & van Eijk, 1997). This underlying factor was captured well and seems to be summarized best by Edith Wharton (1923, p. vii) in her autobiographical work, *A Backward Glance:*

> In spite of illness, in spite of the arch-enemy sorrow, one can remain alive long past the usual date of disintegration if one is unafraid of change, insatiable in intellectual curiosity, interested in big things, and happy in small ways.

DISEASE AND COMORBIDITIES

As we saw earlier, disease and comorbidities are central to a consideration of survival and mortality. Indeed, the causes of death, as reflected on the death certificate and mortality statistics, are not defined in terms of social and behavioral factors, even though they figure in the causal pathways, but rather in terms of disease categories. As shown in later chapters, some conditions have a higher case-fatality rate than others. Leading conditions include coronary heart disease, stroke, chronic obstructive lung disease, diabetes, and, of course, the various forms of cancer, most notably, cancers of the lung and bronchus, colon and rectum, female breast, and prostate. The number and types of conditions a person may have is also strongly associated with survival and mortality (Feinstein, 1975). As noted earlier, a set of concurrent health conditions or comorbidity is especially common in older populations. In addition to specific categorical disease conditions, there is also evidence that very simple, general measures of health have prognostic significance (Idler, 1992; Idler & Benyamini, 1997). Respondents are usually asked to provide an overall assessment of their health:

"How would you classify your overall health—excellent, good, fair, or poor?" or "Compared to other (men or women) your age, would you say that your health is better than most, same as most, or worst than most?" A recent prospective study based on data from the NHANES I epidemiologic follow-up study, which used a representative sample of US adults aged 25–74, indicated that self-reported health predicted subsequent mortality for men, but less so for women (Idler et al., 2000). The researchers (2000, p. 874) conclude that "Self-rated health contributes unique information to epidemiologic studies that is not captured by standard clinical assessments or self-reported histories." It may be that self-rated, overall assessments of health may be based not only on the number and types of conditions a person may have, but also that person's assessment of the impact of those conditions in his or her everyday life. This leads to a consideration of other factors that have been shown to have an independent effect on survival and mortality, and also may help to explain the mechanisms of the association between health status and the risk of death.

FALLS AND INJURIES

Falls and automobile crashes represent the two leading causes of accidental death among people aged 65 and older. Although concepts and measurement of falls, injury, and automobile crashes will be addressed in more detail in Chapter 8, it is important to realize that fatalities are due to important factors. First, there is the force of the trauma itself, i.e., the circumstances of the fall or the crash. Second, there is the vulnerability of the person, i.e., the extent to which a person can withstand the trauma. Of course, falls and automobile crashes can result directly in loss of life. In addition, falls and crashes can render older people functionally limited or disabled, which in turn can initiate a chain of events that will lead to death. Finally, a fall or injury can lead to fear of a subsequent fall or injury. This fear can lead to sedentary behavior, which, in turn, can elevate the risk for a subsequent fall, injury, serious injury, or, over time, death. Lawrence Rubenstein and colleagues (2003, p. 11) summarize the research on fall-related mortality as follows:

> Accidents are the fifth leading cause of death in older adults (after cardiovascular, cancer, stroke, and pulmonary causes), and falls constitute two thirds of these accidental deaths. About three fourths of deaths due to falls in the United States occur in the 13% of the population aged 65

and older (Hogue, 1982; Rubenstein, 2002). Fall-related mortality increases dramatically with advancing age, especially in populations over age 70 years, and nursing home residents 85 years and older account for one out of five fatal falls (Baker & Harvey, 1985). The estimated 1% of fallers who sustain a hip fracture have a 20% to 30% mortality rate within one year of the fracture (Magaziner, 1990).

PHYSICAL FUNCTIONING

Physical functioning refers to the relative ease in the performance of tasks that are necessary for adaptation to everyday life. The tasks may range from generic tasks, such as lifting and balance, to more complicated, everyday tasks, such as driving a car and engaging in voluntary or occupational tasks. In addition to being an important outcome associated with quality of life, research indicates that level of physical functioning is associated with subsequent survival and mortality. For example, a battery of self-reported assessments of function and direct measures of physical performance were administered to subjects (Reuben et al., 1992). At follow-up (average 22 months), each of the four measures was shown to be independently associated with either death or nursing home placement. In a subsequent study by the same research group, a set of functional measures predicted subsequent survival over a 4-year period, following adjustment for a variety of demographic, health, and social measures (Reuben et al., 1992). There is also evidence that direct measures of performance and computation are associated with survival (Williams, Gaylord, & Gerritty, 1994). The timed manual performance requires the participant to unlock, open, and close latches on a series of small doors. Those who required less time to perform the task, a task requiring the integration of a variety of tasks including cognition, vision, and manual dexterity, had lower mortality than those who required more time.

