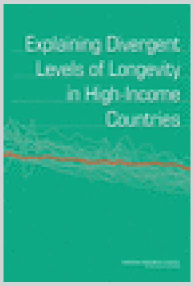

Explaining Divergent Levels of Longevity in High-Income Countries

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Eileen M. Crimmins, Samuel H. Preston, and Barney Cohen, *Editors*

Panel on Understanding Divergent Trends in Longevity in High-Income Countries

Committee on Population

Division of Behavioral and Social Sciences and Education

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PANEL ON UNDERSTANDING DIVERGENT TRENDS IN LONGEVITY IN HIGH-INCOME COUNTRIES

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Acknowledgments

In 2008, at the request of the National Institute on Aging, the Committee on Population of the National Research Council (NRC) established a Panel on Understanding Divergent Trends in Longevity in High-Income Countries to examine trends in life expectancy at older ages, to identify possible lessons about modifiable risk factors, and to discern implications for the future trajectory of mortality at advanced ages. This document represents the final report of the panel and is the collective product of all panel members and staff.

This report would not have been possible without the help of numerous people and organizations. We would especially like to thank the report's sponsor, the National Institute on Aging, and in particular to acknowledge the contributions of Dr. Richard Suzman, director of the Division of Behavioral and Social Research and Dr. John Haaga, deputy director of the Division. The support, encouragement, and intellectual energy that they brought to the panel helped us produce a stronger report.

In addressing its charge, the panel was faced with a large and burgeoning theoretical and empirical literature with contributions from many different fields within the social and health sciences. Consequently, as a first step, the panel decided to commission a set of background papers, each one dealing with a topic relevant to the panel's work. These papers have been published by the National Academies Press in a companion volume titled *International Differences in Mortality at Older Ages: Dimensions and Sources*. These papers served as a valuable resource for the report, and each one was reviewed and debated at length. Members of the panel were heavily involved in the preparation of these papers, and many others contributed as well. The contributors included Dawn Alley, University of Maryland; Mauricio Avendano, Harvard University; Magali Barbieri, Institut National d'Études Démographiques; Carl Boe, University of California, Berkeley; Kaare Christensen, University of Southern Denmark; Michael Davidsen, University of Southern Denmark; Krista Garcia, University of Southern California; Joop Garssen, University of Groningen; Maria Glymour, Harvard University; Jessica Ho, University of Pennsylvania; Knud Juel, University of Copenhagen; Ichiro Kawachi, Harvard University; Jung Ki Kim, University of Southern California; Renske Kok, Erasmus Medical Center; Anton Kunst, University of Amsterdam; Jennifer Lloyd, University of Maryland; France Meslé, Institut National d'Études Démographiques; Laust Mortensen, University of Southern Denmark; Fred Pampel, University of Colorado, Boulder; Roland Rau, University of Rostock; Michelle Shardell, University of Maryland School of Medicine; Andrew Steptoe, University College London; and Anna Wilkman, University College London.

In addition, the panel drew on the expertise of several other experts. As part of this project, the panel organized two public meetings. In December 2008, the panel benefited greatly from the expertise and insights provided by Toni Antonucci, University of Michigan; Steve Blair, University of South Carolina; Virginia Chang, University of Pennsylvania; Jim Harter, The Gallup Organization; Frank Hu, Harvard University; Richard Saltman, Emory University; and Jonathon Skinner, Dartmouth College. In March 2009, the panel benefited from presentations and detailed discussion with Dawn Alley, University of Maryland; Kaare Christensen, University of Southern Denmark; Shiro Horiuchi, Hunter College; Knud Juel, University of Southern Denmark; and Andrew Steptoe, University College London.

Several members of the staff of the National Academies made significant contributions to the report. The panel was established under the auspices of the Committee on Population. Particular thanks are due to Barney Cohen, who was an exceptionally effective study director, as well as to Robert Pool for research and writing assistance, Benjamin Galick for excellent research assistance, Jacqui Sovde for logistical support, Kirsten Sampson Snyder for help guiding the report through review, Rona Briere for skillful editing, and Yvonne Wise for managing the production process.

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the NRC's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process.

We wish to thank the following individuals for their review of this report: Barbara A. Anderson, Ronald Freedman collegiate professor of sociology and population studies, University of Michigan; Mauricio Avendano, Harvard Center for Population and Development Studies, Harvard University; John Bongaarts, Policy Research Division, The Population Council; David Burns, School of Medicine, University of California, San Diego; John Cawley, Department of Policy Analysis and Management, College of Human Ecology, Cornell University; Kaare Christiansen, professor of epidemiology, College of Human Ecology, University of Southern Denmark, and senior research scientist, Sanford Institute of Public Policy, Duke University; James S. House, Angus Campbell distinguished university professor survey research, public policy, and sociology, Gerald R. Ford School of Public Policy, University of Michigan; Michael A. Stoto, professor of health systems administration and population health, Georgetown University School of Nursing and Health Studies; and Klaas R. Westerterp, professor of human energetics, Department of Human Biology, Maastricht University, The Netherlands.

Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations nor did they see the final draft of the report before its release. The review of this report was overseen by Jane Menken, University of Colorado, Boulder. Appointed by the NRC, she was responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring panel and the institution.

Finally, we would like to express our great appreciation to our fellow panel members. This report results from the exceptional efforts of the members of the panel, all of whom had many other responsibilities but who nonetheless generously gave much of their time and their expertise to the project.

Eileen M. Crimmins and Samuel H. Preston, *Cochairs*
Panel on Understanding Divergent Trends in
Longevity in High-Income Countries

Contents

Summary

Over the past 25 years, life expectancy has been rising in the United States at a slower pace than has been achieved in many other high-income countries. Consequently, the United States has been falling steadily in the world rankings for level of life expectancy, and the gap between the United States and countries with the highest achieved life expectancies has been widening. International comparisons of various measures of self-reported health and biological markers of disease reveal similar patterns of U.S. disadvantage. The relatively poor performance of the United States with respect to achieved life expectancy over the recent past is surprising given that it spends far more on health care than any other nation in the world, both absolutely and as a percentage of gross national product. Motivated by these concerns, the National Institute on Aging requested that the National Research Council convene a panel of leading experts to clarify patterns in the levels and trends in life expectancy across nations, to examine the evidence on competing explanations for the divergent trends, and to identify strategic opportunities for health-related interventions to narrow this gap.

PATTERNS OF MORTALITY AT OLDER AGES

To examine trends in life expectancy, the panel chose to rely on data available from the Human Mortality Database. The panel examined trends in life expectancy at birth by year for males and females in the United States and compared them with trends in other high-income countries where the data were considered to be of sufficiently high quality. For U.S. males, life expectancy at birth increased by 5.65 years from 69.99 years in 1980 to

75.6 years in 2007, the equivalent of 2.1 years per decade. While this is a significant achievement, it is less than the average increase for the other 21 countries examined for this study. Similarly, between 1980 and 2007, life expectancy at birth for U.S. women increased 3.3 years from 77.5 to 80.8 years, only slightly more than 60 percent of what was achieved, on average, in the same period in the other 21 countries examined. Among high-income countries that have recorded reductions in adult mortality at advanced ages, the Netherlands and Denmark stand out as the only other two countries that have recently underachieved. For both men and women, the divergence of experience between the United States and the other countries examined is clear both before and after age 50, although it is starker for women than for men. However, because 94–96 percent of newborns in high-income countries now survive to age 50, variation in life expectancy at birth is dominated by what happens over age 50, and the panel therefore chose to concentrate on mortality in this older age group.

The panel undertook a careful examination of cause-of-death statistics to see whether specific causes of death could account for the low level of life expectancy in the United States and were associated with improvements in life expectancy in vanguard countries. Comparative analyses of this sort are complicated by issues of variation in coding practices across countries and over time. Nevertheless, it does appear that higher mortality rates for lung cancer and respiratory diseases in the United States, Denmark, and the Netherlands are an important part of the story of recent trends. About half the gap between the United States and the countries with the highest life expectancies results from differences in mortality due to heart disease, so this condition should be a focus of efforts to bring U.S. life expectancy in line with that of the exemplar countries. Other conditions that account for the poor performance of U.S. women in particular include cerebrovascular conditions (primarily stroke), diabetes, and mental disorders.

EVIDENCE ON POSSIBLE COMPETING EXPLANATIONS

The panel examined a number of possible risk factors and considered how differentials among countries in exposure to these risk factors might account for observed disparities in levels of and improvements in life expectancy. For some factors, comparable cross-country data exist on the current levels of risk, while for others, surprisingly little direct evidence can be brought to bear. The fluid nature of the relationship between mortality and some of the major risk factors also complicated the panel's work. For example, the epidemiological literature still reflects considerable differences of opinion with respect to the magnitude of the relationship between obesity and mortality.

The panel's strategy was to try to establish the strength of the evidence for a number of the most commonly proffered explanations of why the

United States fares poorly on life expectancy relative to other countries—for example, that these differences are the result of a particularly inefficient U.S. health care system or that they are a function of poor health behaviors in the United States, particularly with respect to smoking, overeating, and failing to exercise sufficiently. The panel also considered differences among countries in levels of social integration and in socioeconomic inequality. Ultimately, all of these potential risk factors will need to be examined in an integrated framework across the entire life course, taking account of the effects of differences in socioeconomic status, behavioral risk factors, and social policy, as well as changing effects across particular cohorts and periods.

Smoking appears to be responsible for a good deal of the divergence in female life expectancy. Other factors, such as obesity, diet, exercise, and economic inequality, also have likely played a role in the current gap and divergence between the United States and other countries. Fifty years ago, smoking was much more widespread in the United States than in Europe or Japan: a greater proportion of Americans smoked and smoked more intensively than was the case in other countries. The health consequences of this behavior are still playing out in today's mortality rates. Over the period 1950–2003, the gain in life expectancy at age 50 was 2.1 years lower among U.S. women compared with the average of nine other high-income countries (5.7 vs. 7.8 years gained, respectively). The damage caused by smoking was estimated to account for 78 percent of the gap in life expectancy for women and 41 percent of the gap for men between the United States and other high-income countries in 2003. Smoking also has caused significant reductions in life expectancy in the Netherlands and Denmark, which as noted are two other countries with relatively poor life expectancy trends.

Other factors, particularly the rising level of obesity in the United States, also appear to have played a significant part, although as noted, there is still a good deal of uncertainty in the literature regarding the mortality consequences of obesity and possible trends therein. Obesity may account for a fifth to a third of the shortfall of life expectancy in the United States relative to the other countries studied. Other specific risk factors also are surely important, but their effects are even more difficult to quantify. The panel found some evidence to suggest that adults aged 50 and over in the United States are somewhat more sedentary than those in Europe, but the research base is insufficient even to identify a reasonable range of uncertainty in estimates of the contribution of physical activity to international differences or trends in mortality.

In other cases, the panel determined that certain risk factors are unlikely to have played a major role in the divergence of life expectancy in various countries over the past 25 years. A large body of work shows a causal relationship between social ties and social integration and mortality. Yet there is little basis for concluding that levels or trends in the quality of social networks have played a role in the divergent life expectancies studied. Similarly, little evidence supports the hypothesis that hormone therapy played a part in an emergent longevity shortfall for American women.

Finally, the panel examined whether differences in health care systems across countries might help explain the divergence in life expectancy over the past 25 years. The health care system in the United States differs from those in other high-income countries in a number of ways that conceivably could lead to differences in life expectancy. Certainly, the lack of universal access to health care in the United States has increased mortality and reduced life expectancy. However, this is a smaller factor above age 65 than at younger ages because of Medicare entitlements. For the main causes of death at older ages—cancer and cardiovascular disease—available indicators do not suggest that the U.S. health care system is failing to prevent deaths that would elsewhere be averted. In fact, cancer detection and survival appear to be better in the United States than in most other high-income countries. Survival rates following a heart attack also are favorable in the United States.

Most of the comparative data the panel reviewed relate to the performance of the U.S. health care system relative to those of other high-income countries after a disease has already developed. A separate concern is that the U.S. health care system does a particularly poor job at prevention, an observation that may be especially relevant in the midst of a nationwide obesity epidemic. The panel reviewed scattered evidence on the performance of the United States with respect to preventive medicine relative to European countries and found the evidence to be inconclusive. Certainly the high prevalence of certain health conditions in the United States is consistent with a failure of preventive medicine. But it could also be consistent with a higher prevalence of smoking, obesity, and physical inactivity among Americans, or with a medical system that may be unusually effective at identifying certain diseases.

LOOKING TO THE FUTURE

What will happen to life expectancy rates in the United States and other countries in the coming decades? Although it is impossible to answer that question with any certainty, the analyses described in this report point to some likely patterns for the future. Because there appears to be a lag of two to three decades between smoking and its peak effects on mortality, one can predict how smoking will affect life expectancy in various countries over the next 20 to 30 years. On this basis, life expectancy for men in the United States is likely to improve relatively rapidly in the coming decades in response to changes that have occurred in smoking patterns over the past 20 years. For women, mortality improvements are likely to remain slower than males for the next decade or so. Similarly, life expectancy in Japan can be expected to improve less rapidly than it otherwise would because of the rapid increase in the prevalence of smoking in that country. On the other hand, the United States has been in the vanguard of a global obesity epidemic, and obesity also appears to be an important contributor to the shortfall in life expectancy in the United States. If the obesity trend in the United States continues, it may offset the longevity improvements expected from reductions in smoking. However, recent data on obesity for the United States suggest that its prevalence has leveled off, and some studies indicate that the mortality risk associated with obesity has declined. The interplay between obesity levels and obesity risks bears watching as an important factor in future longevity trends in the United States.

RESEARCH AND POLICY IMPLICATIONS

While the panel believes it made progress in identifying some of the main factors that have been driving differences in life expectancy among wealthy countries, it also identified many research gaps. With respect to behavioral risk factors, a reliable marker of the damage from smoking exists—mortality rates from lung cancer. No such clear-cut and widely available marker has been identified for obesity, physical inactivity, stress, lack of social integration, or the other risks considered in this report. Furthermore, evaluation of the importance of these risks is based primarily on observational studies that follow forward people with differing levels of exposure. These studies are subject to many biases, especially those associated with omitted variables, self-selection into categories, and reverse causation. Without randomized controlled trials, it is difficult to overcome these problems that plague observational studies. While it is sometimes difficult, expensive, and ethically challenging to alter individual behavior, there is no perfect substitute for such trials. On the other hand, studies that take advantage of natural experiments, such as increased cigarette taxes or a dramatic change in the use of hormone therapy, can sometimes serve as valuable supplements to randomized controlled trials.

The panel concluded that a history of heavy smoking and current levels of obesity are playing a substantial role in the relatively poor longevity performance of the United States. Yet these behaviors are products of a broad social and economic context encompassing, for example, a level of affluence that supports large numbers of automobiles, low taxes on gasoline, and dispersed residences and workplaces that encourage driving; a climate and soil in part of the country that are conducive to growing tobacco; a productive agricultural sector that produces inexpensive foods; and a public health system that is highly dispersed and thus heavily dependent on regional rather than national resources. It is also true that these contextual factors are not randomly distributed in the population; rather, they are more likely to affect the health of people of lower social status and those who are less likely to have lifetime access to health care. Finally, the panel did not undertake any analysis of the cost-effectiveness of public interventions designed to change personal health behaviors; therefore, recommendations as to what might be undertaken in this regard are not appropriate. It is clear, however, that failures to prevent unhealthy behaviors are costing Americans years of life compared with their counterparts in other wealthy countries.

1

Difference Between Life Expectancy in the United States and Other High-Income Countries

Great advances have occurred in life expectancy in the United States over the last century. Improvements in the prevention and control of major childhood infectious diseases and in nutrition, housing, hygiene, and medical care resulted in an increase in life expectancy of about 4 years each decade throughout the first half of the 20th century. Advances in medical technology, particularly in relation to the treatment of heart disease and stroke, along with healthier lifestyles, improvements in access to health care, and better general overall health before age 65, enabled continued improvements in life expectancy throughout the second half of the 20th century (Fried, 2000). By June 2010, when the National Center for Health Statistics (NCHS) released its most recent life tables for the United States—for 2006—the average life expectancy at birth was 75.1 years for men and 80.2 years for women, compared with just 47.9 years for men and 50.7 years for women for the period 1900-1902 (Arias, 2010).

This pattern of rising life expectancy has been reproduced in many other high-income countries around the world (Kannisto, 1994; Kannisto et al., 1994; Rau et al., 2008). Between 1950 and 1995, the mortality rate at each age declined at a roughly constant pace in Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States (Tuljapurkar et al., 2000). In Japan, life expectancy in 1950 was 57.6 years for men and 60.9 years for women; by 2007 it had jumped by more than 20 years, to 79.2 years for men and 86.0 years for women (see Table 1-1). Similarly, in France, life expectancy in 1950 was 63.4 years for men and 69.2 years for women and by 2007 had grown to 77.4 years for men and 84.4 years for women. And in Australia,

TABLE 1-1 Life Expectancy by Country

Country	1950			1980			2007		
	e_0	e_{50}	e_{80}	e_0	e_{50}	e_{80}	e_0	e_{50}	e_{80}
Women									
Australia	71.75	26.64	6.45	78.18	30.68	8.06	83.78	35.24	10.00
Canada	70.59	26.79	6.66	78.72	31.35	8.78	82.95	34.53	10.13
Denmark	71.52	26.19	5.65	77.18	29.82	7.70	80.53	31.95	8.74
England and Wales	71.31	26.38	6.05	76.76	29.29	7.46	81.73*	33.31*	9.25*
France	69.19	26.46	6.07	78.40	31.12	7.71	84.39	35.87	10.52
Japan	60.90	23.91	5.45	78.75	30.82	7.28	85.98	37.26	11.40
Italy	67.48	26.40	5.95	77.43	30.05	7.11	84.09*	35.23*	9.83*
Netherlands	72.59	26.92	6.00	79.14	31.31	8.04	81.89*	33.31*	8.92*
Sweden	72.44	26.48	5.72	78.85	30.91	7.67	82.95	34.10	9.23
United States	71.02	26.55	6.88	77.48	30.56	8.58	80.78	33.06	9.82
Men									
Australia	66.53	22.75	5.62	71.01	24.97	6.30	79.27	31.58	8.39
Canada	66.16	23.93	5.93	71.60	25.69	6.83	78.35	30.75	8.40
Denmark	69.10	25.06	5.45	71.17	24.78	6.25	76.13	28.45	7.24
England and Wales	66.51	22.51	5.03	70.74	24.07	5.72	77.46*	29.85*	7.78*
France	63.43	22.49	5.08	70.16	24.79	6.09	77.43	30.03	8.24
Japan	57.58	21.00	4.69	73.38	26.59	6.08	79.20	31.16	8.52
Italy	63.99	24.23	5.44	70.68	24.66	5.83	78.62*	30.58*	7.90*
Netherlands	70.32	25.79	5.77	72.44	25.49	6.45	77.63*	29.45*	7.13*
Sweden	69.83	25.07	5.45	72.78	26.03	6.14	78.92	30.69	7.63
United States	65.40	22.64	5.92	69.99	24.90	6.67	75.64	29.28	8.27

NOTE: e_0 = life expectancy at birth; e_{50} = life expectancy at age 50; e_{80} = life expectancy at age 80.
*Data are for 2006.
SOURCE: Data from Human Mortality Database (http://www.mortality.org/ [accessed December 8, 2010]).

life expectancy grew from 66.5 years for men and 71.8 years for women in 1950 to 79.3 years for men and 83.8 years for women in 2007.

Despite this broad similarity in patterns of increased life expectancy among high-income countries, gains in the United States over the more recent past—especially the last 25 years—have been below those achieved in many other high-income countries and significantly below those achieved in countries that have seen the greatest increases. Table 1-1 presents estimates of life expectancy at birth (e_0), at age 50 (e_{50}), and at age 80 (e_{80}) taken from the Human Mortality Database for both men and women from ten different countries and provides a sense of the extent of the mortality differentials. In 1980, average life expectancy at age 50 for women in the United States was 30.6 years, the same as the average for the other nine countries shown in Table 1-1. By 2007, life expectancy at age 50 for women in the United States had increased 2.5 years to 33.1. But over the same time period, life expectancy at age 50 in Japan had increased 6.4 years; in Italy it had increased 5.2 years; and on average, for the other nine countries apart from the United States shown in Table 1-1, it had increased 3.9 years. (This pattern of U.S. improvement, but at a slower pace than that achieved in many other countries, is repeated throughout Table 1-1 for both men and women although the pattern is less pronounced for men than for women.) Consequently, the list of countries that has overtaken the United States with respect to life expectancy at birth has been growing, and the gap between the United States and the countries with the highest achieved life expectancies has been widening (see Figures 1-1 and 1-2). According to the United Nations' Population Division, life expectancy at birth in the United States for both sexes combined for the period 2005–2010 ranked 28th in the world, just behind the United Kingdom, Korea, Luxembourg, and Malta but more than 2 years behind Australia, Canada, France, Iceland, Italy, Japan, and Switzerland (United Nations, 2009).

New life tables published by NCHS suggest that the extent of the U.S. disadvantage could be even greater than that suggested in Table 1-1.[1] NCHS recently accepted that the prevalence of age misreporting at the oldest ages in U.S. census data is significant enough to lead to underestimated death rates at those ages. As a result, NCHS has revised the basic methodology used to calculate the U.S. life table, which now yields lower estimates of life expectancy at all ages (Arias et al., 2010). The most recent life table for the United States published by NCHS provides estimates of life expectancy at 50 in 2006 that are approximately 0.6 years lower for women and 0.5 years lower for men than the estimates provided in the Human Mortality Database (Arias et al., 2010).

[1]In fact, preliminary mortality data for 2008 indicate a very small decrease in life expectancy because of mortality increase at the oldest ages and among white women (Miniño et al., 2010).

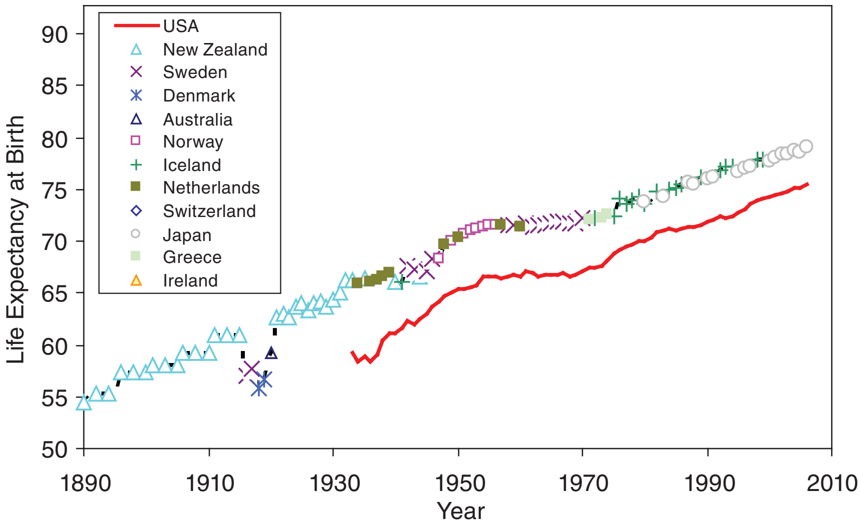

FIGURE 1-1 Trend in highest recorded level of male life expectancy achieved versus trend in life expectancy in the United States.
SOURCE: Data from Oeppen and Vaupel (2002) [Supplementary tables]; Human Mortality Database (http://www.mortality.org/ [accessed December 8, 2010]).