COGNITIVE FUNCTIONING

Cognitive function refers to a variety of different mental tasks that include short- and long-term memory, computation, orientation, and executive processing. Research indicates that cognitive functioning, like physical functioning, is independently associated with survival and mortality in older populations. For example, the longitudinal studies con-

ducted by Reuben and colleagues (1992, 1994) that were noted previously, included the Folstein Mini-Mental State Examination, a standard summary test of general cognitive functioning, as one of the tests independently associated with mortality. Research based on the Longitudinal Aging Study, Amsterdam (LASA), a study of 2380 residents of Amsterdam aged 55–85 years, indicated that five areas of cognitive functioning (general cognitive functioning, information processing speed, fluid intelligence, learning, and proportion retained) were associated with subsequent mortality, after adjustment of age, gender, education, and depressive symptoms (Smits, Deeg, Kriegsman, & Schmand, 1999). Even after adjustment for self-rated health, medication use, physical performance, functional limitations, lung function, specific chronic diseases, information-processing speed, fluid intelligence, learning and proportion retained were still independent predictors of mortality.

DEPRESSION

Depressive symptoms and cognitive functioning often are both present and, in fact, interact among older people (Ostier, Markides, Black, & Goodwin, 2000; Black & Markides, 1999). There is evidence as well that people with depressive symptoms are at elevated risk of death. In fact, depression is considered to be one of the leading comorbid conditions for older people diagnosed with other conditions. Put differently, no matter what combination of diagnosed health conditions an older person may have, the addition of depressive symptoms makes it worse. It is fair to ask what is it about depression that elevates the risk of death. Should we think of depression as a separate condition or should it be thought of as part of the sequelae of one or more other conditions? As is true of both physical and cognitive functioning, does depression affect the immune system directly or does it operate through other pathways, adversely affecting proper health behaviors or relationships with others? Blazer and colleagues (2001) addressed this question in a recent study. In this study, a cohort of elderly subjects was followed for three years. The results indicated that as a variety of social, behavioral, health, and functional variables were systematically introduced into the model, the risk of death associated with depression declined from nearly a two-fold elevation in risk (1.98) to less than a 25% increase (1.21). The researchers conclude (2001, p. M505) that "Unlike other known risk factors for mortality in

the elderly population, depression appears to be associated with mortality through a number of independent mechanisms, perhaps through complex feedback loops of known risk factors."

PHYSIOLOGICAL MECHANISMS

Following Blazer's and his colleagues' observation about the prognostic significance of depression, the ecological model suggests that multiple pathways, integrating biologic, behavioral, social, and environmental factors are associated with patterns of longevity in older populations. Given the range of possible paths, it is fair to say that different biological factors may come into play. These factors may range from affecting the cardiovascular and/or immune systems, to affecting not only the risk of the death, but the specific cause of death. A variety of studies have been conducted to examine biological factors, including body mass index, lean and fat body mass, muscle mass, and changes in weight. Clearly, the specific health outcome and the specific cause of death will determine the specific causal hypotheses. Following John Cassel's (1976) recommendation, it is useful to consider the combination of factors that affect overall host susceptibility. According to Leonard Syme and Claudine Torfs (1987), there are two important questions: Why do some people become ill, while others do not? And, of those who become ill, why do some people develop one health condition, while others develop another? With regard to the first question, it may be possible to identify a set of factors that may be common across a variety of situations and conditions. Why are some people and some populations more likely than others to become ill? As we explained in the previous chapter, it is that question that makes the concept of allostasis and allostatic load so important. To recall that discussion, allostasis is defined as a summary measure of a range of regulatory systems pertinent to disease risks (Seeman et al., 2001). Allostatic load, a summary measure of impaired physiological response or adaptation to cumulative stress, is measured by the dysregulation of those systems. In a prospective study of 1189 men and women aged 70–79, enrolled in the MacArthur Successful Aging Study, those with higher measures of allostatic load were at an elevated risk of death (Odds ratio = 1.23) following adjustment for age, gender, ethnicity, education, income, and baseline health conditions.