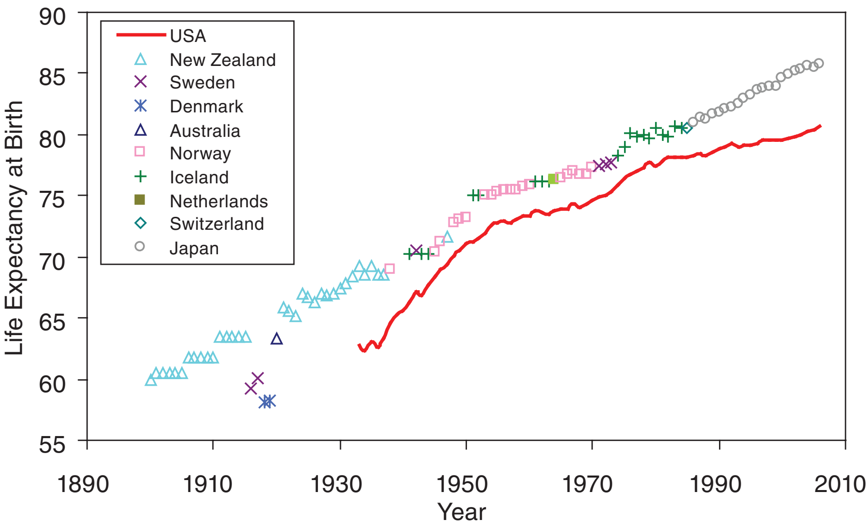

FIGURE 1-2 Trend in highest recorded level of female life expectancy achieved versus trend in life expectancy in the United States.
SOURCE: Data from Oeppen and Vaupel (2002) [Supplementary tables]; Human Mortality Database (http://www.mortality.org/ [accessed December 8, 2010]).

International comparisons of various measures of self-reported health and biological markers of disease reveal similar patterns of U.S. disadvantage. In 2006, Banks and colleagues reported that the U.S. population of late middle age was considerably less healthy than the equivalent English population. For every disease the authors studied, Americans across the socioeconomic distribution reported a higher disease burden: approximately 30 percent higher prevalence for lung disease and myocardial infarction, 60 percent higher for all heart disease and stroke, and 100 percent higher for diabetes (Banks et al., 2006). Furthermore, the design of the study strongly suggested that the American health disadvantage could not be explained simply by reference to problems associated with an inefficient health care system, the lack of universal health care coverage, or large racial and socioeconomic disparities in the United States. Moreover, subsequent analyses have found no significant reason to doubt the basic underlying finding that the burden of disease in America is much higher than that in many other countries (Avendano et al., 2009; Crimmins et al., 2008, 2010). The relatively poor performance of the United States with respect to achieved life expectancy in the recent past is perhaps all the more surprising in light of the fact that the United States spends far more on health care than any other nation in the world, both absolutely and as a percentage of gross national product.

Motivated by these concerns, the National Institute on Aging requested that the National Research Council convene a panel of leading experts to clarify patterns in the levels and trends in life expectancy across nations, to examine the evidence on competing explanations for the divergence among nations, and to identify strategic opportunities for health-related interventions to reduce this divergence. Specifically, the panel was charged with addressing three questions: What accounts for the different trends in mortality at older ages that have been observed in Organisation for Economic Co-operation and Development (OECD) countries? What are the likely implications of these trends for the future trajectory of mortality at older ages in the United States? What can be learned about modifiable risk factors from countries where mortality at older ages has improved most rapidly in the last quarter century?

In addressing its charge, the panel confronted a large and burgeoning theoretical and empirical literature encompassing contributions from virtually every field within the social and health sciences. To deal with this vast body of work, the panel commissioned a set of background papers, each dealing with a specific topic relevant to the panel's charge.[2] This report, which draws heavily on that set of background papers, provides a synthesis of the panel's findings, analyses, conclusions, and recommendations.

[2]Those papers are available from the National Academies Press (see National Research Council, 2010).

DIVERGENT TRENDS IN LIFE EXPECTANCY

Origins of an Inquiry

Until the early 1990s, despite the accomplishments of certain high-income countries in achieving significant continued improvements in life expectancy at birth, there was considerable disagreement among gerontologists and demographers as to what the future might bring. On the one hand, pessimists believed that deaths above age 80 were due to problems associated with senescence and intractable aging processes. Consequently, increases in longevity beyond age 85 or so were unlikely to be achievable without fundamental biomedical breakthroughs that would affect those processes themselves (Fries, 1980; Lohman et al., 1992; Olshansky et al., 1990). On the other hand, optimists believed that continued improvements in life expectancy were to be expected and that the official population projections of the time were too conservative (see, for example, Ahlburg and Vaupel, 1990).

A lack of reliable and internationally comparable data initially limited demographers' ability to study patterns of mortality and morbidity at advanced ages (Jeune and Vaupel, 1999). In the United States, for example, demographers have long been wary of using mortality data at older ages because of concerns about the quality of the data and the validity of age reporting (Coale and Kisker, 1986, 1990; Preston et al., 1999). The coverage of the U.S. civil registration system was incomplete until the mid-1930s, and misspecification of age, particularly at the oldest ages, has been a persistent problem in the U.S. data, particularly for the African American population (Manton et al., 1979; Preston and Elo, 2006; Preston et al., 1996, 1999, 2003).

Once reliable data on mortality at advanced ages began to be assembled and analyzed, demographers discovered that levels of mortality at advanced ages in many countries had declined significantly between the 1950s and the 1980s (see, for example, Kannisto, 1994; Kannisto et al., 1994; Vaupel, 1997). Rather than slowing down, which is what might be expected if life expectancy were approaching some biological or practical limit, the rate of mortality improvement showed little relationship to the level of old-age mortality (Kannisto et al., 1994; Oeppen and Vaupel, 2002; Rau et al., 2008).

Although the debate on the limit to human life expectancy continues (see Christensen et al., 2009, 2010b; Olshansky and Carnes, 2010; Olshansky et al., 2009), the empirical observations outlined above have, to some degree, deflected demographers' attention away from the debate over the limit to life expectancy and toward a new focus on the heterogeneity of mortality experience among countries. In 1995, for example, Manton and Vaupel assembled evidence showing that, for people aged 80 and above, life expectancy was greater in the United States than it was in Sweden, France, England, or Japan, at least until 1987 (Manton and Vaupel, 1995). Similarly, Janssen and colleagues reported a large degree of heterogeneity in the pace of mortality decline at old ages among various European countries (Janssen et al., 2004, 2007). While mortality declines were strong in France and England and Wales in the 1950s and 1960s, the authors found modest or no mortality declines in the Nordic countries. In 2006, Meslé and Vallin presented evidence showing that trends in female old-age mortality in the United States and the Netherlands had diverged from those in Japan and France in the period since 1984 (Meslé and Vallin, 2006). Finally, Rau and colleagues (2008) identified Denmark, the Netherlands, Norway, and the United States as the countries with the smallest mortality improvements. The United States, once a leader in longevity, particularly with respect to mortality at the oldest ages, has been falling further and further behind other countries (Rau et al., 2008).

To examine trends in life expectancy, the panel chose to rely on data available from the Human Mortality Database (http://www.mortality.org [accessed December 8, 2010]). This database, established in 2000 as a collaborative research project of teams of scientists at the University of California, Berkeley, and the Max Planck Institute for Demographic Research (MPIDR) in Rostock, Germany, contains raw data and original calculations of death rates and life tables for national populations by single year of age and single year of time. This chapter presents the panel's analysis of data from 22 countries for which the data were considered to be of sufficiently high quality.[3] This analysis provides a broader perspective than much of the report, which focuses on a group of 10 countries.

Gender Differences in Trends in Life Expectancy

Women on average live longer than men, so it is natural to explore the extent to which any improvements in life expectancy among countries vary by gender. Indeed, this is the focus of the above-cited paper by Meslé and Vallin (2006), which contrasts improvements in female old-age mortality in the United States and the Netherlands with those in Japan and France. More recently, however, other authors have emphasized the importance of looking at men as well (see, for example, Murray and Frenk, 2010, who point out the relatively poor performance in life expectancy for U.S. men aged 15-60 compared with Australian and Swedish men of similar ages).

[3]The countries included in the analysis in this chapter are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Iceland, Ireland, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom, the United States, and West Germany. The countries omitted from the analysis include Belarus, Bulgaria, Chile, East Germany, Estonia, Hungary, Israel, Latvia, Lithuania, Poland, Reunified Germany, Russia, Taiwan, and Ukraine. These countries were excluded because, according to the Human Mortality Database, the data for these countries either were not robust (i.e., were corrupted or had methodological issues) or did not go back far enough.

The panel examined trends in life expectancy at birth by year for men and women in the United States and compared them with trends for 21 other high-income countries with good data (see Figures 1-3 and 1-4). The analysis was restricted to the recent past, defined by the panel as the period 1980 to 2006. For U.S. men (see Figure 1-3), life expectancy at birth increased by 5.5 years over this 27-year period, equivalent to 2.04 years per decade. While this is a significant achievement, it is less than the average rate of change for the other 21 countries shown in the figure. Consequently, the series of dots representing the progress of U.S. men in the figure can be seen as both rising absolutely and falling relatively. The story with regard to U.S. women is similar (see Figure 1-4): between 1980 and 2006, the increase in life expectancy at birth for U.S. women was only slightly more than 60 percent of what was achieved, on average, in the same period in the other 21 countries. Thus as with U.S. men, life expectancy at birth for U.S. women is rising in absolute terms but falling relative to other countries.

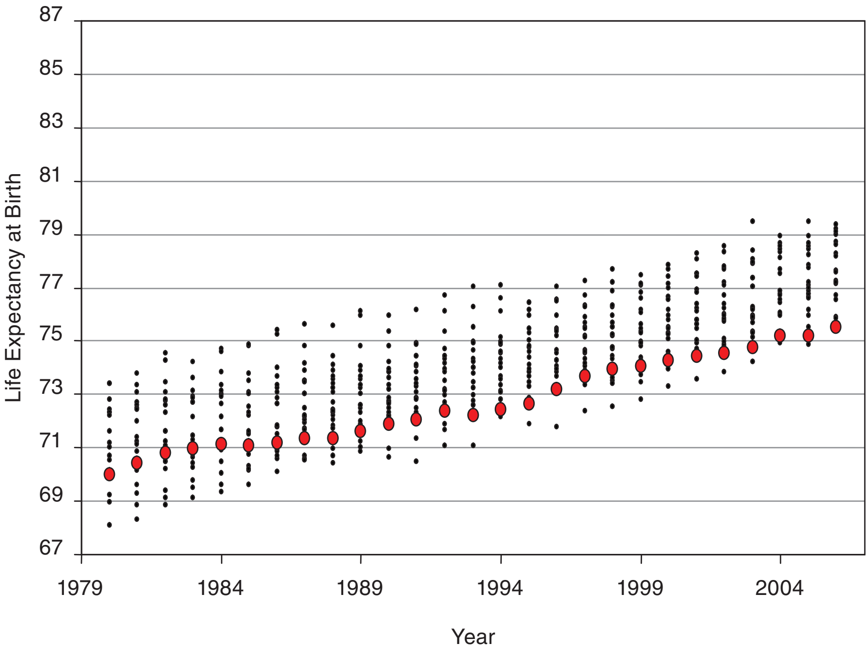

FIGURE 1-3 U.S. male life expectancy at birth relative to that for selected OECD countries.
NOTE: Each dot represents the level of life expectancy in a particular country. The large circle represents the position of the United States each year.
SOURCE: Data from Human Mortality Database (http://www.mortality.org/ [accessed December 8, 2010]).

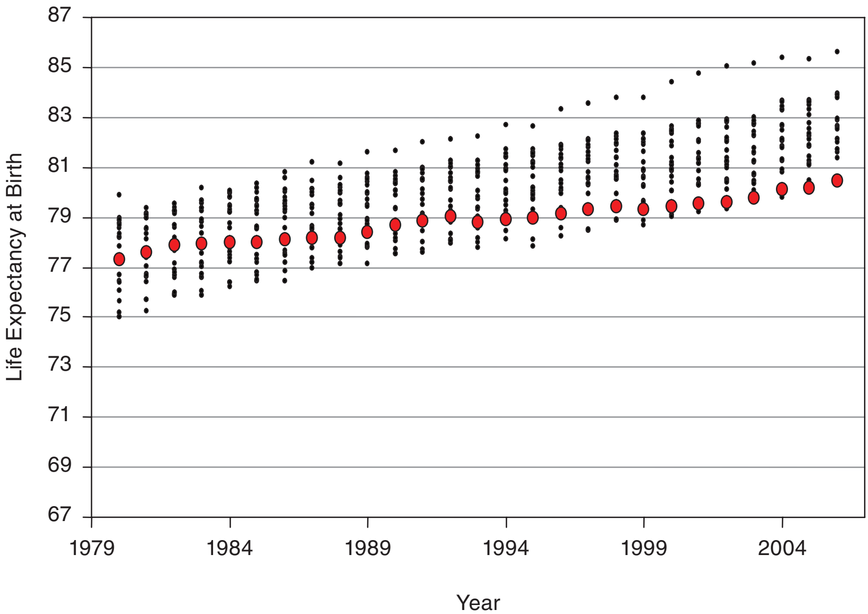

FIGURE 1-4 U.S. female life expectancy at birth relative to that for selected OECD countries.
NOTE: Each dot represents the level of life expectancy in a particular country. The large circle represents the position of the United States each year.
SOURCE: Data from Human Mortality Database (http://www.mortality.org/ [accessed December 8, 2010]).

Age Group Contributions to Life Expectancy Trends

In the first half of the 20th century, life expectancy at birth rose dramatically as a consequence of prevention and control of major childhood infectious diseases, while gains in life expectancy above age 65 were considerably more modest. In contrast, during the second half of the 20th century and continuing over the first decade of the 21st century, improvements in life expectancy are usually attributed to advances in medical technology—particularly in relation to the treatment of chronic diseases, especially heart disease and stroke—along with healthier lifestyles, improved access to health care, and better general overall health after age 65 (see, for example, Fried, 2000). Consequently, the latter half of the 20th century saw smaller gains in life expectancy from mortality decline at younger ages but larger gains in life expectancy above age 65.

The panel considered the extent to which the patterns of divergence in life expectancy among countries shown in Figures 1-3 and 1-4 are a function of differential improvements across different stages of the life course. Figures 1-5 to 1-8 divide the comparison of the experience of men and women in the United States and of men and women in the other 21 countries into two stages of the life course, showing the probability of survival up to age 50 (see Figures 1-5 and 1-6) and life expectancy beyond age 50 (see Figures 1-7 and 1-8). The divergence of experience between the United States and the other countries is clear both before and after age 50.

For men, improvements in survival can be seen in both parts of the life course, although the improvements have been very small below age 50 in the United States. The comparable data for women show a starker contrast between the United States and the other 21 countries. Figure 1-6 shows that over the past 10 years, only the United States has failed to make significant improvements in the probability of survival up to age 50 for women. Once again, while there is a divergence of experience between the United States and the other countries, the figure shows only a small relative decline in the rank of the United States—all that is possible given that it already had one of the worst records. In contrast, Figure 1-8 illustrates the dramatic decline in international ranking for life expectancy among U.S. women at age 50 during the recent past, due to slower progress in reducing adult female

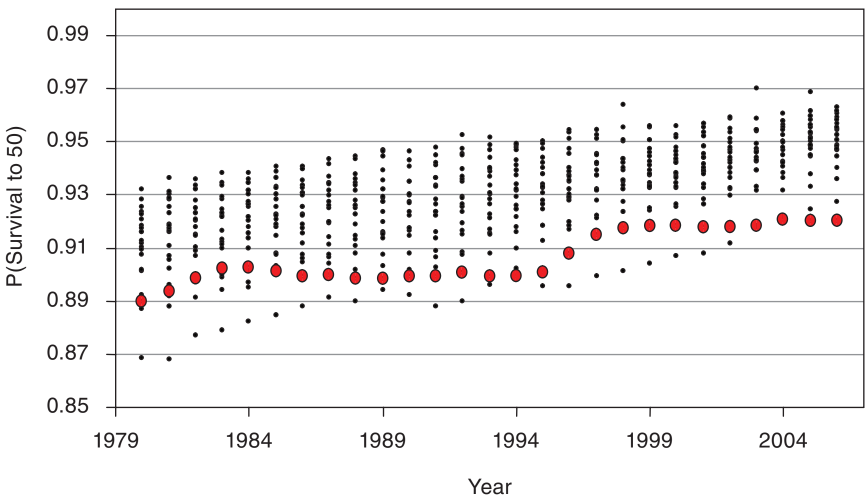

FIGURE 1-5 Probability of survival to age 50 among men in the United States and selected OECD countries.
NOTE: Each dot represents the level of life expectancy in a particular country. The large circle represents the position of the United States each year.
SOURCE: Data from Human Mortality Database (http://www.mortality.org/ [accessed December 8, 2010]).

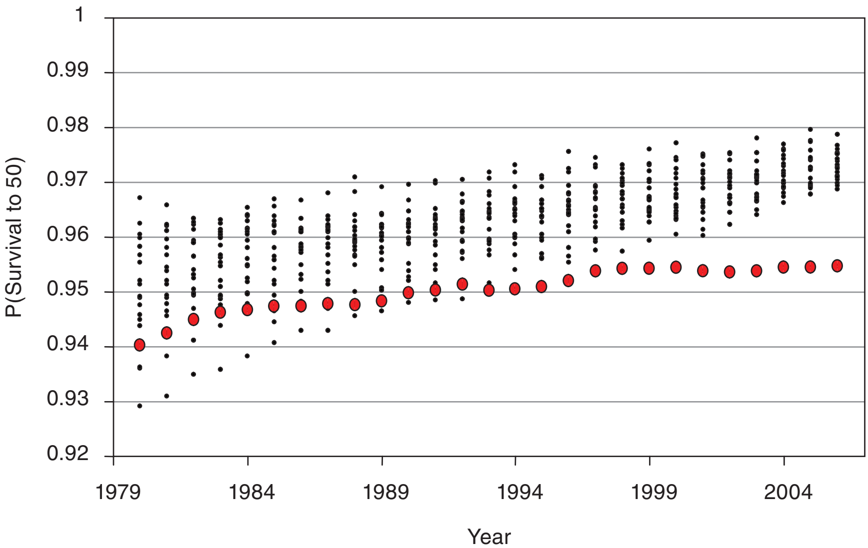

FIGURE 1-6 Probability of survival to age 50 among women in the United States and selected OECD countries.
NOTE: Each dot represents the level of life expectancy in a particular country. The large circle represents the position of the United States each year.
SOURCE: Data from Human Mortality Database (http://www.mortality.org/ [accessed December 8, 2010]).

mortality. In 1980, the United States was ranked 11th on this measure; by 1990 it had fallen to 13th and by 2006 had dropped to 21st. During that time, the difference in life expectancy among women at age 50 between the United States and the highest-ranking country rose from 1.5 years in 1980 to 2.0 years in 1990, 4.1 years in 2000, and 4.2 years in 2007.

Mortality trends below age 50 provide useful background. However, because 94 percent of newborns in the United States now survive to age 50, variation in life expectancy at birth is dominated by what happens above age 50. For this reason, the panel chose to focus on mortality above age 50 and to rely heavily on the summary indicator of life expectancy at age 50: the expected number of additional years to be lived by someone who survives to age 50.

Variation in Trajectories of Mortality at Older Ages

It has long been observed that mortality rates in humans tend to rise exponentially throughout most of the adult age range, although the increase in the risk of death has been shown to decelerate among the oldest old

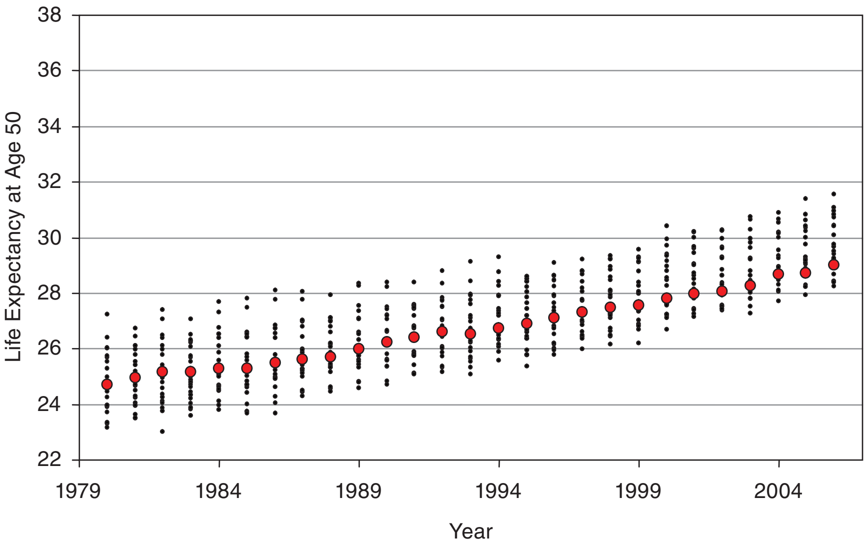

FIGURE 1-7 Life expectancy at age 50 for men in the United States and selected OECD countries.
NOTE: Each dot represents the level of life expectancy in a particular country. The large circle represents the position of the United States each year.
SOURCE: Data from Human Mortality Database (http://www.mortality.org/ [accessed December 8, 2010]).

(Vaupel et al., 1998). How similar, then, should one expect the pattern of survival to be at older ages between one country and another? And to what extent has the pattern of improvement in survival in the United States been different from that in other countries at various ages above 50? To date this topic has received very little attention.

Figures 1-9 and 1-10 show the variation over time in the probability of dying in one year for adults aged 55 ($_1q_{55}$), 65 ($_1q_{65}$), 75 ($_1q_{75}$), and 85 ($_1q_{85}$) in the United States versus the 21 other countries over time. Relative to men in the other 21 countries, U.S. men have a higher mortality risk at the younger older ages (i.e., ages 55 and 65), typical mortality risk at age 75, and much lower mortality risk at age 85 (see Figure 1-9).[4] Similarly, relative to women in the other 21 countries, U.S. women have relatively high mortality rates at the younger older ages but compare quite favorably

[4]A similar observation has been made by Ho and Preston (2010), who use data from the Human Mortality Database for 2005 to compare age-specific death rates for the United States with those for a comparison set of 17 OECD countries. The authors demonstrate that the U.S. position improves dramatically after age 70 for men and after age 75 for women.