CONCLUSION

We began this chapter with the observation that in the epidemiology of aging, as in life, all roads lead to survival and mortality. We have attempted to illustrate, as noted previously, that there are a variety of biologic, behavioral, social, and environmental factors associated with vital status and survival. It should be clear at this point that we do not consider these factors to be independent and disparate. We have proposed the ecological model as a template to describe and explain multiple pathways. In the subsequent chapters, we will, in effect, move back from vital status along the multiple paths to better characterize the backdrop that is the epidemiology of aging, functioning, and longevity.

REFERENCES

Antonovsky, A. (1979). *Health, stress, and coping.* San Francisco: Jossey-Bass.

Arcavi, L., & Benowitz, N. (2004). Cigarette smoking and infection. *Archives of Internal Medicine, 164*(20), 2206–2016.

Austin, J.P., & Convery, K. (1993). Age-race interaction in prostatic adenocracinoma treated with external beam irradiation. *American Journal of Clinical Oncology, 16*(2), 140–145.

Baker, S.P., & Harvey, A.H. (1985). Fall injuries in the elderly. *Clinics in Geriatric Medicine, 1*(3), 501–512.

Bandura, A. (1997). *Self-efficacy: The exercise of control.* New York: W.H. Freeman.

Bassuk, S.S., Berkman, L.F., Amick, B.C., III. (2002). Socioeconomic status and mortality among the elderly: Findings from four U.S. communities. *American Journal of Epidemiology, 155*(6), 520–533.

Berkman, L., Singer, B., Manton, K. (1989). Black/white differences in health status and mortality among the elderly. *Demography, 26*(4), 661–678.

Berkman, L.F., & Syme, S.L. (1979). Social networks, host resistance, and mortality: A nine-year follow-up study of Alameda County residents. *American Journal of Epidemiology, 109*(2), 186–204.

Berkman, L., & Kawachi, I. (2000). *Social Epidemiology.* New York: Oxford University Press.

Berrigan, D., Dodd, K., Troiano, R.P., Krebs-Smith, S.M., Barbash, R.B. (2003). Patterns of health behavior in U.S. adults. *Preventive Medicine, 36*(5), 615–623.

Black, S.A., & Markides, K.S. (1999). Depressive symptoms and mortality in older Mexican Americans. *Annals of Epidemiology, 9*(1), 45–52.

Blazer, D.G., Hybels, C.F., & Pieper, C.F. (2001). The association of depression and mortality in elderly persons: A case for multiple, independent pathways. *Journals of Gerontology: Medical Sciences, 56*(8), M505–M509.

Bosworth, H.B., Schaie, K.W., & Willis, S.L. (1999). Cognitive and sociodemographic risk factors for mortality in the Seattle Longitudinal Study. *Journals of Gerontology: Psychological Sciences, 54*(5), P273–P282.

Breeze, E., Sloggett, A., Fletcher, A. (1999). Socioeconomic and demographic predictors of mortality and institutional residence among middle aged and older people: Results from the Longitudinal Study. *Journal of Epidemiology and Community Health, 53*(12), 765–774.

Burns, D.M. (2000). Cigarette smoking among the elderly: Disease consequences and the benefits of cessation. *American Journal of Health Promotion, 14*(6), 357–361.

Camacho, T.E., Kaplan, G.A., & Cohen, R.D. (1987). Alcohol consumption and mortality in Alameda County. *Journal of Chronic Diseases, 40*(3), 229–236.

Cassel, J. (1976). The contribution of the social environment to host resistance. *American Journal of Epidemiology, 104*(2), 107–123.

Coleman, J. (1988). Social capital in the creation of human capital. *American Journal of Sociology, 94*(Suppl.), S95–S120.

Committee on Chemical Toxicity and Aging, National Research Council (1987). *Aging in Today's Environment.* Washington, DC: National Academies Press.

Cook, N.R., Evans, D.A., Scherr, P.A., Speizer, F.E., Taylor, J.O., Hennedkens, C.H. (1991). Peak expiratory flow rate and 5-year mortality in an elderly population. *American Journal of Epidemiology, 133*(8), 784–794.

Cornoni-Huntley, J., Brock, D.B., Ostfeld, A.M., Taylor, J.O., & Wallace, R.B. (Eds.) (1986). *Established Populations for Epidemiologic Studies of the Elderly.* Washington, DC: National Institutes of Health (NIH Publication No. 86-2443).