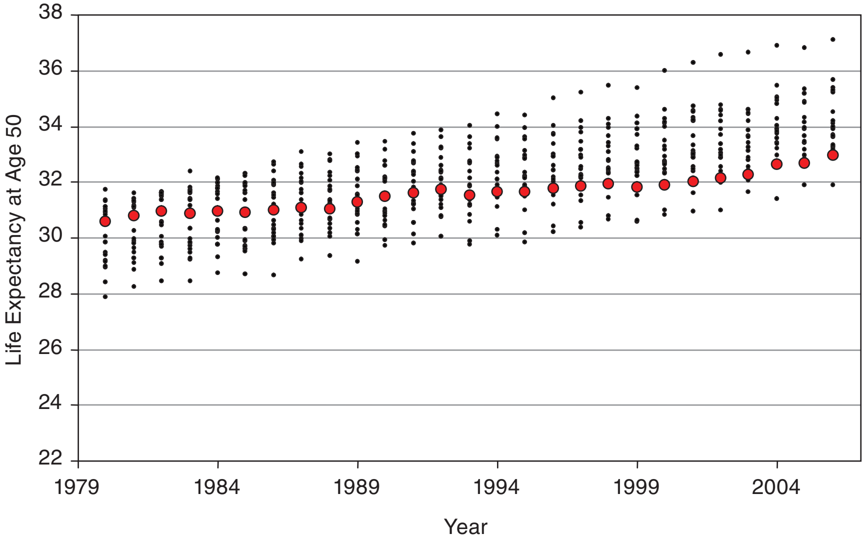

FIGURE 1-8 Life expectancy at age 50 for women in the United States and selected OECD countries.
NOTE: Each dot represents the level of life expectancy in a particular country. The large circle represents the position of the United States each year.
SOURCE: Data from Human Mortality Database (http://www.mortality.org/ [accessed December 8, 2010]).

at age 85 and above (see Figure 1-10). The sharp decline in the rank of U.S. women at age 75 but not at age 85 or 95 (not shown) over the past 25 years suggests important cohort patterns may underlie these mortality trends.[5]

Trailblazers Versus Stragglers

The panel considered whether there are countries other than the United States whose mortality experience over the recent past might provide important clues as to factors that can explain their own relatively poor performance and that of the United States. Since the collapse of communism in 1989, for example, most countries of the former Soviet Union have shared a common pattern of worsening mortality (Shkolnikov et al., 2004). The crisis has been particularly severe in Russia, where excessive alcohol intake has been shown to be an important determinant of premature male mortality (Zaridze et al., 2009a, 2009b).

[5]See Preston et al. (2001) for an explanation of basic concepts and measures in demography.

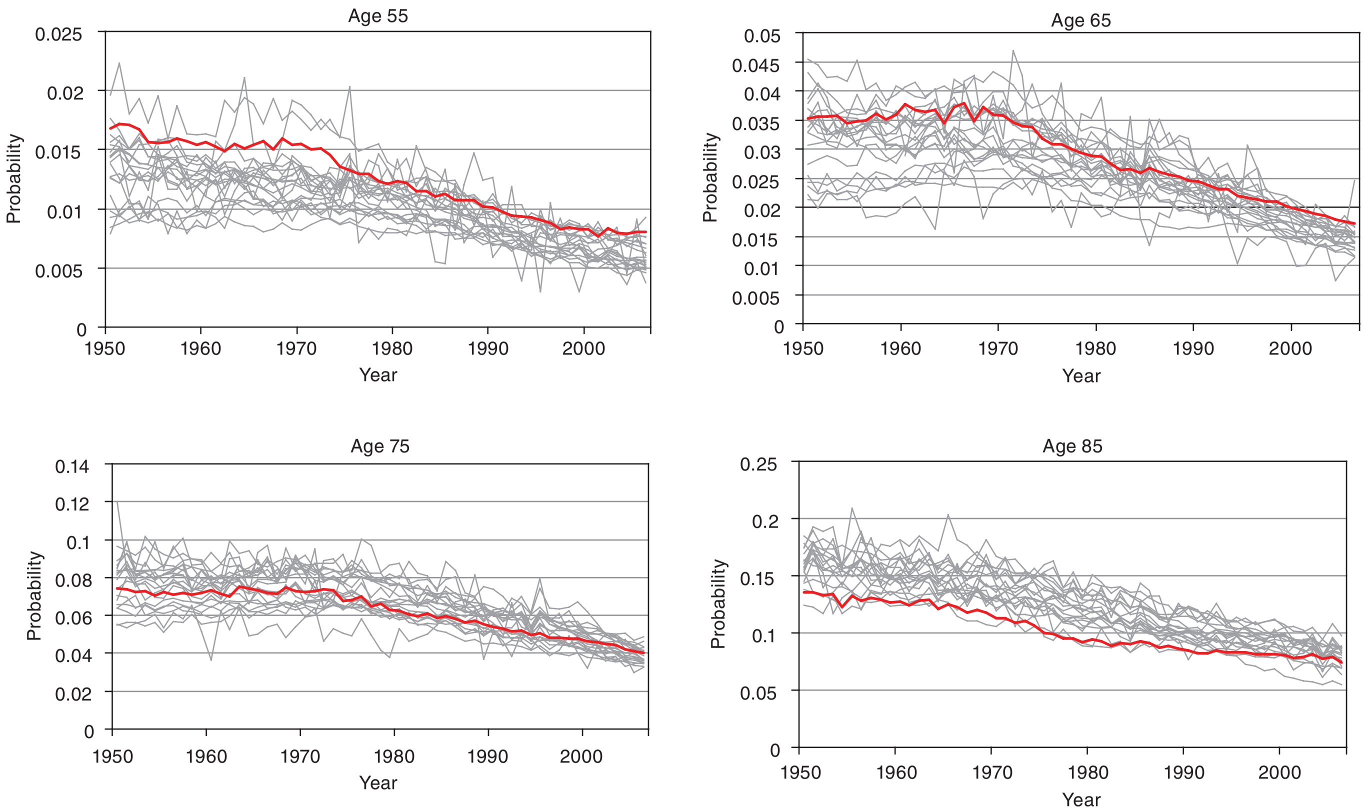

FIGURE 1-9 Mortality rates at ages 55, 65, 75, and 85 for men in the United States and selected OECD countries.
SOURCE: Data from Human Mortality Database (http://www.mortality.org/ [accessed December 8, 2010]).

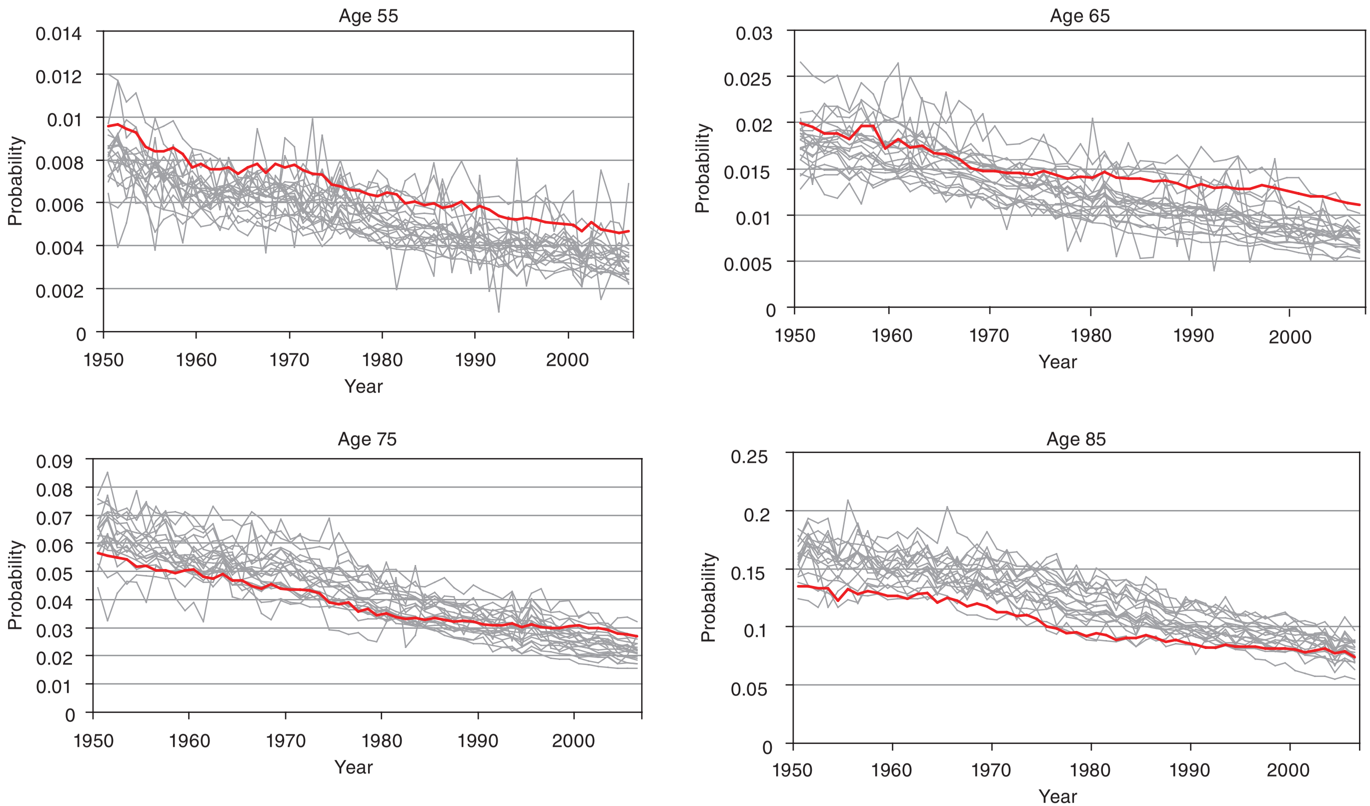

FIGURE 1-10 Mortality rates at ages 55, 65, 75, and 85 for women in the United States and selected OECD countries.
SOURCE: Data from Human Mortality Database (http://www.mortality.org/ [accessed December 8, 2010]).

Among countries that have recorded reductions in adult mortality at advanced ages, the United States, the Netherlands, and Denmark are frequently cited as three that have recently underachieved. Meslé and Vallin (2006) focus on the differences in female old-age mortality among the United States, the Netherlands, France, and Japan. In the early 1950s, American women enjoyed the highest life expectancy at age 65 among these four countries. Life expectancy at age 65 in the four countries converged until the early 1980s, when it was virtually identical in all four. In about 1984, however, trends in female life expectancy began to diverge sharply so that by 2000, the levels of life expectancy in the United States and the Netherlands had fallen significantly behind those in France and Japan.

Janssen and colleagues (2004) examined trends in mortality at age 80 and found that in the 1980s and 1990s, while France and to a lesser extent England and Wales enjoyed continued declines in old-age mortality, the Netherlands, Denmark, and Norway saw progress stagnate. For the Netherlands, the stagnation in old-age mortality occurred around 1980. Subsequent analyses of cause-of-death patterns revealed that smoking-related cancers, chronic obstructive pulmonary disease, and diseases related specifically to old age contributed to this stagnation (Janssen et al., 2003; Nusselder and Mackenbach, 2000). Recently, however, there has been a sharp improvement in life expectancy in the Netherlands. From 2002 to 2008, life expectancy at birth increased by almost 2 years in that country, with the sharpest upturn being achieved at age 85. This improvement is thought to be a period as opposed to a cohort effect, since it coincides with a time of sharply rising health care expenditures and increased health care for the elderly, facilitated by the sudden relaxation of budgetary constraints on health care expenditures by the Dutch government (Mackenbach and Garssen, 2010).

Similar to the Netherlands, Denmark was among the world leaders in low levels of mortality up to the 1980s, for both men and women. Like the United States, however, Denmark experienced a period of stagnation in mortality improvement for 10–15 years. The stagnation ended in the mid-1990s, and more recently, Denmark has once again achieved rates of improvement in life expectancy at older ages that are comparable to those of the highest-performing countries. Nevertheless, Denmark has not been able to catch up with neighboring Sweden, where life expectancy has been among the very longest for many decades. An analysis of cause-specific mortality data suggests that the stagnation in Danish mortality improvement was related to lifestyle factors, especially smoking and excessive alcohol consumption. Differences in smoking- and alcohol-related deaths account for virtually all of the disparity in life expectancy between Denmark and Sweden during the period 1997–2001, with smoking playing the larger role (Christensen et al., 2010a). There are also some indications that lower budgets for Denmark's free national health care system relative to other Nordic countries may have played a role in Denmark's adverse position (Christensen et al., 2010a).

At the other end of the spectrum, Japan and France have achieved remarkable improvements in survival at older ages. The pace of mortality improvement at older ages continues to be particularly rapid in Japan, even though it already enjoys mortality levels lower than those anywhere else. In July 2010, when the Japanese Ministry of Health, Labour, and Welfare published an abridged life table for 2009, it showed that Japanese women are now expected to live, on average, 86.44 years—the highest level in the world for the 25th straight year—while Japanese men are expected to live 79.59 years (Ministry of Health, Labour, and Welfare, 2010). Remarkably, these levels represent increases in average life spans of almost 5 months for women and 4 months for men compared with the previous year. If death rates at older ages were approaching a biological or practical limit, it might be expected that improvements in Japan would be slowing down. Similarly, length of life continues to increase in France, which has the second highest recorded level of life expectancy after Japan. French mortality declined very sharply in 2004 compared with 2003, a year that saw a major heat wave, but also compared with 2002, a more normal year (Pison, 2005). Life expectancy in France increased by 10 months between 2002 and 2004, a significantly more rapid increase than the trend for the previous 50 years, which was about 3 months a year (Pison, 2005).

Discussion

Research on advances in mortality at older ages has unequivocally confirmed the existence of large and growing differences in life expectancy between the United States and many other high-income countries. To date, no satisfactory explanation of these patterns has been proposed. A clearer understanding of what accounts for the observed differences in life expectancy and the observed trends at older ages among high-income countries may help identify important modifiable risk factors that could inform the development of new initiatives aimed at improving life expectancy in the United States still further. The gap between the level of life expectancy currently being achieved in the United States and in countries such as Japan and France indicates how much better the United States might be able to do given the current state of knowledge and practice. A firmer understanding of the proximal and distal causes of mortality differences and improvements also could potentially lead to better mortality forecasts in the future. It should be noted that explanations of mortality differences at a moment in time may not be the same as explanations of differences in mortality trends; certain factors may explain the contemporary gap between the United States and other countries, while different factors may be responsible for changes in the gap. Because the gap has widened substantially in recent decades, the panel believes that study of the factors underlying current patterns will likely contribute to explanations of the widening gap, but that is not necessarily the case.

ORGANIZATION OF THE REPORT

The remainder of this volume moves from basic description toward the search for explanation. As noted, the panel chose to focus much of the report on nine other countries for intensive comparison with the United States: Denmark and the Netherlands, the two other underachievers; Japan and France, two stellar achievers; Italy and Spain, large countries whose life expectancy gains have also outpaced those of the United States; and England and Wales, Canada, and Australia, English-speaking countries that have also seen relatively strong gains in longevity. The panel also chose to focus on one principal indicator of mortality at older ages—life expectancy at age 50, or how long a 50-year-old could be expected to live according to the set of age-specific death rates recorded in any particular country and period. While this measure summarizes mortality circumstances at ages above 50, it does not provide a perfect indicator of what happens at every age in that range or of the age pattern of mortality itself.[6]

Chapter 2 provides a closer look at cause-of-death statistics by gender over the past half century for the selected subsample of 10 countries; it also explores differences in current health status between the United States and the other countries. The heart of the report is contained in Chapters 3 through 9. Each of these chapters takes as its starting point a particular risk factor presumed to affect mortality and examines how differentials in exposure to that risk factor across countries might account for observed disparities in life expectancy improvement. Finally, Chapter 10 presents the panel's conclusions and suggests new areas of research that would augment our knowledge and understanding of this important issue and inform efforts to address it.

It should be noted that the fluid nature of the relationship between some of the risk factors examined in Chapters 3–9 and mortality risk provides one source of uncertainty in the panel's conclusions. Moreover, no report can be expected to examine every conceivable risk factor associated with mortality. The panel therefore chose to focus on the body of evidence for the commonly proffered explanations for why the United States fares poorly

[6]The measure is less attentive to mortality conditions early in the 50+ age range since as noted, mortality rises roughly exponentially above age 50. Deaths peak around age 85 in official U.S. life tables for recent years (Arias et al., 2010). For more detail on factors affecting the age pattern of U.S. mortality in an international context, see Muennig and Glied (2010) and Ho and Preston (2010).

on life expectancy relative to other countries: country-level differences in exposure to risk factors related to obesity (Chapter 3), physical activity (Chapter 4), and smoking (Chapter 5), as well as levels of social integration (Chapter 6); differences in health care systems, including differences in treatment regimes (Chapter 7); use of hormone therapy (Chapter 8); and socioeconomic inequality (Chapter 9). The panel did not pursue differences in alcohol consumption as a potential explanation for the U.S. disadvantage in life expectancy because the United States ranks low in per capita alcohol consumption among OECD countries (Organisation for Economic Co-operation and Development, 2010). Moreover, the panel was unable to address some risk factors because comparable data for the countries of interest (e.g., composition of diet, environmental factors, and stress levels) were not sufficiently detailed to allow intensive investigation. Ultimately, all of these factors will need to be examined in an integrated framework across the entire life course, taking into account the effects of differences in behavioral risk factors, socioeconomic status, and social policy, as well as the effects across particular cohorts and periods.

2

Causes of Death, Health Indicators, and Divergence in Life Expectancy

As discussed in Chapter 1, increases in life expectancy slowed abruptly around 1980 in the United States, Denmark, and the Netherlands. The phenomenon was most noticeable for women in each of these three countries but was also seen to a lesser degree among U.S. men. To better understand these trends, it is useful to examine differences among countries in causes of death, disease prevalence, and biological risk factors.

Because relatively few autopsies are performed and multiple comorbidities are common at older ages, cause-of-death statistics can be somewhat unreliable at older ages. Even though the International Classification of Diseases (ICD) was designed to make it possible to code causes of death uniformly throughout the world, comparative analysis of cause-of-death statistics is complicated by variations in coding practice across countries and changes in the classification scheme over time. Both of these problems can create artificial trends and differentials (see Glei et al., 2010, for a fuller discussion of some of the methodological problems that need to be confronted when using cause-of-death statistics). In any event, information on cause of death is unlikely to tell the whole story. To see whether differences in life expectancy are mirrored in other dimensions of health, it is also useful to examine such factors as disease prevalence; degree of functional disability; and prevalence of risk factors, including high blood pressure, cholesterol, and weight.

THE ROLE OF VARIOUS CAUSES OF DEATH IN DIVERGING LIFE EXPECTANCY TRENDS

Perhaps the most direct approach to understanding diverging trends in life expectancy is to look for differences in trends in the causes of death for different countries. Meslé and Vallin (2006) compared patterns of cause of death for women in the United States, the Netherlands, France, and Japan to better understand the recent divergent trends in female old-age mortality in those countries. To identify the main causes of death responsible for the differences in female life expectancy at older ages, the authors compared the period 1968-1984 against the period 1984–2000 and decomposed the change in life expectancy at age 65 into age- and cause-specific mortality changes. They found that most of the divergence derived from the fact that the declines in mortality due to heart disease and cerebrovascular disease in the United States and the Netherlands were partially offset by increases in several other causes of death in those countries, while Japan and France managed to achieve lower mortality from a variety of causes at increasingly older ages (Meslé and Vallin, 2006).

In a specially commissioned background paper for this report, Glei, Meslé, and Vallin updated and extended this line of work (see Glei et al., 2010). Instead of considering trends in 4 countries, the authors extended their analysis to 10 countries, paying particular attention to the 3 countries identified earlier as underachieving over this period (the United States, Denmark, and the Netherlands) and to the highest achiever, Japan. The authors also extended their analysis to include both men and women and updated their investigation of age- and cause-specific mortality contributions to changes in life expectancy using data up to 2004.

Trends in Causes of Death for the United States, Denmark, the Netherlands, and Japan

Figures 2-1 and 2-2 display trends in age-standardized mortality among men and women aged 50 and above for the United States, Denmark, the Netherlands, and Japan (Glei et al., 2010). To circumvent coding problems, the authors grouped the causes of death into nine clusters.

In the United States, heart disease is the number one cause of death, responsible for more than 600,000 deaths annually (Xu et al., 2010).[1] While the age-standardized mortality rate for both men and women aged 50 and above has declined significantly since 1980 (see Figures 2-1 and 2-2), heart disease remains the number one killer and the major cause of the current

[1]In 2007, the leading 15 causes of death in the United States were (1) heart disease; (2) malignant neoplasms (cancer); (3) cerebrovascular disease (stroke); (4) chronic lower respiratory diseases; (5) accidents (unintentional injuries); (6) Alzheimer's disease; (7) diabetes mellitus (diabetes); (8) influenza and pneumonia; (9) nephritis, nephritic syndrome, and nephrosis (kidney disease); (10) septicemia; (11) intentional self-harm (suicide); (12) chronic liver disease and cirrhosis; (13) essential hypertension and hypertensive renal disease (hypertension); (14) Parkinson's disease; and (15) assault (homicide) (Xu et al., 2010). Note that AIDS has not been one of the 15 leading causes of death in the United States since 1997, although it continues to be one of the five leading causes of death in specific subpopulations.

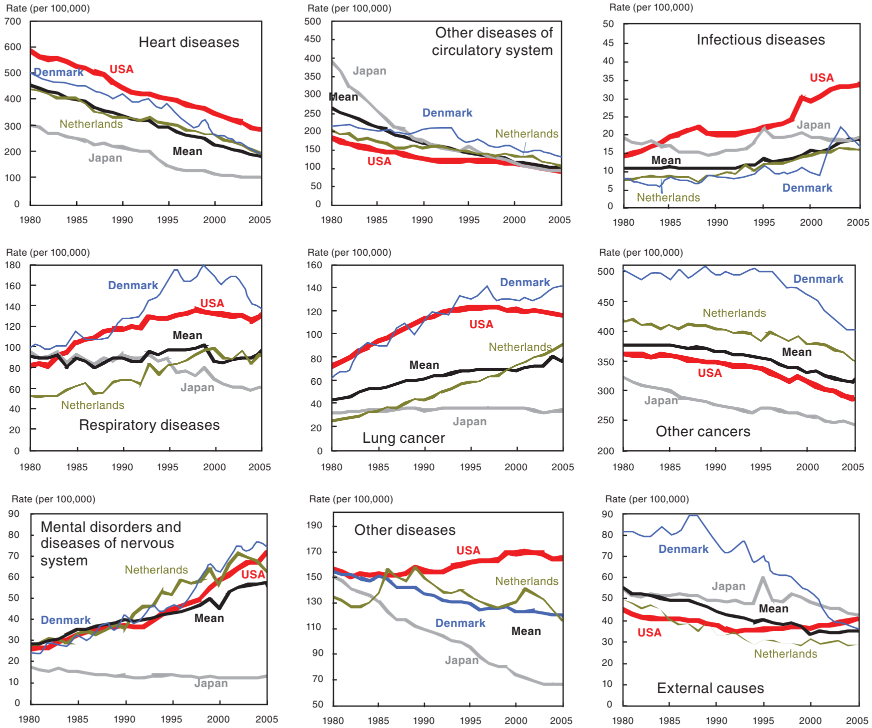

FIGURE 2-1 Age-standardized mortality rates among women aged 50 and older by cause group, United States compared with the Netherlands, Denmark, Japan, and the 10-country average, 1980–2005.
NOTE: Deaths from ill-defined causes have been redistributed proportionately to all other categories.
SOURCE: Glei et al. (2010, Figure 2-6). Reprinted with permission.

gap in female life expectancy at age 50 between the United States and the countries with the highest life expectancies, accounting for 44 percent of the gap with Japan and 50 percent of the gap with France. At the same time, Figures 2-1 and 2-2 demonstrate that the difference in the age-standardized mortality rate due to heart disease has not changed significantly among these four countries over the past 25 years. Consequently, even though the United States has the highest level of mortality due to heart disease of any of the four countries shown, heart disease does not explain the divergent trends in life expectancy. All four countries appear to have experienced similar success in combating heart disease (Glei et al., 2010).

Success in lowering mortality from other diseases of the circulatory system, predominantly cerebrovascular disease, has contributed to life ex-

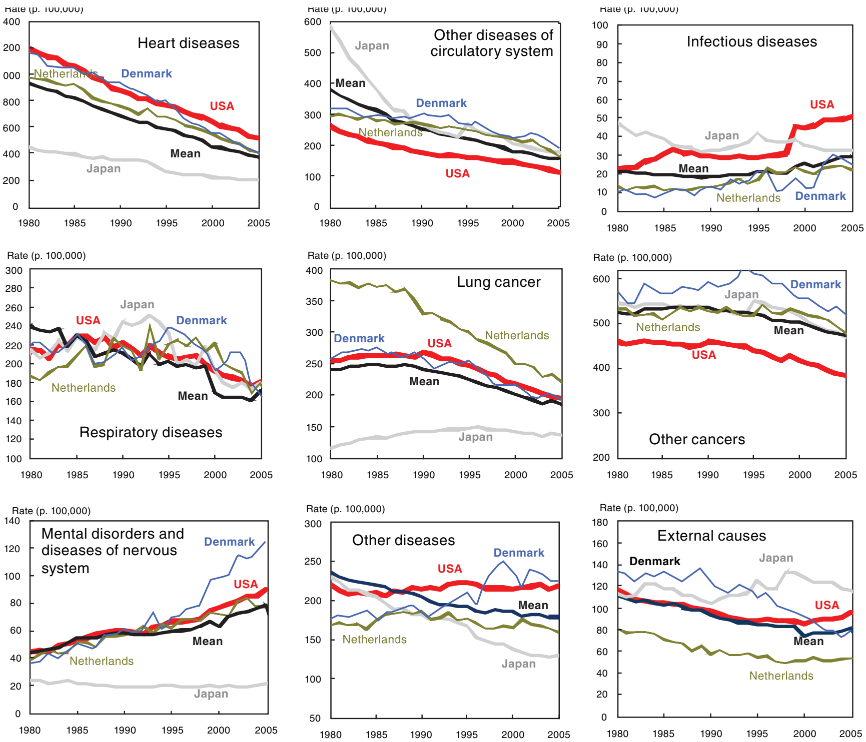

FIGURE 2-2 Age-standardized mortality rates among men aged 50 and older by cause group, United States compared with the Netherlands, Denmark, Japan, and the 10-country average, 1980–2005.
NOTE: Deaths from ill-defined causes have been redistributed proportionately to all other categories.
SOURCE: Glei et al. (2010, Figure 2-7). Reprinted with permission.

pectancy gains in the United States over the past 25 years. But Japan (and other countries such as France, Italy, and Australia) have achieved far greater success, so that differences in mortality related to cerebrovascular disease and other diseases of the circulatory system are an important source of divergence in the trajectories of life expectancy among countries (Glei et al., 2010).

Since 1964, when the first U.S. Surgeon General's report documenting the harmful effects of smoking was published, smoking has been identified as the single greatest cause of preventable morbidity and mortality in the United States. Besides lung cancer, smoking increases the risk of a large number of other cancers, chronic pulmonary obstructive disease (COPD), heart disease, and stroke (Centers for Disease Control and Prevention, 2004).

To examine the extent to which differences in progress in life expectancy can be attributed to smoking-related causes of death, Glei and colleagues (2010) looked at trends in two groups of causes of death strongly associated with smoking: lung cancer and respiratory diseases. For women, they found important differences in both levels and trends in lung cancer among Japan, Denmark, the Netherlands, and the United States. Japan has much lower rates of lung cancer than the three laggards, particularly the United States and Denmark. Age-standardized mortality rates for lung cancer for women over age 50 have risen in the past 25 years in the United States, the Netherlands, and Denmark but have remained flat in Japan. Similarly, women in the United States, Denmark, and to a lesser extent the Netherlands have higher rates of respiratory disease than women in Japan, and these rates have diverged significantly since 1980. The story is slightly different for men (Figure 2-2). The mortality rate for lung cancer among men is lower in Japan than in the other three countries, but these rates appear to be converging rather than diverging over time. In addition, there are virtually no differences in mortality due to respiratory disease among older men in these four countries.

Cause-of-Death Contributions to Country-Level Changes in Life Expectancy at Age 50

Glei and colleagues (2010) used a decomposition technique to separate out the contribution of various causes of death to gains in life expectancy at age 50. Figure 2-3 displays the contributions of the various causes of death to increases in life expectancy at age 50 during 1955–1980 for women (top panel) and men (bottom panel) in the United States, Denmark, and the Netherlands, as well as the mean of the 10 countries the authors analyzed. Figure 2-4 provides the same information for the period 1980–2004. These calculations confirm that the slowdown in life expectancy at age 50 among women in the United States, Denmark, and the Netherlands was not due to heart disease; as noted above, reductions in the rate of mortality from heart disease played an important role in increasing life expectancy in all countries after 1980. On the other hand, other circulatory diseases (which include stroke) did contribute to divergence, as the decreases in mortality from this group of diseases were much smaller for the United States, Denmark, and the Netherlands than they were in other countries for both men and women.

The other important contributors to the slowdown in gains in life expectancy at age 50 among women in the United States, Denmark, and the Netherlands were lung cancer, respiratory diseases, mental and nervous system diseases,[2] and "other diseases." Rising numbers of lung cancer

[2]The term "diseases" here encompasses conditions considered both diseases and disorders.

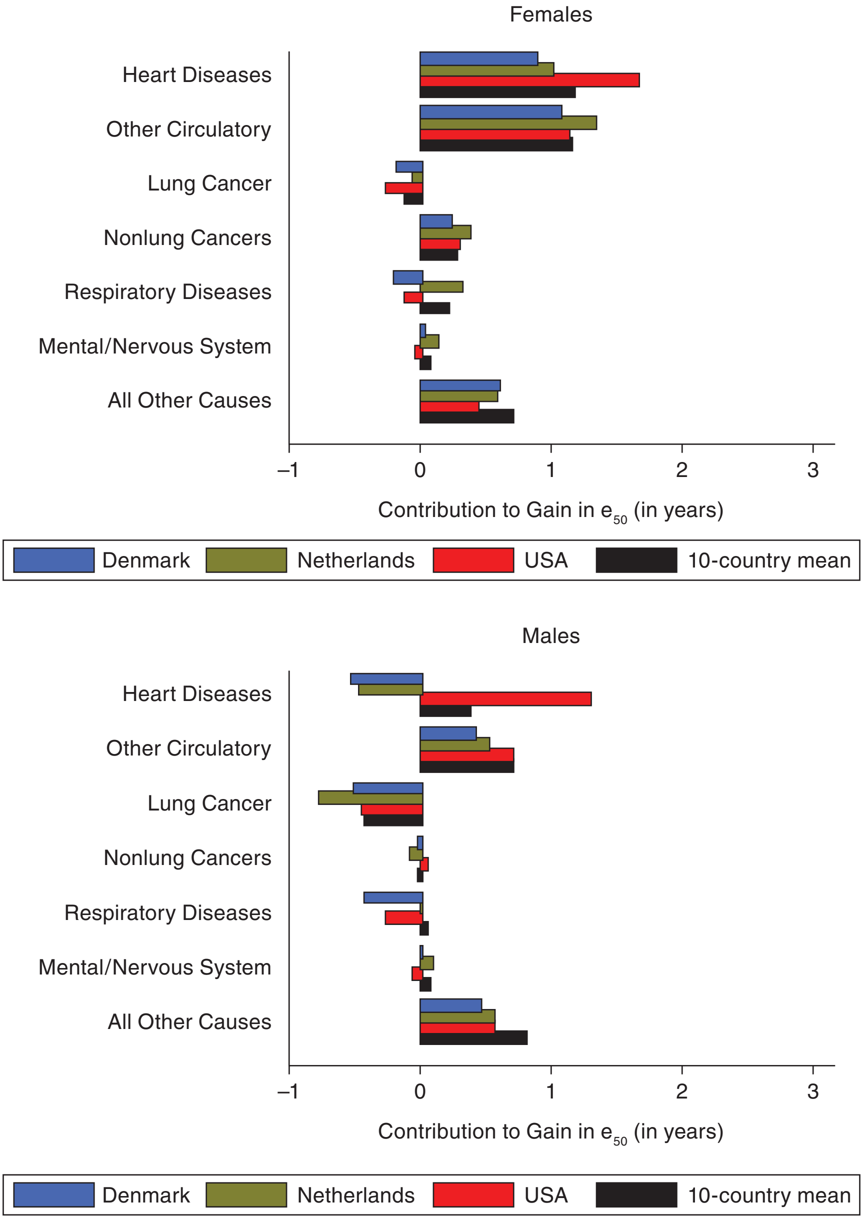

FIGURE 2-3 Contributions of causes of death to gains in life expectancy at age 50, 1955–1980.
NOTE: Deaths from ill-defined causes have been redistributed proportionately to all other categories.
SOURCE: Glei et al. (2010, Figure 2-8). Reprinted with permission.

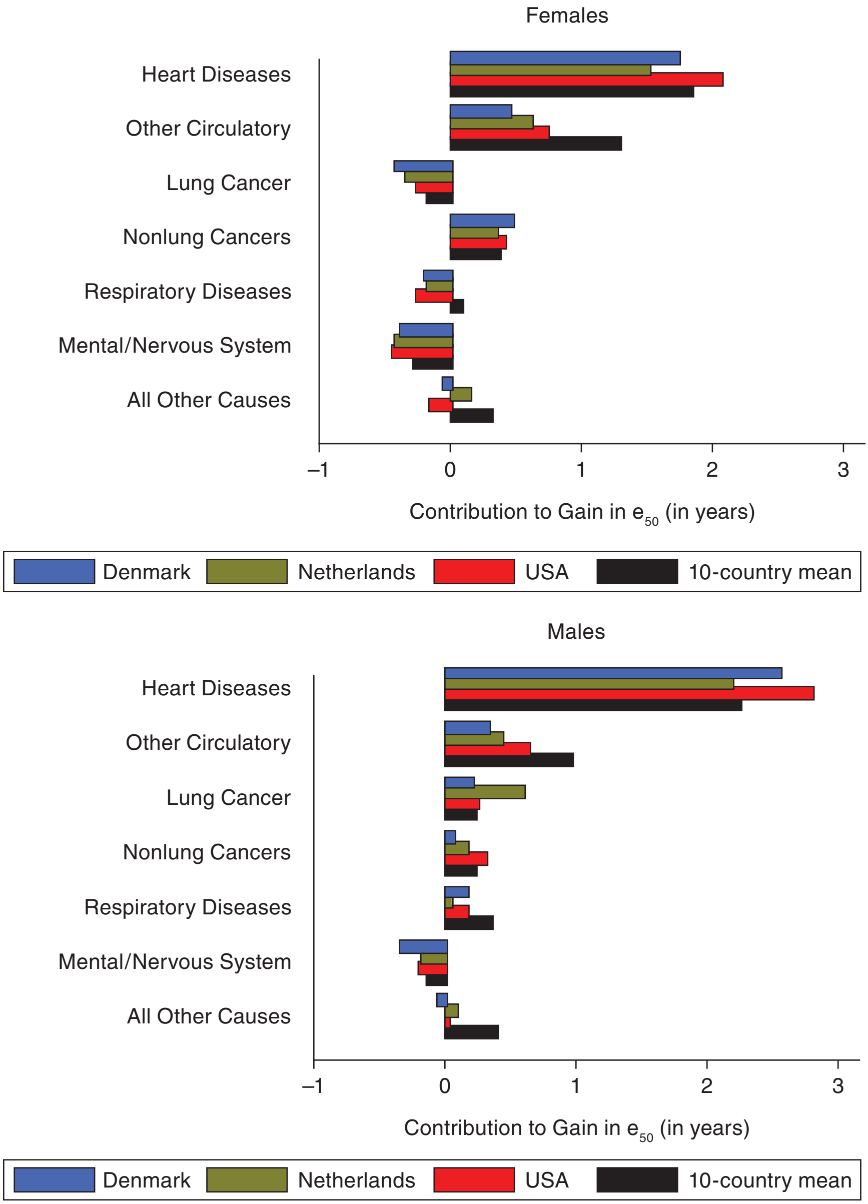

FIGURE 2-4 Contributions of causes of death to gains in life expectancy at age 50, 1980–2004.
NOTE: Deaths from ill-defined causes have been redistributed proportionately to all other categories.
SOURCE: Glei et al. (2010, Figure 2-9). Reprinted with permission.

deaths reduced female life expectancy in the United States, Denmark, and the Netherlands during 1955–1980 and even more so during 1980–2004. It is worth noting that, although lung cancer had a negative effect on gains in life expectancy at age 50 for women in the underperforming countries, the same was not true for other types of cancer. Progress against nonlung cancers in the United States, Denmark, and the Netherlands was comparable to that in other countries during both periods. By contrast, although mortality due to lung cancer had a negative effect on gains in life expectancy at age 50 among men during 1955–1980, its effect was positive for men in the United States and most other countries during 1980–2004.

The importance of smoking as an explanation for the observed divergence in trends in life expectancy is also suggested by the fact that respiratory diseases appear to have played a role in the divergence during 1980–2004. Mortality from respiratory diseases most commonly implies death from COPD, the leading cause of which is smoking. Since 1980, mortality from respiratory diseases has fallen for men in all countries shown in Figure 2-4 but has risen for women in the United States, Denmark, and the Netherlands.

Mental and nervous system diseases had a negative effect on gains in life expectancy at age 50 for nearly all 10 countries and for both men and women for the period 1980–2004, but this effect was largest among women in the United States, the Netherlands, Denmark, Canada, and Spain. It is difficult to say what these trends might mean, however. Some of the numerically important diseases in this category are Alzheimer's, Parkinson's, and Huntington's diseases. There are questions about how systematically this category of diseases is coded in different countries and over time. For instance, as Alzheimer's disease became a recognized and diagnosed disease, the propensity to code it as a cause of death may have varied across countries. It is impossible to distinguish this possibility from real differences in mortality due to these diseases across countries. Finally, while the category of "other diseases" contributed to increases in life expectancy at age 50 in most countries and for both men and women, it had a negative effect on life expectancy among women in the United States and Denmark. The most important single disease in this category is diabetes.

Discussion

One of the most striking features of the divergence in life expectancy trends since 1980 is that it has been seen mainly in women. Cause-of-death data point to the particular areas in which progress has slowed for women. The most notable gender differences in the United States, Denmark, and the Netherlands are in the contributions to changes in life expectancy at age 50 made by lung cancer and respiratory diseases. Both diseases had a positive effect on the change in life expectancy at age 50 among men but a negative effect among women; that is, mortality from these causes was decreasing among men while it was increasing among women. Moreover, women from the United States, Denmark, and the Netherlands exhibited larger increases in mortality related to lung cancer and respiratory diseases during the period 1980–2004 compared with 1955–1980 and compared with women from the remaining countries during 1980–2004 (Glei et al., 2010). In short, the increase in mortality from these diseases during this period and in these countries was an anomaly regardless of what it is measured against: mortality in the earlier period, male mortality, or female mortality in other countries.

Although this analysis does not identify the factors underlying the differences in the cause-of-death trends, it does point clearly in a particular direction: "Based on the evidence presented here, the most obvious explanation for the slowing of mortality decline among women in the United States, Denmark, and the Netherlands is smoking, which is strongly correlated with lung cancer and respiratory diseases such as chronic obstructive pulmonary disease" (Glei et al., 2010, p. 44). The existence of gender differences in the contributions of lung cancer and respiratory diseases to life expectancy would appear to point to gender differences in smoking behavior within the United States, Denmark, and the Netherlands, and such differences have indeed been observed: increases in smoking occurred later among women, while declines in smoking took place earlier among men (Forey et al., 2009).

While the evidence presented in the Glei et al. analysis is consistent with the hypothesis that smoking was an important factor in the slowing of mortality decline among women in these three countries, smoking is unlikely to be the entire story. The data suggest that mental and nervous system diseases, including Alzheimer's disease, may also play a role. Of interest, in the Netherlands, where women again began seeing a steady increase in life expectancy at age 50 after 2002, the gains in mortality resulted from improvement in the mortality risk for mental disorders as well as other causes of death, such as diabetes (Glei et al., 2010).

The cause-of-death data reviewed here provide some important insights into the reasons for diverging levels and trends in life expectancy. For a more complete picture, however, it is necessary to examine how these countries differ in a variety of health indicators.

THE ROLE OF DIFFERENCES IN HEALTH INDICATORS IN DIVERGING LIFE EXPECTANCY TRENDS

The panel considered the questions of whether increasing life expectancy has been a result of improvements in health and whether the countries with the greatest increases in life expectancy also have seen greater improvements in health. Such questions cannot be answered fully, as the data are both incomplete and not totally comparable from country to country. Nonetheless, enough data exist to address the issue of whether countries lagging behind in life expectancy currently have worse health than countries experiencing more rapid improvement.

Health Versus Life Expectancy

It makes sense intuitively that better health should be directly correlated with greater life expectancy—that a "healthier" population should be one in which people live longer—but this relationship is not always simple. In the past, when infectious diseases played a major role in mortality, healthier groups of people were likely to have lower death rates (Crimmins et al., 2010). Today, however, death is more likely to be caused by long-term chronic conditions that have been treated but not cured. Modern medicine enables people to live for many years with conditions that have been ameliorated and controlled, so modern populations include large numbers of people living with various diseases and disorders, some of them for decades. This means that a longer-lived group may not necessarily be "healthier" than a group with a shorter life expectancy; the group may instead consist of many ill people whom modern medicine has kept alive but not cured.

One important type of data denotes the percentage of people in a country who are experiencing a particular health problem at a particular point in time, termed the prevalence of the problem (Crimmins et al., 2010). A population can be "healthier" in terms of the prevalence of a particular disease in two ways: (1) the incidence of the disease can be lower—that is, fewer people develop it to begin with—or (2) the people who develop the disease do not survive as long. Conversely, prevalence will be higher if either the incidence of the disease is higher—more people develop it—or people live longer after developing it. A further difficulty in international comparisons arises from varying levels of screening and identification of some health problems and some risk factors. A country, such as the United States, with aggressive screening will appear to have both greater incidence and greater prevalence of health problems than a country with poorer screening, all other things being equal. So the existence of national differences in health problems—incidence or prevalence—is not free of some difficulty in interpretation.

Several different dimensions of health—risk factors, diseases, disability—may be related to life expectancy in varying ways (Crimmins et al., 2010). A number of conditions, such as arthritis, cause disability but are not major causes of mortality. Conversely, diseases such as cancer affect mortality but are not a major cause of disability. And some diseases, such as heart disease, lead to both disability and mortality. In the remainder of this section, data from a variety of self-reports in nationally representative surveys and medical records are presented for the 10 countries that are the focus of this study. The data, taken mainly from Crimmins et al. (2010), include various indicators of functioning and disability, estimates of disease prevalence, and estimates of the prevalence of three major risk factors—high body mass index, cholesterol levels, and levels of hypertension.

Differences in Disease Prevalence

Heart Disease, Stroke, and Diabetes

Cardiovascular disease accounts for about half of the female gap in life expectancy at age 50 between the United States and the nine other countries studied here and for most of the male gap. Self-reports of having been diagnosed with heart disease among those aged 65 and over are more numerous in the United States than in the other countries: only England has a rate close to that of the United States, while people in Japan and Denmark report heart disease at a rate less than half that in the United States (see Table 2-1). The highest prevalence of self-reported stroke is found among Danish men, with men from the United States, Japan, and England fairly close behind. By contrast, the highest rates among women are reported in the United States, followed by women from the Netherlands and Denmark. Glei and colleagues (2010) report a convergence in death rates from cerebrovascular disease between the United States and other countries; this is the category that includes stroke deaths. This convergence has occurred because other countries have improved more than the United States, which used to have relatively favorable stroke death rates.

TABLE 2-1 Percentage of Population Self-Reporting Diseases by Gender and Country: Ages 65+

	Men			Women		
Country	Heart Disease	Stroke	Diabetes	Heart Disease	Stroke	Diabetes
United States	36.4	9.4	21.4	28.0	8.6	17.6
Denmark	15.9	9.9	11.1	13.0	7.3	8.7
France	28.8	5.5	13.0	16.3	5.8	10.8
Italy	18.7	5.8	17.6	14.3	4.0	15.7
Netherlands	21.7	7.1	10.6	12.9	7.8	12.2
Spain	15.1	2.9	20.4	15.5	2.8	17.1
England	32.2	8.2	11.2	26.4	6.4	8.0
Japan	14.4	9.3	10.1	12.2	6.0	7.5
Canada	21.8	5.2	15.6	18.1	3.9	11.9
Australia			16.2			11.5

SOURCE: Adapted from Crimmins et al. (2010, Table 3-2). Reprinted with permission.

Glei and colleagues found that deaths from diabetes contributed about 0.1 year to the difference in life expectancy at age 50 between the United States and the other nine countries (Glei et al., 2010). When Crimmins and colleagues (2010) examined the self-reported prevalence of diabetes in the different countries, they found it to be highest in the United States, with Spain and Italy close behind. The prevalences in Denmark, England, and Japan were only about half those in the United States (see Table 2-1).

When all three of the diseases—heart disease, stroke, and diabetes—are considered, a pattern emerges: Americans report a high prevalence of each of these diseases relative to the other nine countries. It is not always the highest prevalence, but it is generally in the top two or three. Other countries may rank high on one disease, but it is usually just one. The high prevalence of these diseases in the United States is not surprising given the comparative mortality levels for heart disease and some other diseases shown in Figures 2-1 and 2-2; however, it is also true that national levels of self-reported rates of these three diseases do not correlate well with life expectancy. When the prevalence of self-reported heart disease, stroke, and diabetes is compared with life expectancy from country to country, little correlation is found (see Crimmins et al., 2010).[3]

Cancer

It may be particularly difficult to know which countries have a high incidence of cancer because variations in intensity of screening can produce differences in reported incidence that are unrelated to actual incidence. Rates of screening for prostate, breast, and colorectal cancers differ across these countries (Crimmins et al., 2010; Garcia, 2010; Preston and Ho, 2010). With respect to reported incidence, the United States has the highest rates for lung, prostate, and breast cancers (Crimmins et al., 2010; Preston and Ho, 2010), while Japanese men have the highest rates for colorectal cancer.