Corti, M.C., Guralnik, J.M., Ferrucci, L., Izmirlian, G., Leveille, S.G., Pahor, M., et al. (1999). Evidence for a black-white crossover in all-cause and coronary heart disease mortality in an older population: The North Carolina EPESE. *American Journal of Public Health, 89*(3), 308–314.

Davis, M.A., Mortz, D.J., Neuhaus, J.M., Barclay, J.D., Gee, L. (1997). Living arrangements, changes in living arrangements, and survival among community dwelling older adults. *American Journal of Public Health, 87*(3), 333–334.

Davis, M.A., Neuhaus, J.M., Moritz, D.J., Segal, M.R. (1992). Living arrangements and survival among middle-aged and older adults: The NHANES I epidemiologic follow-up study. *American Journal of Public Health, 82*(3), 401–406.

Dowd J., & Bengston, V. (1978). Aging in minority populations: An examination of the double jeopardy hypothesis. *Journal of Gerontology, 33*(3), 427–436.

Elo, I.T., & Preston, S.H. (1996). Educational differentials in mortality: United States, 1979-1985. *Social Science & Medicine, 42*(1), 47–57.

Federal Interagency Forum on Aging Related Statistics (2005). *Older Americans 2004: Key Indicators of Well-Being.* www.agingstats.gov/chartbook2004/healthstatus.html (Accessed, February 5, 2005).

Feinstein, A.R. (1970). The pre-therapeutic classification of co-morbidity in chronic disease. *Journal of Chronic Diseases, 23,* 455–469.

Ferraro, K.F., & Farmer, M.M. (1996). Double jeopardy, aging as leveler, or persistent health inequality? A longitudinal analysis of white and black Americans. *Journals of Geronotology: Social Sciences, 51*(6), S319–S328.

Glass, T.A., Mendes de Leon, C., Marottoli, R.A., & Berkman, L.F. (1999). Population-based study of social and productive activities as predictors of survival among elderly Americans. *British Medical Journal, 319,* 478–483.

Haan, M., Kaplan, G.A., & Camacho, T. (1987). Poverty and health: Prospective evidence form the Alameda County Study. *American Journal of Epidemiology, 125*(6), 989–998.

Hayward, M.D., Pienta, A.M., McLaughlin, D.K. (1997). Inequality in men's morality: The socioeconomic status gradient and geographic context. *Journal of Health and Social Behavior, 38*(4), 313–330.

Hazzard, W.R. (1986). Biological basis of the sex differential in longevity. *Journal of the American Geriatrics Society, 34*(6), 455–471.

Hazzard, W.R. (1989). Why do women live longer than men? Biologic differences that influence longevity. *Postgraduate Medicine, 85*(5), 271–278.

Helm, H.M., Hays, J.C., Flint, E.P., Koenig, H.G., & Blazer, D.G. (2000). Does private religious activity prolong survival? A six-year follow-up study of 3,851 older adults. *Journals of Gerontology: Medical Sciences, 55*(7), M400–M405.

Hill, M.E., Preston, S.H., & Rosenwaike, I. (2000). Age reporting among white Americans aged 85+: Results of a record linkage study. *Demography, 37*(2), 175–186.

Hogue, C. (1982). Injury in late life: Part I. Epidemiology. *Journal of the American Geriatrics Society, 30*(3), 183–190.

House, J.S., Kessler, R.C., & Herzog, A.R. (1990). Age, socioeconomic status, and health. *Milbank Quarterly, 68*(3), 383–411.

Hummer, R.A., Benjamins, M.R., & Rogers, R.G. (2004). Racial and ethnic disparities in health and mortality among the U.S. elderly population. In N.B. Anderson, R.A. Bulatao, & B. Cohen (Eds.). *Critical perspectives on racial and ethnic differences in health in late life* (pp. 53–94). Washington, DC: National Academies Press: 53–94.

Idler, E.L. (1992). Self-assessed health and mortality: A review of studies. In S. Maes, H. Leventhal, & M. Johnston (Eds.). *International Review of Health Psychology, 1,* 33–56.

Idler, E.L., & Benyamini, Y. (1997). Self-rated health and mortality: A review of twenty-seven community studies. *Journal of Health and Social Behavior, 38*(1), 21–37.

Idler, E.L., Russell, L.B., & Davis, D. (2000). Survival, functional limitations, and self-rated health in the NHANES I Epidemiologic Follow-up Study, 1992. First National Health and Nutrition Examination Survey. *American Journal of Epidemiology, 152*(9), 874–883.

International Longevity Institute (2004). *Promoting men's health: Addressing barriers to healthy lifestyle and preventive health care.* New York: International Longevity Institute.

Johnson, N.J., Backlund, E., Sorlie, P.D., Loveless, C.A. (2000). Marital status and mortality: The National Longitudinal Mortality Study. *Annals of Epidemiology, 10*(4), 224–238.

Kaplan, G.A., Seeman, T.E., Cohen, R.D., Knudsen, L.P., & Guralnik, J. (1987). Mortality among the elderly in the Alameda County Study: Behavioral and demographic risk factors. *American Journal of Public Health, 77*(3), 307–312.

Karter, A.J., Gazzaniga, J.M., Cohen, R.D., Casper, M.L., Davis, B.D., & Kaplan, G.A. (1998). Ischemic heart disease and stroke mortality in African-American, Hispanic, and non-Hispanic white men and women, 1985 to 1991. *Western Journal of Medicine, 169*(3), 139–145.

Kawachi, I., Kennedy, B.P., Lochner, K., Prothrow-Stith, D. (1997). Social capital, income inequality, and mortality. *American Journal of Public Health, 87*(9), 1491–1498.

Keil, J.E., Sutherland, S.E., Hames, C.G., Lackland, D.T., Gazes, P.C., Knapp, R.G., et al. (1995). *Archives of Internal Medicine, 155*(14), 1521–1527.

Keil, J.E., Sutherland, S.E., Knapp, R.G., Lackland, D.T., Gazes, P.C., Tyroler, H.A. (1993). Mortality rates and risk factors for coronary disease in black as compared with white men and women. *The New England Journal of Medicine, 329*(2), 73–78.

Kilbourne, E.M., Choi, K., Jones, T.S., Thacker, S.B. (1982). Risk factors for heatstroke: A case-control study. *Journal of the American Medical Association, 247*(24), 3332–3336.

Klinenberg, E. (2002). *Heat wave: A social autopsy of disaster in Chicago.* Chicago, IL: University of Chicago Press.

Kposowa, A.J. (2000). Martial status and suicide in the National Longitudinal Mortality Study. *Journal of Epidemiology and Community Health, 54*(4), 254–261.

Langer, E.J., & Rodin, J. (1976). The effects of choice and enhanced personal responsibility for the aged. *Journal of Personality and Social Psychology, 34,* 191–198.

Lobmayer, P., & Wilkinson, R.G. (2002). Inequality, residential segregation by income, and mortality in U.S. cities. *Journal of Epidemiology & Community Health, 56*(3), 165–166.

Lochner, I.K., Pamuk, E., Makuc, D., Kennedy, B.P., Kawachi, I. (2001). State-level income inequality and individual mortality risk: A prospective multilevel study. *American Journal of Public Health, 91*(3), 385–391.

Lochner, K.A., Kawachi, I., Brennan, R.T., Buka, S.L. (2003). Social capital and neighborhood mortality rates in Chicago. *Social Science & Medicine, 56*(8), 1797–1805.

Manton, K.G., Wrigley, J.M., Cohen, H.J., & Woodburgy, M.A. (1991). Cancer mortality, aging, and patterns of comorbidity in the United States: 1968 to 1986. *Journal of Gerontology, 46*(4), S225–S234.

Marshall, S.W., Runyan, C.W., Bangdiwala, S.I., Linzer, M.A., Sacks, J.J., & Butss, J.D. (1998). Fatal residential fires: Who dies and who survives? *Journal of the American Medical Association, 279*(20), 1633–1637.

Mendes de Leon, C.F., Kasl, S.V., Jacobs, S. (1993). Widowhood and mortality risk in a community sample of the elderly: A prospective study. *Journal of Clinical Epidemiology, 46*(6), 519–527.

Meyyazhagan, S., & Palmer, R.M. (2002). Nutritional requirements with aging: Prevention of disease. *Clinics in Geriatric Medicine, 18*(3), 557–576.

Newman, A.B., & Brach, J.S. (2001). Gender gap in longevity and disability in older persons. *Epidemiologic Reviews, 23*(2), 343–350.

Ny-Mak, D.S., Dohrenwend, B.P., Abraido-Lanza, A.F., & Turner, J.B. (1999). A further analysis of race differences in the National Longitudinal Mortality Study. *American Journal of Public Health, 89*(11), 1748–1751.