Preston and Ho (2010) discuss the link between high levels of screening and the relatively low mortality from both prostate and breast cancers in the United States. The Japanese have particularly low rates of both incidence and mortality for these cancers. Relative to Europe, mortality rates from colorectal cancers in the United States are quite low (Garcia, 2010). The high levels of mortality from lung cancer among American women were discussed above; because lung cancer is not screened for, its incidence is likely to reflect clinically diagnosed cases. The fact that several cancer incidence rates are so high in the United States while cancer mortality rates—except for lung cancer among women—are not particularly high is likely to stem

[3]Because prevalence rates are based on self-reports, another possible explanation for higher rates of heart disease and diabetes is that older Americans have more screening for these diseases (as discussed later in the report).

from differences in screening. It appears probable that higher levels of cancer screening in the United States have led to the greater reported incidence of a number of cancers and to a reduction in mortality (Crimmins et al., 2010; Preston and Ho, 2010). Denmark and the Netherlands have higher mortality from prostate, breast, and colorectal cancers than the United States; as indicated above, they also have relatively high levels of lung cancer. Screening appears to be markedly less prevalent in Denmark (Garcia, 2010).

Differences in Risk Factors

A high cholesterol level, high blood pressure, diabetes, smoking, and obesity are well known to be risk factors for morbidity and mortality from cardiovascular disease and other causes of death. The panel considered whether differences in these risk factors might play a role in the diverging trends in life expectancy between the United States and other high-income countries. Recent research indicates that certain biological risk factors, such as high levels of glycated hemoglobin, cholesterol, C-reactive protein, systolic blood pressure, or fibrinogen, are more common among Americans than among the English and Japanese (Banks et al., 2006; Crimmins et al., 2008).

High Cholesterol Levels

Self-reports of ever having been diagnosed with high cholesterol are two to three times more frequent in the United States than in other countries (Crimmins et al., 2010). According to available data from the World Health Organization (WHO), however, people in the United States do not have higher measured cholesterol levels than people in other high-income countries (see Table 2-2). Among the countries under study with comparable data, measured cholesterol levels are broadly similar, with the exception of higher levels among the English. This national difference in the ranking

TABLE 2-2 Percentage of Population Having Measured Prevalence of High Cholesterol (≥240 mg/dl), Ages 50–64

Country	Men	Women
United States (2001–2006)	19.7	26.7
Netherlands (2001)	23.8	28.3
Spain (1992)	24.3	32.8
England (2004)	38.7	51.2
Japan (2004)	14.4	28.6
Canada (1990)	27.8	28.6

SOURCE: Adapted from Crimmins et al. (2010, Table 3-3). Reprinted with permission.

of ever having been diagnosed with high cholesterol and currently being measured as having high cholesterol is related to the increasing tendency to take drugs that lower cholesterol levels. Although the use of cholesterol-lowering drugs is increasing rapidly in most high-income countries, it is particularly high in the United States (see Table 2-3). In short, more people in the United States have been diagnosed with high cholesterol levels and prescribed drugs to lower those levels, and because the drugs are effective, the percentage of people in the United States with measured high cholesterol is lower than that in some other countries (see Table 2-2).

High Blood Pressure

The picture for high blood pressure is in many ways parallel to that for high cholesterol levels. People in the United States are more likely to report that they have been told they have hypertension at some time in the past (Crimmins et al., 2010). Yet men in the United States generally have relatively low measured blood pressure levels compared with men in other countries; this is less true for women (see Table 2-4). Notably, Japan appears

TABLE 2-3 Percentage of Population Taking Lipid-Lowering Drugs

	Ages 50+	
Country	Men	Women
United States (2001–2006)	26.8	24.1
Denmark (2004)	12.9	9.4
France (2004)	23.3	21.6
Italy (2004)	12.2	12.9
Netherlands (2004)	15.0	12.3
Spain (2004)	15.4	16.1
Japan (2004, 2006)	8.3	15.1
Canada (2003)	24.5	20.3
Australia (1999–2001)	16.3	16.5

SOURCE: Adapted from Crimmins et al. (2010, Table 3-4). Reprinted with permission.

TABLE 2-4 Percentage of Population Having Measured High Blood Pressure (≥140/90 mm Hg), Ages 50–64

Country	Men	Women
United States (2001–2006)	28.1	36.6
France (1996)	60.6	65.2
England (2004)	33.4	27.9
Japan (2000)	52.5	41.2
Australia (1999–2000)	39.0	33.4

SOURCE: Adapted from Crimmins et al. (2010, Table 3-5). Reprinted with permission.

TABLE 2-5 Percentage of Population Using Antihypertensive Drugs by Gender and Country: Ages 50+

Country	Men	Women
United States	47.2	50.4
Denmark	28.3	25.8
France	29.4	34.6
Italy	34.1	38.8
Netherlands	22.4	27.7
Spain	24.6	36.9
England	27.7	29.8
Japan	28.0	31.0
Canada	27.0	30.7
Australia	28.0	36.2

SOURCE: Adapted from Crimmins et al. (2010, Table 3-6). Reprinted with permission.

to have more measured high blood pressure than the United States. The fact that Americans have the highest use of antihypertensive medications (see Table 2-5) is probably part of the explanation: it appears that hypertension has been screened for and treated much more aggressively in the United States than in most other countries (Wang et al., 2007).

Obesity

One of the most notable health issues in the developed world over the past several decades is the rise of obesity. Obesity is linked to higher risk of cardiovascular disease, cancer, hypertension, type-2 diabetes, and a host of other cardiovascular and metabolic disorders (Hu, 2008). People have been getting heavier in every developed country, but nowhere is that pattern as pronounced as in the United States. Americans have been gaining more weight and gaining it at earlier ages than people in other countries (Andreyeva et al., 2007; Bleich et al., 2008; Rabin et al., 2007), and the percentage of those who are obese is higher in the United States than in any other developed country (Michaud et al., 2007). For ages 50 and above, the only groups with current levels of obesity even close to those in the United States are English men and Spanish women; for ages 65 and over, the levels of obesity are actually higher among English men and women and Spanish women. On the other hand, the obesity rate is very low in Japan. The link between obesity and mortality in the 10 countries studied here is addressed in detail in Chapter 3.

Differences in Levels of Disability

In studying disability, Crimmins and colleagues (2010) used two measures, indicating less severe and more severe disability. The first was difficulty in performing at least one of 10 tasks known as Nagi functions, which include such things as lifting one's arms above the head, carrying an object that weighs as much as 10 pounds, walking two to three blocks, and grasping small objects. The second measure was having difficulty performing at least one of the six so-called activities of daily living (ADLs), which include walking, eating, dressing, and using the toilet. Difficulty in performing an ADL typically indicates a higher level of disability than difficulty performing a Nagi function.

Americans aged 50 and older report greater levels of functional disability than people in the seven other countries for which data are available (see Table 2-6); the Danish and the Dutch report the lowest levels. The situation is similar for ADLs, except that among those aged 50 and over, English men and women report the highest levels of ADL disability, with U.S. men and women in second place. For those over age 65, somewhat smaller differences exist among the countries: Japan and the Netherlands are the only two whose prevalence of ADL disability is lower than that of the other countries.

Although there do appear to be higher levels of functional disability in the United States than in most of the other countries in the study, higher disability does not appear to be significantly correlated with lower life expectancy (see Crimmins et al., 2010).

Discussion

The United States appears to have worse health than the comparison countries by many indicators. Death rates from two leading causes of death—heart disease and diabetes—are both relatively high in the United States. The fact that heart disease accounts for most of the differences in life expectancy between the United States and the other countries must be related to higher levels of heart disease *per se* in the United States, although

TABLE 2-6 Percentage of Population Self-Reporting Functioning Problems: Ages 50+

Country	Men	Women
United States	61.5	74.0
Denmark	34.2	50.3
France	38.3	59.0
Italy	43.8	60.2
Netherlands	31.7	51.5
Spain	43.1	64.9
England	49.2	64.0

SOURCE: Adapted from Crimmins et al. (2010, Table 3-1). Reprinted with permission.

it may also be related to the much higher levels of diagnosed heart disease in the United States. Through high levels of diagnosis and treatment, however, the levels of measured risk from high blood pressure and cholesterol—two major cardiovascular risk factors—have been reduced below those in most of the comparison countries. National levels of obesity, which are related to national levels of diabetes, may explain the high levels of the latter condition and its relative contribution to loss of life expectancy in the United States.

In many ways, Japan is the antithesis of the United States. Its population has relatively little heart disease and diabetes; functioning is good, and disability is low. In addition, a number of cancers are quite low in terms of both incidence and mortality in Japan. On the other hand, Japan has managed to be the world leader in life expectancy despite relatively high levels of high blood pressure and stroke. While the United States and Japan line up well at the extremes of longevity and disease prevalence, the association is less clear for other countries. In particular, while they share poor life expectancy trends with the United States, the Netherlands and Denmark differ from the United States in a number of aspects of health. They report relatively low levels of heart disease and diabetes and have relatively little disability. On the other hand, women in these three countries report more stroke than those in other countries. While morbidity and disability supply some pieces to the longevity puzzle, then, their signals are somewhat ambiguous.

3

The Role of Obesity

It is well known that people in the United States have, on average, higher weight for a particular height than people in other developed countries. It is also well known that obesity is associated with a variety of negative health effects, such as diabetes, heart disease, high blood pressure, and certain types of cancer (Prospective Studies Collaboration, 2009). So it is natural to ask whether the higher rates of obesity in the United States may help explain the divergence in life expectancy trends that has been observed over the past quarter of a century.

In discussing the role of obesity in mortality, it should be recognized that one becomes obese by virtue of caloric expenditure falling short of caloric intake. Thus, lack of adequate physical activity is intrinsic to the process of becoming obese. Empirically, obese people maintain, on average, lower levels of physical activity (Adams et al., 2006). Some epidemiologic studies consider the effects of both low levels of physical activity and obesity on mortality. Typically, both are shown to have independent effects (see, for example, Hu et al., 2004). Other studies do not consider the roles of physical activity and obesity separately. In these cases, the effects of obesity on mortality will also reflect the effects of physical activity since obesity and lack of physical activity are correlated.

INTERNATIONAL TRENDS IN OBESITY

To explore the relationship between obesity levels and life expectancy trends, one must first define obesity, which is not as simple as it might appear, and then track trends in obesity in the various countries under study.

It then becomes possible to look for correlations between those trends and the varying trends in life expectancy.

Body Mass Index and Weight Categories

The standard way of assessing a person's weight relative to height is with body mass index (BMI), defined as a person's weight in kilograms divided by the square of the person's height measured in meters. Thus, a person who weighs 75 kilograms (165 pounds) and is 1.75 meters high (5 feet, 9 inches) has a BMI of 24.5.

According to the World Health Organization (2006), a person is of normal weight if he or she has a BMI between 18.50 and 24.99. A person with a BMI of 25 or more is considered overweight, while anyone with a BMI of 30 or more is considered obese. Obesity is further subdivided into Class 1 (30–34.99), Class 2 (35–39.99), and Class 3 (40 and above). For instance, a person who is 1.6 meters (5 feet, 3 inches) tall and weighs 77 kilograms (169 pounds) has a BMI of slightly more than 30, or is borderline obese.

BMI is the most widely used measure for determining obesity mainly because it is convenient. It is easy and straightforward to obtain a person's height and weight and then apply the BMI formula. Other measures of obesity, such as percentage of body fat, are generally much more difficult to determine accurately. However, errors are not uncommon in self-reports of height and weight (Ezzati et al., 2006). Balancing out its convenience, moreover, is the fact that BMI is no more than a rough measure of how fat a person is. People who are particularly muscular will have a high BMI, for instance, even if they have very low body fat. Furthermore, there is evidence that not all fat is created equal and that certain fat distributions—such as intra-abdominal fat around the waist area—are unhealthier than others (Bergman et al., 2006; Snijder et al., 2006). Thus, many studies use other measures, such as waist-to-hip ratio or body fat percentage, to gauge health risks. Still, BMI has the advantage that, because it is so convenient, far more data—particularly historical and international data—exist for it than for any of the other measures. For that reason, this chapter focuses on BMI data while noting the limitations of relying strictly on these data and describing other relevant data where they exist.

Obesity Trends in the United States and Other Countries

One of the most striking health-related trends in the United States over the past 50 years has been the rise of obesity. As can be seen in Figure 3-1, in 1960–1962 only 10.7 percent of adult males and 15.8 percent of adult females in the country were obese. By 2007–2008, those numbers had risen to 32.2 and 35.5 percent, respectively. For both sexes, the growth in obesity

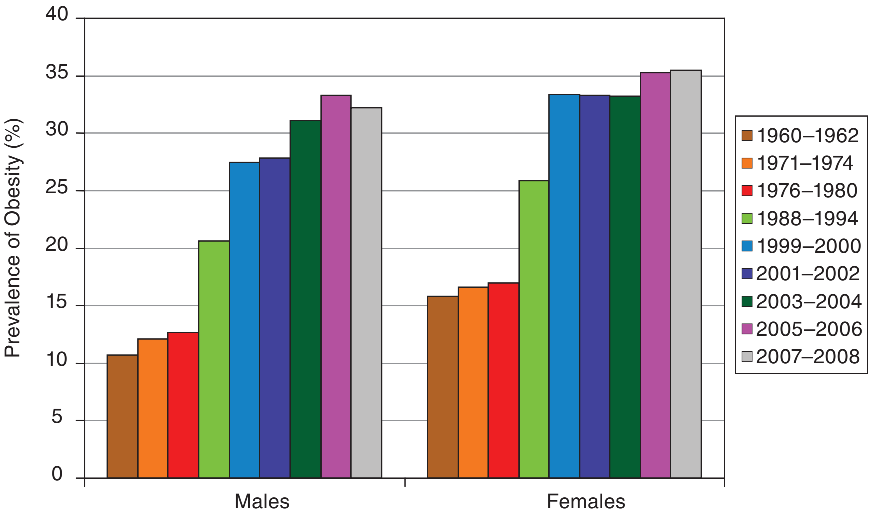

FIGURE 3-1 Age-adjusted percentage of obesity in Americans aged 20+, by gender.
SOURCE: Data from Flegal et al. (2002, 2010).

was relatively slow in the 1960s and 1970s, increased sharply in the 1980s and 1990s, and then slowed in recent years.

The same pattern has played out in most other high-income countries, including those studied here, but it has generally been less pronounced than in the United States. Figure 3-2 displays the adult obesity rates for the 10 high-income countries under study. As can be seen from the top panel in the figure, U.S. men have had the highest rate of obesity among those countries for the past 30 years. Around 1978 (the data were collected between 1976 and 1980), the rate of obesity among U.S. men was about 13 percent. Obesity rates in the other countries at that time ranged from 0.8 percent in Japan to about 12 percent in Canada, with most countries at 5 to 10 percent.

Twenty-five years later, in 2003, the rate of obesity among U.S. men had jumped to 32 percent—an increase of nearly 150 percent above the 1978 rate. During the same quarter century, adult male obesity rates were also increasing in the other high-income countries, so that by 2003 only Japan and Italy had rates below 10 percent. Canada and England, at 23 percent, had the highest rates after the United States.

The pattern among adult women was similar. Around 1978, some 17 percent of U.S. women were obese, a figure that grew to 35 percent by 2003. The obesity rate among Japanese women remained below 5 percent, the rate among Italian women stayed below 10 percent, and the rates for women in the remaining countries were between 10 and 25 percent in 2003.

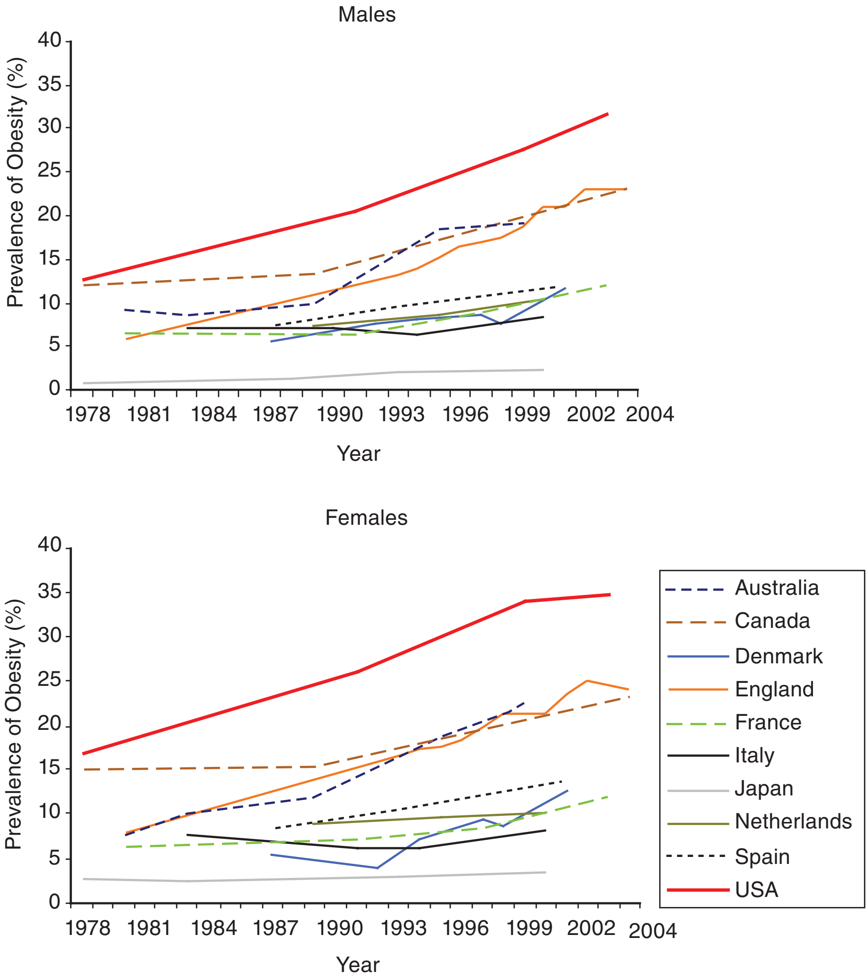

FIGURE 3-2 Trends in prevalence of adult obesity by country and gender, 1978–2004.
NOTE: Age ranges vary. The majority of data sources were designed to be nationally representative (with the exception of data before 1999 in Australia and all data from the Netherlands, which were collected in major cities only). Where surveys spanned multiple years, prevalence estimates shown are based on the midpoint of survey collection.
SOURCE: Alley et al. (2010, Figure 6-1). Reproduced with permission.

In short, most of the high-income countries studied here have experienced a similar trend of increasing obesity among adult men and women, but the United States is ahead of the curve. The rates of obesity in the United States during the late 1970s were already higher than the rates in most of the other high-income countries today. In general, obesity rates in the United States appear to be ahead of those in the other countries by 15 to 25 years. If the obesity rates in the United States are indeed leveling off, it is possible that these other countries may catch up sometime in the next few decades, but for now the United States is far ahead of the other high-income countries.

The data on obesity rates for older adults are not as complete as they are for all adults, but as can be seen in Figure 3-3, the existing data show similar trends for this group. In particular, the rates in the United States are again higher than those in the other high-income countries, although the divergence is not as great. In the United States, the rate of obesity among men aged 50–59 grew from 14 percent in 1978 to 35 percent in 2003, while the rate among women grew from 23 to 38 percent. Again, the Japanese have the lowest rates of obesity for older men and women—less than 5 percent—while England and Australia are the closest to the United States.

Of interest, Denmark and the Netherlands—the two other countries with less-than-expected growth in life expectancy over the past 25 years—have obesity rates much lower than those in the United States. In 2002, only 18 percent of older Dutch men were obese, compared with 35 percent of older U.S. men; 28 percent of older Dutch women were obese, compared with 38 percent of older U.S. women. Danish men aged 50+ have approximately the same level of obesity as men in the Netherlands and the same level as Danish women (18 percent) (Crimmins et al., 2010).

RELATIONSHIP AMONG OBESITY, HEALTH, AND MORTALITY

Obesity is known to be harmful in a number of interrelated ways: it is associated with various diseases, it leads to different types of disability, and it shortens lives. To identify what role, if any, obesity has played in causing the divergent trends in life expectancy, it is necessary to distinguish these various effects and to examine them individually to the extent possible.

Disease and Disability

Numerous studies have documented the ways in which being overweight or obese damages health. The most common effects include diabetes; high blood pressure; heart disease; gallstones; and certain cancers, such as colorectal cancer, breast cancer in women, endometrial cancer, and cancers of the kidney, pancreas, liver, and gallbladder (Hu, 2008). Type 2 diabetes

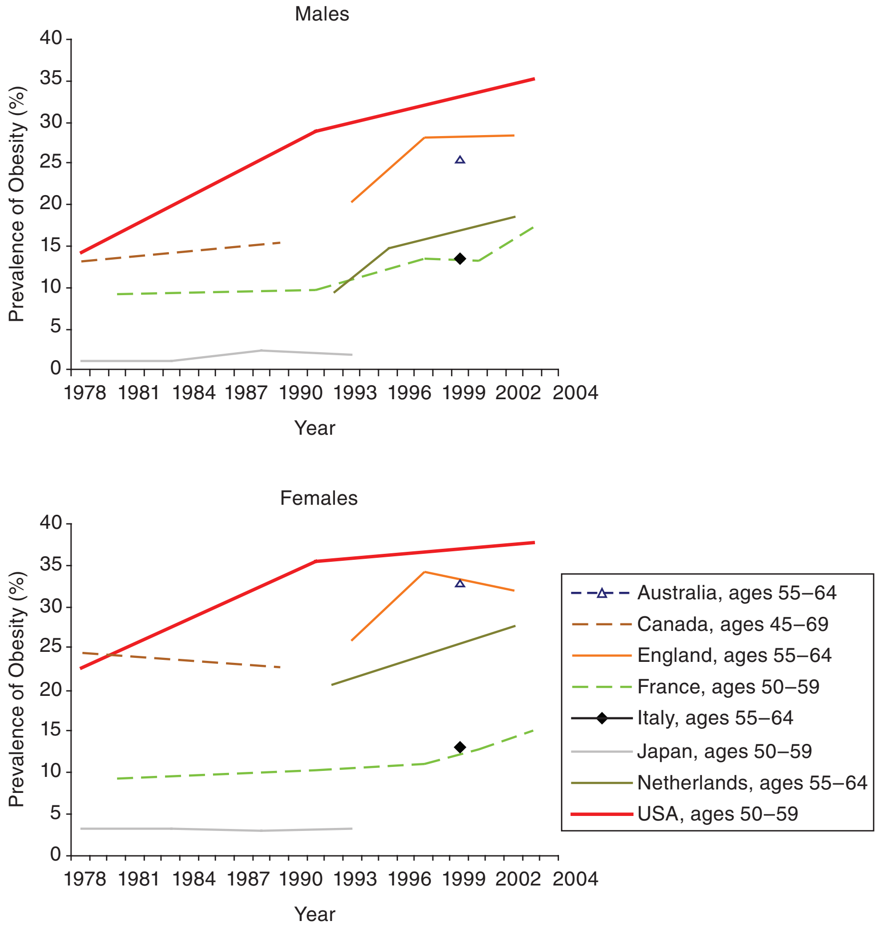

FIGURE 3-3 Trends in obesity prevalence by country and gender: Older adults, 1978–2004.
NOTE: Data are nationally representative unless otherwise noted. Australia: measured height and weight (Cameron et al., 2003); Canada: self-reported height and weight (Torrance et al., 2002); England: measured height and weight (Rennie and Jebb, 2005); France: self-reported height and weight (Charles et al., 2008; Maillard et al., 1999); Italy: self-reported height and weight (Calza et al., 2008); Japan: measured height and weight (Yoshiike et al., 2002); Netherlands: measured height and weight from three cities (Schokker et al., 2007); United States: measured height and weight (Flegal et al., 2002) and author analysis of National Health and Nutrition Examination Survey (NHANES) data.
SOURCE: Alley et al. (2010, Figure 6-2). Reproduced with permission.

is particularly sensitive to body weight. It is very rare in people of normal weight, and the risk for developing it increases rapidly with increasing BMI. The risks of developing high blood pressure, coronary heart disease, and gallstones also grow as BMI increases, as do the risks for the various obesity-related cancers, but none of these conditions is as sensitive to BMI as diabetes (Hu, 2008).

The relationship between obesity and various diseases is also apparent in international comparisons. In analyzing the 10 high-income countries considered in this study, Crimmins and colleagues (2010) found a clear relationship between national levels of obesity and national rates of diabetes and heart disease among people over 50. Those countries with the highest rates of obesity were those hardest hit by diabetes and heart disease in older adults.

Obesity in older adults is also associated with various types of disabilities. The excess weight itself can make it difficult to perform certain activities, such as climbing stairs or walking for long distances, and it frequently leads to joint problems. These limitations are often exacerbated by the various chronic diseases associated with obesity—diabetes, high blood pressure, heart disease, gallstones, and others—which lead to their own characteristic disabilities. When Crimmins and colleagues compared the rates of obesity in people over 50 in various high-income countries with the percentage reporting disabilities, they found a strong relationship, with the countries with higher rates of obesity also having greater numbers of older adults with disabilities (Crimmins et al., 2010, Table 3-9).

Mortality

The effect of being overweight (i.e., having a BMI between 25 and 29) or obese (i.e., having a BMI over 30) on the risk of dying has been an area of rather contentious debate. Some well-publicized studies have claimed, for instance, that hundreds of thousands of Americans die prematurely each year because they are overweight or obese. In 1999, Allison and colleagues calculated that in 1991, between 280,000 and 325,000 deaths of U.S. adults were due to overweight and obesity (Allison et al., 1999a, 1999b). Six years later, Mokdad and colleagues announced that overweight and obesity (together with physical inactivity) had been responsible for 365,000 excess deaths among U.S. adults in 2000, making it the second-leading preventable cause of death in the United States, behind only smoking (Mokdad et al., 2005).

Those numbers, which were publicized widely, now appear likely to have been major overestimates. For example, one study published shortly after the Mokdad et al. (2005) article that used more recent data and took into account how mortality risk varies by age yielded much smaller numbers (Flegal et al., 2005). According to that study, obesity, defined as a BMI of 30 or above, caused approximately 112,000 excess deaths among U.S. adults in 2000, while being overweight had a protective effect and led to 86,000 fewer deaths than would have been expected if all of those people had had a BMI in the normal range. The net result was that overweight and obesity together resulted in an excess of 26,000 deaths in 2000, the authors concluded, which was less than a tenth of the earlier estimate.

Complicating the discussion of weight and mortality is the fact that as BMI decreases below normal range, mortality increases. Virtually all studies find that the curve of mortality risk and BMI is U-shaped or J-shaped, with mortality somewhat higher at the low- and high-BMI ends (e.g., Flegal et al., 2005; Prospective Studies Collaboration, 2009). However, the shape of the relationship between BMI and mortality may vary depending on the sample examined and how other variables are taken into account. Smoking is an example of another health behavior that is related to obesity. It is usually related to lower weight, and giving up smoking can produce weight gain. When only people who have never smoked are considered, there is modest elevation of mortality risk at low BMI, minimal risk for BMIs between 23.5 and 25, and then sharply increasing risk as BMI rises (Alley et al., 2010).

A recent analysis looked carefully at the mortality risk and years of life lost due to different levels of obesity, breaking the numbers down by age, gender, race, and smoking status (Finkelstein et al., 2010). In general, the authors found that being overweight does not increase mortality risk and sometimes decreases it, although the effect usually is not statistically significant either way. The excess mortality risk is noticeable for Class 1 obesity and rises sharply as BMI increases. Obesity has a greater effect on years of life lost for men than for women and for whites than for blacks, and its effects are similar for smokers and nonsmokers, with smoking adding greatly to the mortality risk for all groups. Thus, while an 18-year-old white male who is of normal weight and does not smoke can expect to live to 81, the life expectancy of an 18-year-old white male who smokes and is Class 3 obese is only 60 years—a decrease in life expectancy of 21 years, approximately 10 years of which can be attributed to obesity.

Alley and colleagues surveyed the body of research on weight and mortality and drew some general conclusions (Alley et al., 2010). First, in the general population, Class 1 obesity is correlated with a small increase in overall mortality, and the higher the BMI, the greater is the elevation. Generally speaking, falling in the overweight category (BMI between 25 and 30) does not increase one's chances of dying from all causes, although being overweight is associated with a slightly increased risk of dying from coronary heart disease. Again, the higher the BMI, the greater is the mortality risk. According to one international study, each increase of 5 units in BMI results in a 30 percent increase in overall mortality (Prospective Studies

Collaboration, 2009). In short, the authors concluded, obesity does increase mortality risk; the increase is relatively modest for Class 1 obesity (BMI between 30 and 35) but is significantly greater for those with a BMI above 40. The authors also found that the relationship between BMI and mortality risk changes with age. BMI has its largest effect on the risk of mortality for adults under 50, and the correlation between BMI and mortality decreases beyond that age. The older adults at greatest risk of dying are those at the extreme ends of the BMI spectrum—either extremely underweight or extremely overweight. Thus at older ages, the curve relating mortality risk to BMI changes in shape from a J to a U.

Limitations of BMI in Older Adults

Any study that seeks to understand the relationship between BMI and mortality in older adults must deal with various complications that are particularly relevant in this age group (Hu, 2008). For one thing, BMI is a less accurate estimate of body fat in older adults than in others because of the differential loss of muscle and lean body mass that accompanies aging. A sedentary older adult may lose half a pound of muscle mass per year, or 5 pounds a decade, significantly altering the meaning of BMI.

More important, older adults also are more likely to have various existing diseases and to have experienced illness-related weight loss, either of which can confound the relationship between weight and mortality risk. In particular, a number of chronic diseases associated with weight change, such as diabetes and cardiovascular disease, are associated with both weight loss and mortality in older adults (Alley et al., 2010). For these diseases, lower BMI is generally associated with higher mortality, while higher BMI often carries no greater mortality risk than normal BMI.

To sidestep these problems, some studies have looked at BMI earlier in life as a predictor of mortality. In this way, one can avoid many of the complications caused by weight loss due to obesity-related chronic diseases. Applying this approach does indeed change the shape of the risk curve, with risks at low BMIs decreasing and risks at higher BMIs increasing. One study that looked at mortality versus BMI at age 50 found that every category of BMI above 26.5 was associated with an increased risk of mortality (Adams et al., 2006). Other approaches include focusing on the waist–hip ratio or abdominal adiposity instead of BMI, as both of these measures have been shown to be correlated with mortality risk in older adults (Hu, 2008).

OBESITY AND LIFE EXPECTANCY TRENDS

Given that obesity increases mortality in at least some groups, it makes sense to ask whether this obesity–mortality connection combined with the higher rates of obesity in the United States might explain at least part of this country's lower-than-expected life expectancy. The answer is complicated.

Country-to-Country Comparisons

One place to look is the association between obesity and life expectancy at the national level. Alley and colleagues collected data on both obesity rates and life expectancy for the 10 high-income countries in this study (Alley et al., 2010). The results are shown in Table 3-1. Among males, the life expectancy at 50 in the United States was eighth highest out of the 10, ahead of only the Netherlands and Denmark, and the rate of obesity among U.S. males was the highest of any of the countries. On the other hand,

TABLE 3-1 Life Expectancy at Age 50 and Rate of Obesity, by Country and Gender, 2004

Country	Life Expectancy at Age 50 (e_{50}), 2006[a]	Change in e_{50}, 1980–2006[c]	Adult Obesity (%)[b]	Obesity Change/Yr: 1978–2004
	Males			
Australia	31.5	6.6	19.3	0.54
Canada	30.7	5.0	22.9	0.42
Denmark	28.2	3.5	11.8	0.44
England[c]	29.7	5.7	23	0.71
France	29.9	5.1	12	0.24
Italy	30.6	5.9	8.3	0.07
Japan	31.0	4.4	2.3	0.07
Netherlands	29.4	4.0	10.4	0.32
Spain	29.9	3.7	11.9	0.18
United States	29.2	4.3	31.7	0.76
	Females			
Australia	35.3	4.6	22.2	0.76
Canada	34.5	3.2	23.2	0.58
Denmark	31.9	2.1	12.5	0.51
England[a]	33.1	4.0	24	0.67
France	35.7	4.5	12	0.25
Italy	35.2	5.2	8.1	0.03
Japan	37.1	6.3	3.4	0.01
Netherlands	33.3	2.0	10.1	0.10
Spain	35.4	4.4	13.6	0.37
United States	33.0	2.4	34.6	0.70

[a]Data from Glei et al. (2010, Table 2-1).
[b]Based on most recent observations.
[c]Mortality is for England and Wales, obesity for England.
SOURCE: Alley et al. (2010, Figure 1); Glei et al. (2010, Table 2-1).

Denmark and the Netherlands had obesity rates that were not particularly high relative to the other countries, ranking seventh and eighth among the 10. Conversely, among the countries with the highest life expectancy at 50 among males—Australia, Japan, Italy, and Canada—two (Japan and Italy) had the lowest rates of obesity, and two (Australia and Canada) had rates among the highest.

The picture for females is similar. The lowest life expectancies were in Denmark, the United States, the Netherlands, and England and Wales. Among those countries, two (the United States and England) had the highest rates of obesity among the 10 countries, while the other two (Denmark and the Netherlands) had among the lowest rates. Comparing rates of change in obesity with the rise in life expectancy from 1980 to 2004 produces a similar lack of pattern. For example, both American and Australian men and women had rapid gains in obesity, but life expectancy improvements were quite slow in the United States and rapid in Australia. In short, these sorts of macro-level comparisons do not indicate an effect of obesity rates at the national level on the increase in life expectancy over the past several decades. It is helpful to look more closely at the problem by examining the mortality rates associated with obesity at an individual level and applying them to the BMI distributions of the populations under consideration.

Calculating the Effect of Obesity on Life Expectancy

Most calculations estimating the effect of obesity on life expectancy have been performed with respect to individuals rather than populations. Using data from the National Health and Nutrition Examination Survey (NHANES), Fontaine and colleagues calculated the number of years of life lost for various BMI levels relative to a BMI of 24 (Fontaine et al., 2003), assuming that a person remained in his or her BMI category for life. They found, for example, that for white males, having a BMI between 30 and 35 shortened life by an average of 0–1 years, having a BMI between 35 and 40 shortened life by 1–3 years, and having a BMI above 40 shortened life by 1–7 years. The numbers were similar for white women but not for black men and women; for those in the latter groups, obesity shortened life only among younger people and those with a very high BMI.

Estimating the contribution of differences in obesity to the life expectancy gap between the United States and other countries requires an attributable risk approach that combines BMI distributions in different countries with sets of mortality risk associated with BMI. Useful for this purpose are estimates by Preston and Stokes (2011), who perform primary analyses of survey data to identify the distribution of BMI by age and gender in 16 countries, including the United States and 7 of the 9 comparison countries studied. The United States has the highest proportion obese of any population considered. The detailed BMI distributions are combined with three alternative sets of mortality risk by BMI to estimate the proportion of deaths attributable to above-optimal weight, by age and gender. These estimates are then converted into their implications for longevity. It should be noted that the use of alternative measures of obesity yields results on the number of deaths attributable to obesity that are not significantly different from those obtained using BMI (Flegal and Graubard, 2009).

The baseline analysis of Preston and Stokes uses the largest, longest, and most internationally diverse collection of obesity risks, the Prospective Studies Collaboration (PSC) (2009). The mean date of death in this study is 1986. Using this set of risks, which are adjusted for smoking behavior, the authors estimate that U.S. life expectancy at age 50 in 2006 was reduced by 1.28 years for women and by 1.61 years for men as a result of obesity. Because the proportions obese are higher in the United States than elsewhere, especially at the upper extremes of BMI, these hypothetical changes from eliminating obesity are substantially larger than those in any other country.

As noted above, there is suggestive evidence that the mortality risk associated with obesity has been declining in the United States (Flegal et al., 2005; Mehta and Chang, 2010). Such a decline may result from improvements in the treatment of cardiovascular disease, the main disease through which obesity affects mortality (Gregg et al., 2005). To account for this possibility, Preston and Stokes introduce two sets of relative risks recorded more recently in the United States. One set is adapted from Adams and colleagues (2006). These data were derived from a large study of 527,000 enrollees in a National Institutes of Health (NIH)–AARP Diet and Health Study that was conducted in six U.S. states and two cities. Enrollees were followed from enrollment in 1995–1996 through the end of 2005. Relative risks are adjusted for smoking, social status, and physical activity. The second alternative set of relative risks is derived from NHANES III, linked to death certificate data (Mehta and Chang, 2010). Initial enrollment at ages 50–69 occurred during 1988 to 1994; individuals were followed into the National Death Index through 2006. The sample size was 4,375 individuals, and the mean follow-up time was 13.3 years. Relative risks are adjusted for smoking and socioeconomic status. Relative to those of normal weight (BMI between 18.5 and 24.9), overweight and obese Class 1 people have a 1–6 percent increase in risk; for those with a BMI of 35 or greater, the excess risk in this study is 63 percent.

In every country for both genders, use of these alternative sets of relative risks reduces the estimated gain in life expectancy from eliminating obesity. Using the Adams and colleagues (2006) set, the gain in life expectancy at 50 for females in the United States is 0.71 years and for males is 0.52 years. The gains with the Mehta and Chang set are similar, at 0.61 and 0.64 years, respectively. These remain the largest gains for any country.

Discussion

Since life expectancy at age 50 in the United States would increase significantly more than in other countries through the hypothetical elimination of obesity, the U.S. longevity shortfall would be reduced and in some cases eliminated. U.S. life expectancy for women is 1.37 years lower than the mean in 12 other countries with higher life expectancies. Based on the PSC risk factors, U.S. female life expectancy would be an estimated 0.80 years lower than this mean without obesity, so that obesity would account for an average of 41 percent of the gap. For men, the equivalent percentage of the difference in life expectancy accounted for by obesity, relative to 10 countries with higher life expectancies, is 67 percent.

These effects are much larger than those based on the Adams et al. or Mehta and Chang risk sets. The mean life expectancy gap for the 12 countries with higher life expectancies is reduced by 29 percent for women using Adams' risks to account for the effects of obesity and by 22 percent using Mehta and Chang's. For men, the equivalent reductions are 32 percent and 29 percent respectively.

Thus, differences in the prevalence of obesity continue to explain about 20–35 percent of the shortfall in U.S. life expectancy relative to countries with superior levels, even when one uses much lower sets of obesity risks. The risks derived from the studies of Adams and colleagues (2006) and Mehta and Chang (2010) have the advantage of pertaining to a later period, on average, than those of the PSC. This period is closer to the time when the levels of both obesity and mortality are recorded in the various countries and when attributable risks are modeled. These studies also control for socioeconomic status, indexed by education and income, in their analyses of the impact of obesity on mortality, unlike the analysis based on risks in the PSC. Using data from the Health and Retirement Study, Mehta and Chang (2009) show that controlling for educational attainment reduces estimated obesity risks by 20–50 percent. The panel is inclined to believe that the two sets of relative risks recorded more recently in the United States yield more reliable estimates of the impact of obesity on life expectancy comparisons than those obtained using the PSC risks. Even using the sets of lower obesity risks, however, it appears that differences in obesity account for a fifth to a third of the shortfall in life expectancy in the United States relative to other countries. Obesity appears to be an important part of the explanation of the current U.S. shortfall in life expectancy, but uncertainty remains as to its role in explaining the divergence.

4

The Role of Physical Activity

Over the past several decades, as Americans have gotten heavier, they have also adopted an increasingly sedentary lifestyle, becoming less physically active and less physically fit (Centers for Disease Control and Prevention, 2010). These two trends are certainly related. The role of obesity was examined in the previous chapter, so it is natural to ask what role, if any, this decline in physical activity and fitness has played in the nation's slower-than-expected growth in life expectancy over the past several decades.

EFFECTS OF PHYSICAL ACTIVITY ON HEALTH

There is nothing new about the observation that physical activity and exercise lead to a greater sense of health and well-being. Nearly two millennia ago, the Roman poet Juvenal wrote of the importance of *mens sana in corpore sano*, or a healthy mind in a healthy body, and the ancient Greeks and Romans were well aware of the importance of exercise in maintaining a healthy body. Despite this ancient wisdom, accurate quantification of the effect of physical activity or physical fitness on various health outcomes, including the risk of mortality, has yet to be determined. Not surprising, then, the extent to which differences in physical activity might contribute to variations in observed life expectancy across countries is poorly understood (Steptoe and Wikman, 2010).

Measurement Issues

Accurate measurement of the level of physical activity in a normal day-to-day environment is obviously fundamental to the study of the relationship between physical activity and mortality. A variety of techniques are available for assessing levels of physical activity, including use of self-reported data from diaries or recall questionnaires and objective measurement using pedometers, accelerometers, or other similar devices. Each method has advantages and drawbacks (Vanhees et al., 2005; Westerterp, 2009). Self-reported data are easier to obtain but are vulnerable to recall error, reporting bias (if respondents systematically tend to exaggerate or downplay their level of physical activity), and cross-national differences in interpretation of questions. The net result of such measurement errors is generally to weaken any effect that is present in the data; thus to the extent that these issues are a problem, the effects of physical activity are likely to be greater than estimated, rather than less.

Cross-national studies also need to take account of cross-cultural differences in customary forms of physical activity (Steptoe and Wikman, 2010). For example, bicycling, ice-skating, playing softball, lawn bowling, and playing boules are all activities whose popularity varies enormously across countries. Differences among countries in the physical demands of occupations, urban design, or the built environment can also generate differences in moderate or light activity that occurs as part of everyday life, which can easily be missed in surveys of leisure activities or purposeful exercise. Objective measurement of physical activity is more expensive but usually preferable as it can eliminate some of the problems associated with obtaining information from self-reports.

A variety of methods for obtaining objective measures are available. The most useful for population studies is the use of accelerometers (Westerterp, 2009). One of the most comprehensive measures of the level of physical activity among Americans was performed by Troiano and colleagues on more than 6,000 participants in the 2002–2003 National Health and Nutritional Examination Survey (NHANES). These subjects, who ranged in age from 6 to older adults, agreed to wear an accelerometer for at least an entire day and, for nearly 5,000 of them, 4 or more days. The accelerometer-derived data indicated that very few Americans engage in the recommended level of physical activity—at least 30 minutes of moderate or vigorous activity at least 5 days per week—and the percentage that do so decreases with age. Teenagers (aged 16–19) performed poorly, with only 7.1 percent of boys and 4.1 percent of girls getting the recommended minimum amount of exercise. But adults fared even worse: among those aged 20–59, just 3.8 percent of men and 3.2 percent of women performed enough exercise, and only 2.5 percent of older men and 2.3 percent of older women (Troiano et al., 2008).[1]

[1]Of interest, the subjects were less active than they reported in answer to survey questions, but the overall patterns of differences in activity by age and gender were similar to those reported in the survey.

Observational Studies Linking Physical Activity and Health in Older Adults

Observational studies in older adults have found that physical activity is correlated with a number of measures of health, including increased strength and flexibility, increased aerobic capacity, improved balance and fewer falls, a reduced decline in bone density, improved glucose metabolism and insulin sensitivity, enhanced emotional well-being, and a reduced decline in cognitive function (Steptoe and Wikman, 2010). It should be noted, however, that drawing conclusions about the link between physical activity in older adults and health based on observational studies is somewhat hazardous because individuals can self-select into various states of physical activity. This selection is likely to be affected by their health. For example, people with chronic obstructive lung disease may be less likely to engage in vigorous activities. Both their high relative mortality risk and their low levels of exercise would likely be attributable to preexisting disease rather than to any effect of physical activity on mortality. It is also true that people with certain characteristics and behaviors (e.g., being poor and smoking) may be both less likely to exercise and more likely to be unhealthy. This section reviews the results from the large number of observational studies that have attempted to quantify the benefits of physical activity for older adults. The following section describes the far fewer studies that have used a randomized design to assign people to levels of activity.

Hamer and Chida (2008) performed a meta-analysis of 18 prospective studies that looked at the effects of walking on the risk of cardiovascular disease. The likelihood of developing cardiovascular disease was 31 percent lower among the group that walked the most compared with the group that walked the least. The benefits of walking were similar for men and women, and greater benefit came from walking briskly rather than from walking for longer periods of time. There was also some evidence of a dose–response relationship—that is, the more walking people did, the more it decreased their risk of developing cardiovascular disease.

In a subsequent review, the same authors examined the effects of physical activity on neurodegenerative diseases, such as dementia and Alzheimer's disease (Hamer and Chida, 2009). Based on a meta-analysis of 16 prospective studies, they found that people in the highest physical activity category were 28 percent less likely to develop dementia and 45 percent less likely to develop Alzheimer's disease than those in the lowest physical activity category. There is also good evidence that older adults who exercise are less likely to become depressed. Hamer and colleagues (2009) followed 4,300 older men and women (average age of 63) for 4 years. None reported symptoms of depression at the beginning of the study, while 8 percent did so 4 years later. The authors found that the people who reported engaging in regular, moderate physical activity were 29 percent less likely to develop the symptoms of depression, while those who engaged in vigorous physical activity were 42 percent less likely.

A more recent study covered a longer period and focused on sedentary behavior. Among 7,800 men surveyed in 1982, time spent watching television and time spent riding in a car were significantly and positively related to mortality from cardiovascular disease over the next 21 years (Warren et al., 2010). The pattern of the association did not change materially after the introduction of covariates.

In short, there is considerable observational evidence that regular physical activity leads to improved health among older adults and, conversely, that a sedentary lifestyle with little physical activity is associated with an increased risk of developing a variety of physical, emotional, and mental problems.