Nuland, S.B. (1993). *How We Die: Reflections on Life's Final Chapter.* New York, New York: Vintage Books.

Omran, D., & Reed, D. (1998). Religion and mortality among the community-dwelling elderly. *American Journal of Public Health, 88*(10), 1469–1475.

Osterweis, M., Soloman, F., & Green, M. (Eds.). *Bereavement: Reactions, Consequences, and Care.* Washington, DC: National Academies Press.

Ostier, G.V., Markides, K.S., Black, S.A., Goodwin, J.S. (2000). Emotional well-being predicts subsequent functional independence and survival. *Journal of the American Geriatrics Society, 48*(5), 473–478.

Penninx, B.W., van Tilbrug, T., Kriesgsman, D.M., Deeg, D.J., Boeke, A.J., & van Eijk, J.T. (1997). Effects of social support and personal coping resources on mortality in older age: The Longitudinal Aging Study, Amsterdam. *American Journal of Epidemiology, 146*(6), 510–519.

Pirlich, M., & Lochs, H. (2001). Nutrition in the elderly. *Best Practice & Research Clinical Gastroenterology, 15*(6), 869–884.

Preston, S.H., & Elo, I.T. (1995). Are educational differentials in adult mortality increasing in the United States? *Journal of Aging and Health, 7*(4), 476–46.

Putnam, R.D. (2000). *Bowling Alone: The Collapse and Revival of American Community.* New York, New York: Simon & Schuster Publishers.

Rakowski, W., & Mor, V. (1992). The association of physical activity with mortality among adults in the Longitudinal Study of Aging Study (1984–1988). *Journals of Gerontology: Medical Sciences, 47,* M122–M129.

Reid, M.E., Boutros, N.N., O'Connor, P.G., Cararіu, A., & Concato, J. (2002). The health-related effects of alcohol use in older persons: A systematic review. *Substance Abuse, 23*(3), 149–164.

Reuben, D.B., Siu, A.L., Kimpau, S. (1992). The predictive validity of self-report and performance-based measures of function and health. *Journal of Gerontology, 47*(4), M106–M110.

Rivara, F.P., Ebel, B.E., Garrison, M.M., Christakis, D.A. Wiehe, S.E., & Levy, D.T. (2004). Prevention of smoking-related deaths in the United States. *American Journal of Preventive Medicine, 27*(2), 118–125.

Rosengren, A., & Wilhelmsen, L. (1997). Physical activity protects against coronary death and deaths from all causes in middle-aged men: Evidence from a 20-year follow-up of the primary prevention study in Goteberg. *Annals of Epidemiology, 7*(1), 69–75.

Rubenstein, L.

Russell, A., Langlois, T., Johnson, G., Trentham-Dietz, A., Remington, P. (1999). Increasing gap in breast cancer mortality between black and white women. *Western Journal of Medicine, 98*(4), 47–49.

Sampson, R.J., Raudenbush, S.W., Earls, F. (1997). Neighborhoods and violent crime: A multilevel study of collective efficacy. *Science, 277*(5328), 918–924.

Satariano, W.A., Ragland, K.E., & Van Den Eeden, S.K. (1998a). Cause of death in men diagnosed with prostate carcinoma. *Cancer, 83*(6), 1180–1188.

Satariano, W.A., & Ragland, D.R. (1994). The effect of comorbidity on 3-year survival of women with primary breast cancer. *Annals of Internal Medicine, 120,* 104–110.

Satariano, W.A., Smith, J., Swanson, A., & Tager, I.B. (1998b). A census-based design for the recruitment of a community sample of older adults: Efficacy and costs. *Annals of Epidemiology, 8*(4), 278–282.

Schaefer, C., Quesenberry, C.P., Jr., Wi, S. (1995). Mortality following conjugal bereavement and the effects of a shared environment. *American Journal of Epidemiology, 141*(12), 1142–1152.

Schiamberg, L.B., & Gans, D. (2000). Elder abuse by adult children: An applied ecological framework for understanding contextual risk factors and the intergenerational characteristics of quality of life. *International Journal of Aging and Human Development, 50*(4), 329–359.

Schoenfeld, D.E., Malmrose, L.C., Blazer, D.G., Gold, D.T., Seeman, T.E. (1994). Self-rated health and mortality in the high-functioning elderly—a closer look at healthy individuals: MacArthur Field Study of Successful Aging. *Journal of Gerontology: Medical Sciences, 49*(3), M109–M115.