Intervention Studies Linking Physical Activity and Health in Older Adults

Several investigators have conducted randomized intervention studies of the effect of physical activity on various measures of health among older adults. These studies are more difficult and expensive to perform than observational studies and thus typically have far fewer subjects, but the research design is clearly superior for assessing causal relationships. Not all validity problems will be solved with this approach, however, as persons who agree to participate in such trials are unlikely to be representative of the general population. Randomized controlled trials are inherently nonrepresentative, as those who are the best functioning, most motivated, and most capable of understanding and being enthusiastic about the trial are more likely to participate. However, by assigning subjects randomly to different groups, some of them exercising more and some less, these behavioral intervention studies avoid the issue of whether subjects who are more physically active might also have other characteristics—such as being in better health—that could explain the different outcomes seen.

In one randomized controlled trial, Martin and colleagues (2009) recruited 430 postmenopausal women and assigned each to one of four groups: no exercise and exercise at 50 percent, 100 percent, and 150 percent of the physical activity recommendation. After 6 months they measured the women's physical and mental health, including physical functioning, body pain, social functioning, and sense of well-being or vitality. Consistently, in every category of physical and mental health, the women who were assigned to the exercise groups reported being healthier than those who were assigned to the no-exercise group, and the higher the level of exercise, the healthier they were.

A study in Australia looked at 170 adults aged 50 and older who were at risk of Alzheimer's disease. Half were entered into a 24-week home-based program of physical activity, while the other half were provided only with education and standard care. At the end of 6 months, the participants who had exercised showed improvements in cognitive functioning, while those in the other group had become worse. After the subjects in the physical activity group stopped exercising, most of the effect disappeared, implying that the benefits of physical activity lasted only as long as the activity was continued (Lautenschlager et al., 2008).

Another randomized controlled trial looked at the effect of exercise on depression, although this trial did not include older adults. Eighty adults aged 20–45 who had been diagnosed with major depressive disorder were assigned to perform different levels of aerobic exercise weekly. After 12 weeks, those in the higher-intensity group scored significantly lower on a depression scale than those in the lower-intensity group and those in the control group (Dunn et al., 2005).

Using a quasi-experimental design, MacDonald and colleagues (2010) studied the effect of introducing a light rail system in Charlotte, North Carolina, on a variety of health outcomes. After the system was introduced, those who used it significantly increased their physical activity levels relative to those who did not, with baseline characteristics being controlled for. The odds of obesity were significantly reduced among users of the system.

Mechanisms

Given the wide range of benefits of exercise for physical and mental health, it would appear likely that these benefits would be mediated through numerous physiological mechanisms. Indeed, the evidence does indicate that physical activity affects a number of bodily functions, from the cellular level on up. Steptoe and Wikman (2010) provide a list of such effects that have been identified in various studies. Regular physical activity has been linked to reduced blood pressure, improved lipid profiles, improved glucose metabolism, reduced levels of inflammatory markers, the induction of growth factors, and increased strength and flexibility. Ekelund and colleagues (2007) found that increases in energy expenditure as a result of greater physical activity are associated with reduced metabolic risk factors, independent of any change in fatness or fitness.

A good deal of research has been conducted on how exercise and training affect brain function, particularly in older adults (see National Research Council, 2000a). One recent study found that the medial temporal lobe tended to shrink with age among older adults who did little or no exercise but not among adults of the same age who engaged in high levels of exercise (Bugg and Head, 2009). Generally speaking, the best evidence of the benefits of exercise for brain function is the links between physical activity and the alleviation of depression, positive effects on learning and memory, and protection from neurodegeneration. A basic mechanism underlying these effects is the exercise-induced production of growth factors, molecules that direct the brain to make various structural and functional changes (Cotman et al., 2007). Such findings suggest numerous possibilities for effective intervention to improve cognitive function in older people.

EFFECTS OF PHYSICAL ACTIVITY ON MORTALITY

Over the past several decades, numerous large cohort studies have attempted to quantify the protective effect of physical activity on cardiovascular and all-cause mortality. Nocon and colleagues (2008) reviewed 33 cohort studies with 883,372 participants that assessed the primary prevention impact of physical activity on all-cause and cardiovascular mortality. Follow-up ranged from 4 years to more than 20 years. The majority of studies reviewed reported significant risk reductions for physically active participants. Being in the most physically active subgroup was associated with a 35 percent increase in cardiovascular mortality and a 33 percent increase in all-cause mortality relative to the most active group. Studies that used patient questionnaires to assess physical activity generally reported lower risk reductions than studies that used objective measures.

While many studies have reported the positive effects of regular exercise, the dose–response relationship remains unclear. Consequently, several researchers have attempted to quantify the relationship between various levels of physical activity and mortality risk. Löllgen and colleagues (2009) report the results of a meta-analysis of 38 prospective cohort studies conducted between 1990 and 2006 to investigate the effect of various levels of intensity of physical activity on all-cause mortality. All-cause mortality was significantly lower for active compared with sedentary individuals. For studies with three levels of activity, highly active men had a 22 percent lower risk of all-cause mortality compared with mildly active men; highly active women had a 31 percent lower risk. Similar results were observed for moderately active compared with mildly active individuals.

A critical question with respect to the effect of physical activity on mortality is whether the incremental benefits of additional physical activity vary with the level of activity. Woodcock and colleagues (2011) conducted a systematic review and meta-analysis of the dose–response relationship between nonvigorous physical activity and all-cause mortality. They found that moderate activity reduced mortality risk by 24 percent compared with no activity.

Quantifying the effects of physical activity on mortality is complicated by the difficulty of determining physical activity over long periods of time. Is the current level of physical activity important, or is it the levels at early ages? Byberg and colleagues (2009) examined how changes in the level of physical activity after middle age influence mortality. They followed a group of 2,200 men who were age 50 in 1970–1973, keeping track of their levels of physical activity over the years. The men who maintained a high level of physical activity over that time had a 32 percent lower chance of dying compared with the men who maintained a low level of physical activity. Furthermore, as shown in Figure 4-1, the study found that men who previously had a low level of physical activity and then increased their activity level had relatively lower mortality risks over time. They continued to have a high mortality rate for 5 years or so after increasing their physical activity, but after 10 years of this increased activity, their risk of dying was reduced to that of the men who had maintained a high level of physical activity all along (Byberg et al., 2009). It should be noted that while these results may reflect the effect of exercise patterns on mortality, reverse causation is also possible—that the results reflect instead the effect of health on physical activity.

Many of the studies that have looked at the relationship between physical activity and mortality have been forced to rely on self-reports of physical activity. Manini and colleagues (2006) measured energy expenditure directly using a technique known as doubly labeled water. The researchers measured the daily energy expenditure of 300 older adults (aged 70–82) and followed them for just over 6 years. They found that nearly a

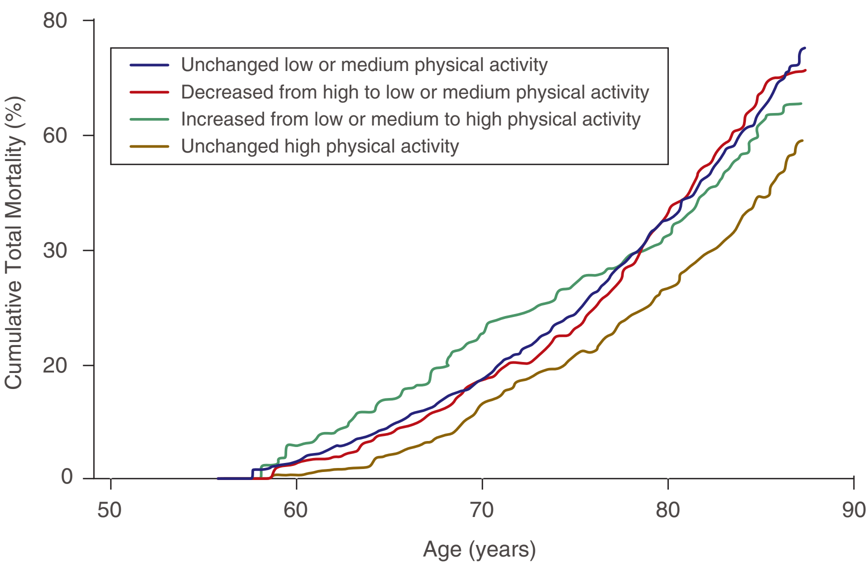

FIGURE 4-1 Association between physical activity level and mortality.
SOURCE: Byberg et al. (2009). Reprinted with permission.

quarter of the subjects with the lowest daily energy expenditure died during that period, compared with only an eighth of the subjects with the highest energy expenditure.

Another way to study the effects of physical activity is to focus on cardiorespiratory fitness instead, assuming that fitness is achieved through physical activity. Fitness should result from routine physical activity over a period of time. The Aerobics Center Longitudinal Study followed more than 80,000 patients between 1970 and 2005 to study the effects of fitness and other factors on health and mortality. More than 3,000 women and 10,000 men were given baseline treadmill tests between 1970 and 1981 to determine their cardiorespiratory fitness. Blair and colleagues (1989) compared mortality risks over a follow-up period averaging 8 years among groups of patients categorized as having low, moderate, or high fitness at baseline. Men with high levels of fitness at baseline were less than a third as likely to die during the study period than men with low levels of fitness, while women with high levels of fitness at baseline were less than a quarter as likely to die than women with low levels of fitness. Similar findings are reported in a subsequent study focused on older adults: across the age range, those with high levels of cardiorespiratory fitness were significantly less likely to die than those with moderate or low levels of fitness (see Figure 4-2) (Sui et al., 2007). As noted earlier, however, the observation that fitter people live longer is not indicative of a causal relationship between physical activity and mortality, since many causal pathways could produce such a correlation. One striking result from the Sui et al. (2007) study is that obesity did not affect mortality risk once fitness was taken into consideration. This result has led some researchers (Sui et al., 2007) to emphasize the role of fitness over fatness, but not all (Stevens et al., 2002). We return to this discussion in Chapter 10.

INTERNATIONAL COMPARISONS

Given the large body of evidence linking physical activity and fitness to better health and lower mortality risk, it is natural to ask whether the perceived low levels of fitness and physical activity in the United States relative to other countries have contributed in some way to the recent underperformance of U.S. life expectancy. Unfortunately, a significant gap exists in international physical activity surveillance, and cross-national comparisons of physical activity using comparable objective measures currently do not exist (Steptoe and Wikman, 2010). Nevertheless, survey instruments have been developed and validated for use in collecting internationally comparable self-reported data on physical activity (see, for example, Craig et al., 2003). These instruments make it possible to explore whether the popular perception that levels of physical activity in the United States are signifi-

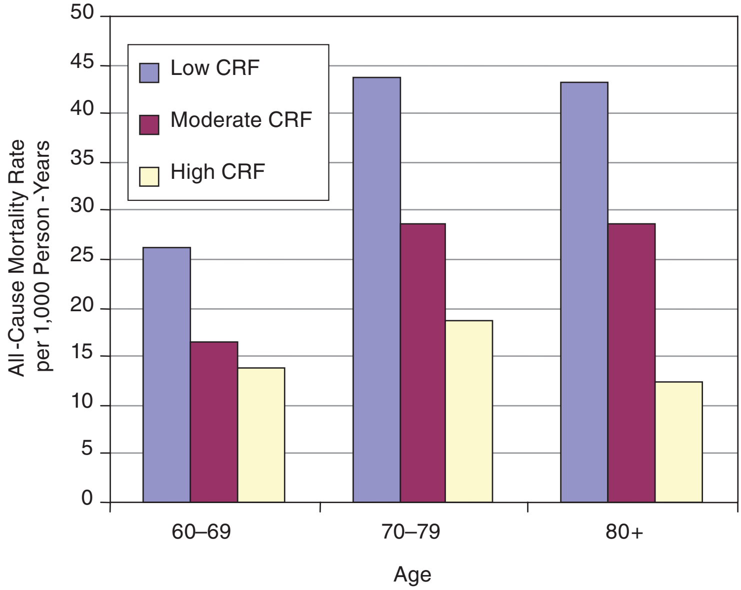

FIGURE 4-2 Cardiorespiratory fitness (CRF) and mortality from all causes for different age groups.
SOURCE: Adapted from Sui et al. (2007).

cantly lower than in other countries is accurate, particularly in relation to those countries where life expectancy has been increasing at a faster rate than in the United States.

Steptoe and Wikman (2010) review the available evidence on international differences in the prevalence of physical activity across countries from self-reported data. Four recent attempts have been made to compare levels of physical activity across countries (see Table 4-1). Each of these four studies used a slightly different survey instrument, adopted a slightly different criterion for assessing moderate or vigorous activity, and surveyed a slightly different target population. Consequently, the level of reported physical activity varies from one survey to another, and it is not possible to compare the levels of physical activity for a particular country across surveys for purposes of validation. Nevertheless, it is possible to compare the rank ordering of countries within the various surveys. Three points stand out almost immediately. First, the United States, which appears only in the International Prevalence Study on Physical Activity (IPS), does not appear to be atypical when it comes to the proportion of the population aged 40–65 that engages in moderate or intense physical activity (Bauman et al., 2009). Second, each of the surveys produces a slightly different rank

TABLE 4-1 Ranking of Levels of Moderate or Intense Physical Activity Across Countries

	IPS[a]	Eurobarometer[b]	EPIC[c]	EU Study[d]
	Moderate/Intense Activity %	Sufficient Activity (IPAQ, %)	Total Recreational Activity (hr/week)	MET/hr/wk (median %)
Country Ranking (High to Low)				
1	Czech R (88.0)	Netherlands (44.2)	Netherlands (19.38)	Sweden (24.0)
2	New Zealand (86.5)	Germany (40.2)	United Kingdom (14.34)	Netherlands (21.0)
3	Canada (83.0)	Greece (37.0)	Germany (13.17)	Denmark (19.5)
4	United States (82.5)	Denmark (34.1)	Spain (11.82)	United Kingdom (16.0)
5	Australia (81.5)	Finland (32.5)	Greece (11.08)	Germany (12.7)
6	Sweden (73.0)	United Kingdom (38.7)	Denmark (10.29)	France (10.0)
7	Norway (71)	Ireland (29.0)	Italy (8.35)	Italy (8.0)
8	Spain (70.5)	Italy (25.8)	Sweden (5.86)	Spain (8.0)
9	Belgium (51.5)	Spain (25.2)		Greece (8.0)
10		Belgium (25.0)		
11		France (24.1)		
12		Sweden (22.9)		

NOTE: IPAQ = International Physical Activity Questionnaire; MET = metabolic equivalents.
[a]International Prevalence Study on Physical Activity (Bauman et al., 2009), conducted 2002–2004; ages: 40–65; sample size = 2,746.
[b]Eurobarometer Study (Sjöström et al., 2006), conducted 2002; ages ≥15; sample size = approximately 15,000.
[c]European Prospective Investigation into Cancer and Nutrition (Haftenberger et al., 2002), conducted 1992–2000; ages: 50–64; sample size = 236,386. Data from the largest center in each country are included.
[d]European Union Study (Martínez-González et al., 2001), conducted 1997; ages: ≥15; sample size = 15,239.
SOURCE: Adapted from Steptoe and Wikman (2010).

ordering of countries with respect to levels of moderate or intense physical activity, although there are some similarities across surveys. Denmark, one of the three countries identified in Chapter 1, along with the Netherlands and the United States, as having slightly lower growth in life expectancy relative to other high-income countries, appears to be particularly difficult to classify. The Eurobarometer Study, which used the International Physical Activity Questionnaire (IPAQ), found that Denmark had slightly lower levels of activity than Germany and Greece but significantly higher levels than Spain (Sjöström et al., 2006). The European Prospective Investigation into Cancer and Nutrition (EPIC) study found that older adults in Denmark reported lower levels of recreational activity than those in Germany, Spain, or Greece, while another European Union study found that adults in Denmark expended more metabolic equivalents (MET) than those in Germany, Spain, or Greece (Haftenberger et al., 2002; Martínez-González et al., 2001). Finally, the Netherlands consistently ranks high in international comparative studies of physical activity, a finding that reflects in part the relatively frequent use of bicycles in that country (Steptoe and Wikman, 2010).

In addition to the studies cited above, the Survey of Health, Ageing, and Retirement in Europe (SHARE), the Health and Retirement Study (HRS) in the United States, and the English Longitudinal Study of Ageing (ELSA) all employed a similar measure of physical activity in a large population sample of men and women aged 50 and above (Steptoe and Wikman, 2010). Participants were asked about the frequency with which they had participated in a variety of forms of vigorous, moderate, or light physical activity over the course of the past week. Figure 4-3 displays the proportion of respondents in each country who reported that they had engaged in vigorous or moderate activity at least once during the past week. Reassuringly, the SHARE/HRS/ELSA samples reported levels of vigorous or moderate activity quite similar in many cases to those in the first column of Table 4-1, which were derived using the IPAQ. One notable exception, however, is the United States. The level of physical activity reported in the HRS is significantly lower than that in the IPS sample, probably because the former was restricted to adults aged 50 and above, while the IPS survey was based on a sample aged 40–65.

Potentially as important as the percentage of the population that is engaged in vigorous or moderate physical activity is the percentage that is sedentary. As can be seen in Figure 4-4, about 22 percent of U.S. adults aged 50 and over reported engaging in no vigorous or moderate activity, which is higher than the percentage in all European countries in the figure except Poland. In both Denmark and the Netherlands—the two European countries that, along with the United States, had lower-than-expected increases in life expectancy—a relatively small percentage of the population, around 7 percent, was sedentary. Thus at this level of abstraction, there ap-

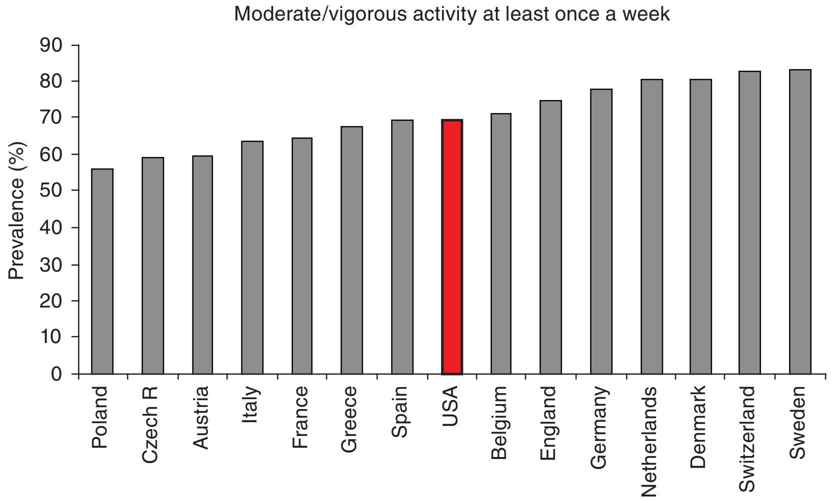

FIGURE 4-3 Proportion of adults aged 50 or older who report being moderately or vigorously physically active at least once per week.
NOTE: Data from the Survey of Health, Ageing, and Retirement in Europe (SHARE) (2006–2007), the English Longitudinal Study of Ageing (ELSA) (2004–2005), and the Health and Retirement Study (HRS) (2004).
SOURCE: Steptoe and Wikman (2010), Figure 7-2. Reproduced with permission.

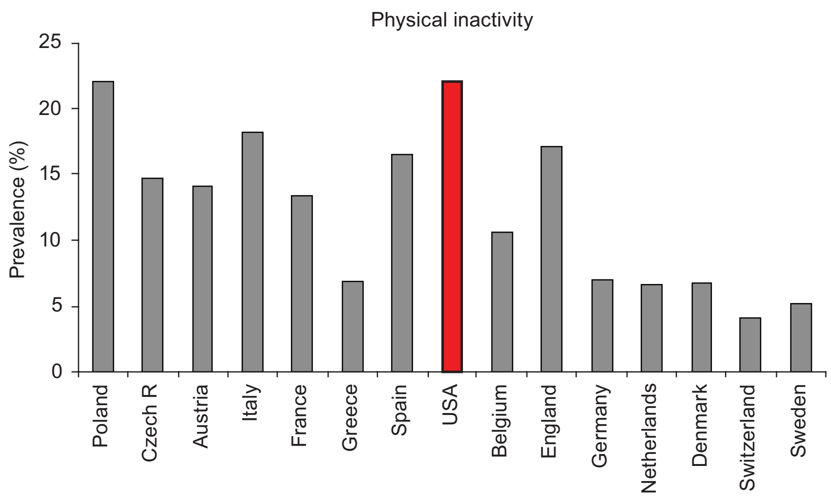

FIGURE 4-4 Physical inactivity in adults aged 50 and over in Europe and the United States.
NOTE: Data from the Survey of Health, Ageing, and Retirement in Europe (SHARE) (2006–2007), the English Longitudinal Study of Ageing (ELSA) (2004–2005), and HRS (2004).
SOURCE: Steptoe and Wikman (2010, Figure 7-3). Reprinted with permission.

pears to be little correlation between international levels of physical activity or inactivity and changes in life expectancy at older ages.

Steptoe and Wikman (2010) found that these measures of physical activity were significantly correlated with self-reported health for both men and women, while levels of inactivity were positively correlated with the prevalence of diabetes across countries. On the other hand, a regression analysis of the relationship between levels of physical activity and life expectancy at age 50 for men in various countries failed to find a significant relationship after controlling for one outlier. Furthermore, no statistically significant association was seen for women.

DISCUSSION

The bottom line is that at such a high level of aggregation and in the absence of suitable controls, it is not possible to demonstrate convincingly that international differences in levels of fitness or increased levels of physical activity are associated with international patterns of longevity. Given that the available data relate to levels of fitness and physical activity at only one point in time, it is impossible to assess the role played by fitness and physical activity in the divergent trends in life expectancy from 1980 to 2005. In contrast to the discussion of obesity in Chapter 3, the research base is not sufficient to identify a reasonable range of uncertainty in estimates of the contribution of physical activity to international differences in mortality. Physical activity may be an important determinant of mortality, significant in explaining cross-national differences and trends, but its role cannot be adequately evaluated with current data.

5

The Role of Smoking

Smoking is a natural candidate for explaining the divergence in life expectancy among high-income countries for two reasons. First, it is a major cause of mortality. In the United States, according to some estimates, smoking is the number one cause of preventable deaths, killing more than 440,000 Americans each year (American Heart Association, 2009; Centers for Disease Control and Prevention, 2004). Second, the number of smokers and historical smoking patterns vary from country to country, so smoking has the potential to explain differences among countries in mortality and life expectancy trends. This chapter describes the relationship between smoking and mortality, international trends in smoking, and various analyses of the effects of smoking-related mortality on life expectancy in different high-income countries. As will be seen, the evidence implies that smoking may indeed be a major factor explaining the divergent trends in life expectancy among high-income countries over the past several decades.

SMOKING AND MORTALITY

Although lung cancer is the best-known cause of death associated with smoking, a number of other smoking-related diseases increase the mortality rate among smokers, including various other types of cancer, coronary heart disease, chronic obstructive pulmonary disease (COPD), and cerebrovascular disease (Centers for Disease Control and Prevention, 2004). Thus determining the overall smoking-related mortality rate in a population can pose a challenge, as all of these diseases—even lung cancer to a relatively minor degree—appear in nonsmokers as well, making it difficult to determine the percentage of deaths that can be attributed to smoking.