Seeman, T.E., Guralnik, J.M., Kaplan, G.A., Knudson, L., Cohen, R. (1989). The health consequences of multiple morbidity in the elderly: The Alameda County study. *Journal of Aging & Health, 1*(1), 50–66.

Seeman, T.E., Kaplan G.A., Knudsen, L., Cohen, R., Guralnik, J. (1987). Social network ties and mortality among the elderly in the Alameda County study. *American Journal of Epidemiology, 126*(4), 714–723.

Seeman, T.E., Berkman, L.F., Kohout, F., LaCroix, A., Glynn, R., & Blazer, D. (1993). Intercommunity variations in the association between social ties and

mortality in the elderly: A comparative analysis of three communities. *Annals of Epidemiology, 3*(4), 448–450.

Seeman, T.E., Singer, B., Rowe, J.W., & McEwen, B.S. (2001). Exploring a new concept of cumulative biological risk—allostatic load and its health consequences: MacArthur studies of successful aging. *Proceedings of the Naitonal Academy of Sciences of the United States of America, 98*(8), 4770–4775.

Simon, M.S., & Severson, R.K. (1997). Racial differences in breast cancer survival: The interaction of socioeconomic status and tumor biology. *American Journal Obstetrics & Gynecology, 176*(6), S233–S239.

Smith, M.H., Anderson, R.T., Bradham, D.D., Longino, C.F., Jr. (1995). Rural and urban differences in mortality among Americans 55 years and older: Analysis of the National Longitudinal Mortality Study. *Journal of Rural Health, 11*(4), 274–285.

Smits, C.H., Deeg, D.J., Kriegsman, D.M., & Schmand, B. (1999). Cognitive functioning and health as determinants of mortality in an older population. *American Journal of Epidemiology, 150*(9), 978–986.

Smoyer, K.E. (1998). A comparative analysis of heat waves and associated mortality in St. Louis, Missouri—1980 and 1995. *International Journal of Biometerology, 42*(1), 44–50.

Sorlie, P.D., Baclund, E., Keller, J.B. (1995). U.S. mortality by economic, demographic, and social characteristics: The National Longitudinal Mortality Study. *American Journal of Public health, 85*(7), 903–905.

Syme, S.L. (1998). Social and economic disparities in health: Thoughts about intervention. *The Milbank Quarterly, 76*(3), 493–505.

Syme, S.L., & Torfs, C. (1987). Epidemiologic research in hypertension: A critical appraisal. *Journal of Human Stress, 4*(1), 43–48.

Tager, I.B., Haight, T.J., Hollenberg, M., & Satariano, W.A. (2003). Physical functioning and mortality in older women: Assessment of energy costs and level of difficulty. *Journal of Clinical Epidemiology, 56*(8), 807–813.

Takano, T., Nakamura, K., Watanabe, M. (2002). Urban residential environments and senior citizens' longevity in megacity areas: The importance of walkable green spaces. *Journal of Epidemiology and Community Health, 56*(12), 913–918.

Tucker, J.S., Friedman, H.S., Wingard, D.L., & Schwartz, J.E. (1996). Marital history at midlife as a predictor of longevity: Alternative explanations to the protective effect of marriage. *Health Psychology, 15*(2), 94–101.

West, D.W., Satariano, W.A., Ragland, D.R., & Hiatt, R.A. (1996). Comorbidity and breast cancer survival: A comparison between black and white women [Special issue]. *Annals of Epidemiology, 6,* 413–419.

Wharton, E. (1923). *A Backward Glance.* New York: Scribners Publishing.

Williams, M.E., Gaylord, S.A., & Gerritty, M.S. (1994). The time manual performance test as a predictor of hospitalization and death in a community-based elderly population. *Journal of the American Geriatric Society, 42*(1), 21–27.

Wilson, R.S., Bienias, J.L, Mendes de Leon, C.F., Evans, D.A., & Bennett, D.A. (2003). Negative affect and mortality in older persons. *American Journal of Epidemiology, 158*(9), 827–835.

Yancik, R., Havlik, R.J., Wesley, M.N., Ries, L., Long, S., Rossi, W.K., et al. (1996). Cancer and comorbidity in older patients: A descriptive profile. *Annals of Epidemiology, 6*(5), 399–412.