Prospective Cohort Studies

The most straightforward approach is to follow a large number of people over a number of years and compare the mortality rates of smokers and nonsmokers to determine the additional risk of death caused by smoking. Such prospective cohort studies, as they are called, have the advantage of allowing researchers to collect a great deal of information from participants and then use that information to determine the relationship between various medical and lifestyle factors—smoking history or high blood pressure, for example—and the various causes of death. Nonsmoking factors affecting mortality can be controlled in statistical analyses of the effects of smoking.

The main weakness of such studies in determining the risks of smoking is the difficulty of obtaining a precise measure of smoking behavior. Most prospective cohort studies ask participants about their smoking behavior when they first enter the study and assume that this behavior remains fixed throughout the course of the study (Preston et al., 2010b). In reality, people vary their smoking behavior over time, with some quitting and others starting or restarting and still others increasing or decreasing how much they smoke. Furthermore, 20 to 30 years can elapse between the time a person starts smoking and the time serious health effects appear (Lopez et al., 1994). The resulting errors in recording the smoking behavior of study participants will generally weaken whatever connections the study might find between smoking and various causes of death. Thus such studies will typically underestimate the risk of smoking.

The Cancer Prevention Studies (CPS-I and CPS-II) conducted by the American Cancer Society, which cover the years 1959–1965 and 1982–1986, respectively, are two of the largest such studies to date to examine the effects of smoking on mortality, and they have provided some of the most important information available on the subject. In the CPS-II, investigators asked 1.2 million volunteers to fill out questionnaires asking about their jobs, diet, alcohol and tobacco use, medical history, and family history of cancer as of 1982. Since then the study has kept track of deaths among the 1.2 million participants by monitoring the National Death Index (American Cancer Society, 2009). By 2006, 488,000 of the participants had died.

Working from the data accumulated by the CPS-II and comparing the numbers of smoking-related deaths among smokers with the number of deaths among nonsmokers, Mokdad and colleagues (2004) calculated that smoking had been responsible for 435,000 deaths in 2000. A second group used the CPS-II data to calculate how smoking affects life expectancy. Focusing on the difference in life expectancy between smokers who quit smoking and those who never smoked, the researchers estimated that quitting smoking at age 35 added 6.9 to 8.5 years of life expectancy for men and 6.1 to 7.7 years of life expectancy for women compared with those who kept smoking (Taylor et al., 2002).

The reason why the number of deaths attributable to cigarette smoking has stayed as high as it has despite large reductions in the prevalence of smoking is that heavy smoking in the past has left a clear imprint on current mortality levels. One feature of that imprint is that the relative mortality levels of smokers have risen relative to nonsmokers, reflecting the heavy smoking histories of smokers today. Comparisons of the CPS-I and CPS-II data indicate that the age-adjusted death rate from lung cancer per 100,000 person-years increased among current smokers between the period covering the CPS-I (1959–1965) and that covering the CPS-II (1982–1986), from 187.1 to 341.3 in men and from 26.1 to 154.6 in women (Thun et al., 1997). The increased mortality risk appears to be partially attributable to differences between the two studies in smokers' average age of initiation, number of cigarettes smoked per day by smokers, and duration of smoking. Among those who had never smoked, the age-adjusted death rate did not change substantially between studies for either males or females.

Indirect Measures of Mortality Due to Smoking

Prospective cohort studies make it possible to estimate directly the number of deaths caused by smoking or other factors, but they are expensive to carry out, require decades of commitment, and often are not available for populations one wishes to study. In particular, while the CPS-II offers reliable data on a large (but nonrepresentative) subgroup of the U.S. population, few other countries have comparable studies. Therefore, researchers have developed a variety of indirect ways to determine the number of deaths caused by smoking.

The major challenge researchers face when attempting to estimate smoking-related mortality in a population is obtaining reliable information about the smoking habits of the population. Peto and colleagues (1992) devised an innovative way of getting around the fact that good data on the smoking habits and histories of most populations one wishes to study are relatively scarce. The basic idea is that one can use the rate of lung cancer in a population to obtain a reasonably good estimate of the total smoking burden in that population. One starts with the amount of lung cancer mortality in the population, which is available wherever careful cause-of-death statistics are kept. The underlying assumption is that even if no one in a particular population of people smoked, there would still be a certain small number of lung cancer deaths, and it is possible to know what that small number would be by, for example, looking at the lung cancer mortality rate among nonsmokers from the CPS-II. Then the number of lung cancer deaths in the population over and above the expected baseline is assumed to reflect the amount of smoking in that population—and in particular, the amount of damage caused by smoking, which is a function of the number of smokers and how much each has smoked over his or her lifetime. Although this method depends on several assumptions, they are reasonable ones, and this indirect measure of smoking behavior may even provide a better indication of smoking-inflicted damage in a population than measures based on asking people to report how much they have smoked over their lives (Preston et al., 2010b).

With this indirect measure of smoking, it is then possible to use mortality statistics in a population to estimate the mortality from various causes that can be attributed to smoking. This is what Peto and colleagues (1992) did to estimate the smoking-related deaths in various developed countries. In particular, they used relative risks of smokers versus nonsmokers for various diseases, calculated from the CPS-II. That is, they looked at how much more likely smokers were to die from such causes as coronary heart disease or cerebrovascular disease, based on the CPS-II cohort study, and then assumed that the same relative risks would hold for smokers in other countries. Then by applying these relative risks to the population of smokers in a given country—estimated from the lung cancer mortality rates—they could calculate what percentage of deaths from each disease was due to smoking. According to their estimates, 35 percent of the deaths attributable to smoking are from vascular diseases, 24 percent from lung cancer, and 16 percent from COPD. The authors estimate that among U.S. men aged 35 and older in 2000, 24 percent of all deaths were attributable to smoking; the comparable figure for women is 20 percent (Peto et al., 2006).

Preston and colleagues (2010a) developed an alternative approach for estimating smoking-related mortality from cause-of-death statistics. Instead of using relative risks derived from a cohort study, they performed a large-scale statistical analysis of deaths from lung cancer and from all other causes in 21 countries over the period 1950–2006. The idea behind this approach is that "lung cancer mortality is a reliable indicator of the damage from smoking and that such damage has left an identifiable imprint on other causes of death at the population level" (Preston et al., 2010a, p. 2).

There have been a number of other variations on the original Peto method, each with the goal of estimating the amount of smoking-related mortality in a population. Before using this sort of approach to analyze the effects of smoking on mortality in the various countries studied here, it is useful to examine historical smoking patterns in those countries, which are at the root of the patterns seen in smoking-related mortality. In doing so it is important to keep in mind that smoking trends lead mortality trends by 20 to 30 years (Lopez et al., 1994).

INTERNATIONAL SMOKING PATTERNS

Fifty years ago, smoking was much more widespread in the United States than in Europe (see Figure 5-1). Compared with most Europeans, a greater proportion of Americans smoked, and they smoked more intensively (Pampel, 2010). There are probably many reasons for the higher level of smoking in the United States, including the fact that cigarettes were made freely available to many military and civilian groups during World War II; higher per capita income in the United States, which made cigarettes seem more affordable than in other countries; excellent growing conditions for tobacco in part of the United States; intense advertising campaigns in magazines, on billboards, and on the radio; the widespread smoking of popular movie stars on the silver screen; and the presence of a number of major tobacco companies (Brandt, 2007; Ravenholt, 1990). Over the next two decades, the prevalence of smoking grew steadily in most countries, with the United States continuing to have one of the highest levels. After 1964, when the Surgeon General's office released its authoritative report on the adverse effects of cigarette smoking, the increase in smoking slowed, stopped, and eventually reversed in the United States. The peak of smoking among males occurred in cohorts born around 1915–1920 and among women in cohorts born around 1940–1944 (Preston and Wang, 2006). During the 1970s, smoking began to decline in most high-income countries, but the decline has been much greater in the United States than in most of Europe, particularly among men (Cutler and Glaeser, 2006). Today there are a number of European countries, as well as Japan, where the per capita consumption of cigarettes is greater than in the United States (see Figure 5-1).

Within each of the countries, the diffusion of smoking among the population has tended to follow a similar pattern. Smoking first catches on among people in higher socioeconomic brackets, then makes its way into the rest of the population. When smoking-related health issues begin to emerge, it is the people in the higher socioeconomic brackets who first begin to cut back on smoking so that in later stages, when smoking is in decline, it is much more common among those in the lower socioeconomic brackets (Pampel, 2010). The difference between men and women shows a similar pattern across countries. Smoking catches on first among men, and women are generally a couple of decades behind in terms of the numbers who smoke. Over time, smoking levels off among men while it continues to grow among women, and when smoking decreases, it tends to decrease more rapidly among men than among women, closing the gap between them (Pampel, 2010).

Focusing specifically on smoking among females, Pampel (2003) found that women in the United States and Northern Europe took up smoking in large numbers much earlier than women in Southern Europe and Japan. In particular, he identified two "clusters" of countries with similar patterns of

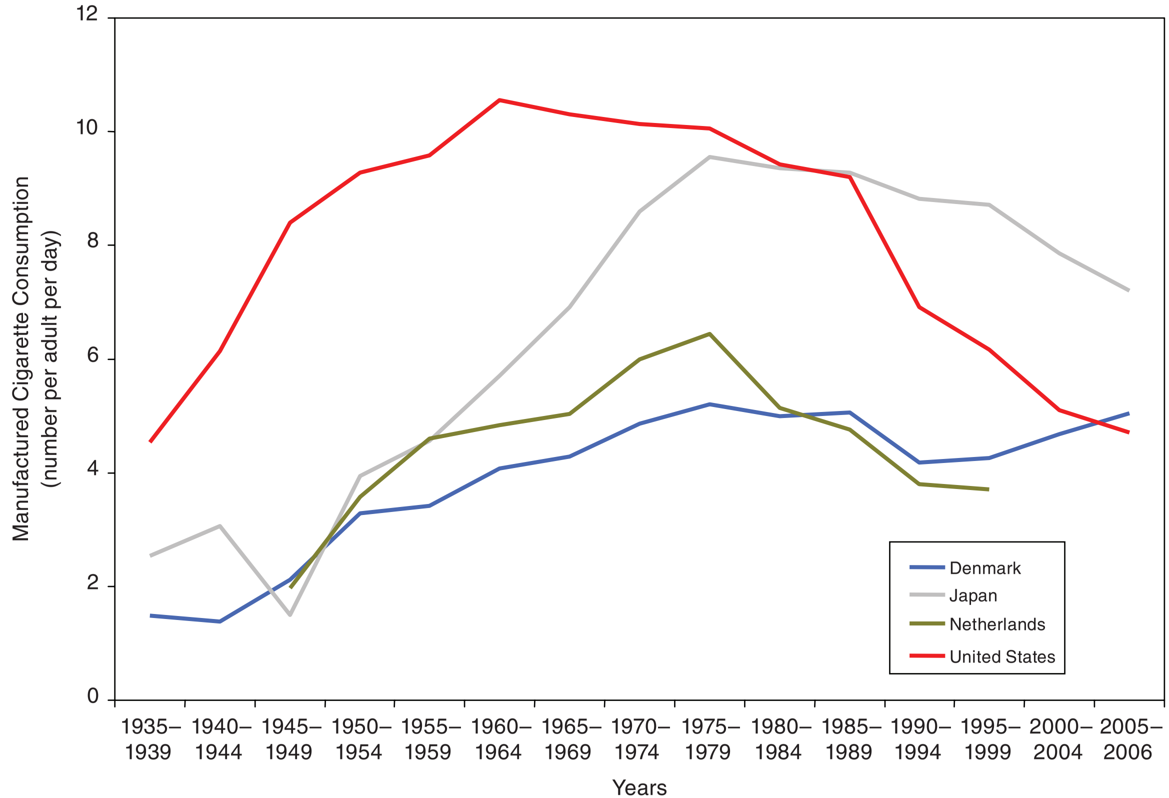

FIGURE 5-1 Trends in per capita consumption of cigarettes for selected countries.
SOURCE: Data from Forey et al. (2002, 2009).

female smoking. In the first, consisting of the United States, Denmark, the Netherlands, and England and Wales, about a third of middle-aged women were smoking during the 1970s. In the second, consisting of France, Italy, Spain, and Japan, many fewer middle-aged women—from 5 to 17 percent—were smoking during the 1970s. As Pampel notes, if indeed smoking was a major factor in the diverging trends in life expectancy, the mortality trends from country to country should mirror these trends in smoking.

SMOKING AND LIFE EXPECTANCY IN HIGH-INCOME COUNTRIES

By using the method of Peto and colleagues (1992) or one of its variants to derive estimates of total smoking-related mortality from data on lung cancer mortality, it is possible to compare smoking-related deaths across countries and through time and thus to estimate the role of smoking in the divergence in life expectancy trends. This section describes two such studies that used different approaches and came up with very similar answers.

Preston, Glei, and Wilmoth (2010b)

Preston and colleagues (2010b) began with yearly cause-specific death counts from the World Health Organization's (WHO's) Mortality Database (World Health Organization, 2009) for 21 high-income countries from 1950 to the present. The distribution of deaths by cause of death, divided into 5-year age groups (50–54, 55–59, 60–64, 65–69, 70–74, 75–79, 80–84, and 85 and up) and into males and females, was combined with annual all-cause death counts and mortality rates from the Human Mortality Database (Human Mortality Database, n.d.) to determine the numbers of deaths due to lung cancer by country, year, gender, and age group. Then, instead of assuming that relative mortality risks for smokers based on the CPS-II (in the United States) could be extrapolated to other populations, as Peto and colleagues (1992) had done, the authors applied a regression analysis to investigate the macro-level statistical association between lung cancer mortality and mortality from all other causes of death. Using these results, they estimated how many of the deaths were due to smoking, on the assumption that the mortality due to smoking could be inferred from the number of lung cancer deaths over and above the baseline for lung cancer mortality.

The results of this analysis are shown in Table 5-1, which gives the estimated fraction of deaths for ages 50 and above that can be attributed to smoking for males and females in the 21 high-income countries during the years 1955, 1980, and 2003. One obvious result is that smoking was responsible for a much greater percentage of deaths among men than among women, although women were catching up in a number of countries. In

TABLE 5-1 Estimated Fraction of All Deaths at Ages 50 and Older Attributable to Smoking in 1955, 1980, 2003, by Gender and Country

	Males			Females		
Country	1955	1980	2003	1955	1980	2003
Australia	0.07	0.22	0.17	0.00	0.04	0.10
Austria	0.15	0.21	0.17	0.01	0.02	0.05
Belgium	0.09	0.30	0.27*	0.00	0.01	0.05*
Canada	0.07	0.22	0.24	0.01	0.06	0.19
Denmark	0.07	0.22	0.20	0.01	0.06	0.16
Finland	0.18	0.28	0.17	0.01	0.02	0.04
France	0.05	0.17	0.19	0.00	0.00	0.02
Hungary	0.07	0.22	0.30	0.01	0.05	0.13
Iceland	0.03	0.06	0.16	0.00	0.11	0.18
Ireland	0.04	0.17	0.19	0.02	0.07	0.14
Italy	0.04	0.20	0.23	0.00	0.01	0.04
Japan	0.01	0.11	0.20	0.00	0.03	0.09
Netherlands	0.10	0.32	0.26	0.00	0.01	0.09
New Zealand	0.08	0.21	0.17	0.00	0.06	0.12
Norway	0.02	0.09	0.16	0.00	0.01	0.07
Portugal	0.02	0.07	0.12	0.00	0.00	0.01
Spain	0.04	0.14	0.22	0.00	0.00	0.00
Sweden	0.03	0.10	0.09	0.00	0.02	0.06
Switzerland	0.09	0.19	0.16	0.00	0.01	0.04
United Kingdom	0.16	0.30	0.20	0.02	0.09	0.15
United States	0.08	0.23	0.22	0.01	0.08	0.20

*Estimates based on data from 2004 for Belgium.
SOURCE: Preston et al. (2010b, Table 4-2). Reproduced with permission.

Iceland by 2003, smoking actually accounted for a larger percentage of deaths among women than among men. The United States was one of only a few other countries in which the percentages for women approached those for men. In general, although smoking accounted for a negligible percentage of deaths among women in every country in 1955, the numbers have grown steadily since that time, particularly in the past quarter century. The exceptions to that trend are France, Portugal, and Spain, where smoking-related deaths still account for just a tiny percentage of total deaths among women. The pattern among men has been different. By 1980 smoking-related deaths were a significant percentage of all deaths among men for almost every country, and thereafter the risk increased in 10 countries and decreased in 11, including the United States.

Next, Preston and colleagues (2010b) calculated what the life expectancy numbers would have been for different years if there had been no smoking. By comparing these estimated nonsmoking life expectancy rates with the real rates, they could see the effect of smoking on life expectancy in the different countries. The results for life expectancy at age 50 in 2003 for the 10 countries considered in this report are shown in Table 5-2 and Figures 5-2 and 5-3. As can be seen from Table 5-2, smoking had a negative effect on life expectancy at 50 for both men and women in all the countries surveyed. The smallest effect—a loss of 0.08 years—was among women in Spain, and the largest—a loss of 2.58 years—was among Dutch men. Other than in the Netherlands, the greatest effect on male life expectancy at 50 was seen in the United States (a loss of 2.52 years), Canada (2.49 years) and Italy (2.41 years). Among women, smoking had the greatest effect on life expectancy in the United States (a loss of 2.33 years), Denmark (2.12 years), and Canada (2.06 years). Figures 5-2 and 5-3 show graphically that there is much less variability in the male than in the female gains from eliminating smoking, probably because smoking was much more widespread among males than females in developed countries.

The average effect of smoking on female life expectancy in the nine countries other than the United States was a loss of 1.07 years. Since the effect in the United States was a loss of 2.33 years, smoking cost U.S. women an average of 1.26 years in life expectancy relative to women in the other countries. By contrast, smoking cost U.S. men only 0.31 year in life expectancy relative to the average for men in the other nine countries.

The total gap in life expectancy at age 50 between the United States and the nine other countries is 1.61 years for women and 0.76 year for men (see Table 5-2). Thus, the difference in the estimated damage caused by smoking accounts for 78 percent (1.26/1.61) of the shortfall of U.S. female

TABLE 5-2 Life Expectancy at Age 50 in 2003 Before and After Removal of Deaths Attributable to Smoking

	Males			Females		
Country	With Smoking	Without Smoking	Difference	With Smoking	Without Smoking	Difference
Australia	30.63	32.25	–1.63	34.59	35.61	–1.02
Canada	29.82	32.31	–2.49	33.85	35.91	–2.06
Denmark	27.77	29.89	–2.13	31.66	33.78	–2.12
France	28.83	31.01	–2.18	34.59	34.92	–0.33
Italy	29.46	31.88	–2.41	34.19	34.64	–0.45
Japan	30.47	32.52	–2.05	36.66	37.41	–0.75
Netherlands	28.34	30.92	–2.58	32.55	33.69	–1.15
Spain	29.00	31.39	–2.39	34.44	34.52	–0.08
United Kingdom	28.62	30.67	–2.05	32.21	33.87	–1.66
United States	28.46	30.98	–2.52	32.25	34.58	–2.33
Non-U.S. average	29.22	31.43	–2.21	33.86	34.93	–1.07

SOURCE: Adapted from Preston et al. (2010b, Table 4-4). Reproduced with permission.

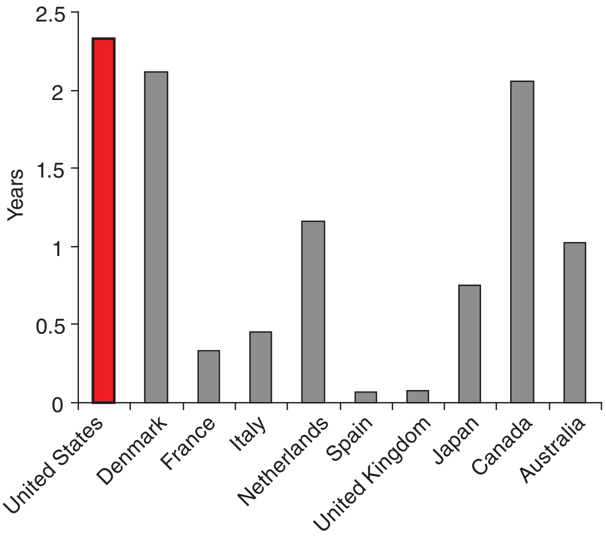

FIGURE 5-2 Gains in female life expectancy at age 50 from eliminating smoking in 2003.
SOURCE: Based on calculations in Preston et al. (2010b).

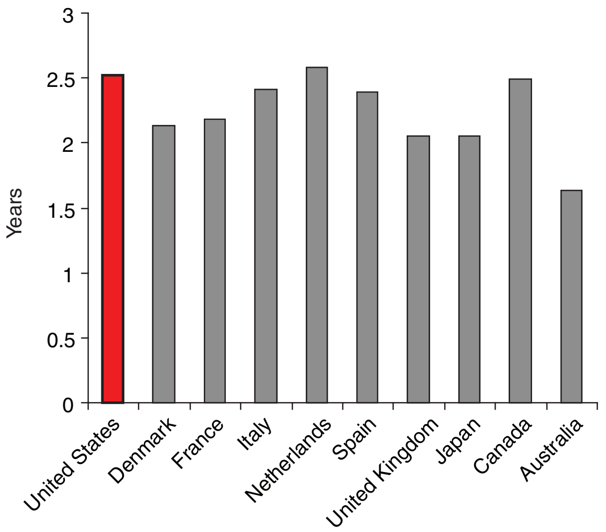

FIGURE 5-3 Gains in male life expectancy at age 50 from eliminating smoking in 2003.
SOURCE: Based on calculations in Preston et al. (2010b).

life expectancy relative to the mean of the nine other countries. For males, smoking accounts for about 41 percent (0.31/0.76) of the much smaller U.S. shortfall. Thus, smoking appears to be a very important factor in the subpar life expectancy of the United States, especially among women.

The numbers tell an interesting story about Japanese life expectancy. A number of observers have noted the anomaly that although the Japanese smoke heavily, the country is at the top of the life expectancy rankings (Stellman et al., 2001). As Table 5-2 shows, removing the effects of smoking-related mortality increases Japanese life expectancy in both men (by 2.05 years) and women (0.75 year) by values that are close to the average for the rest of the countries in the study. Thus, despite Japan's high life expectancy, smoking has left a clear imprint on its mortality.

Preston and colleagues (2010b) also pinpoint how trends in life expectancy between 1950 and 2003 were affected by smoking during that period. Among men, smoking-related mortality had a negative effect on trends in life expectancy at age 50 in 9 of the 10 countries examined here. Only in the United Kingdom did declines in smoking-related mortality have a positive effect: an increase of 0.5 year in life expectancy at 50. In contrast, men in the United States lost an additional 0.8 year in life expectancy at 50 between 1950 and 2003 because of smoking, but changes in smoking cost men even more in Spain (1.3 years), Italy (1.2), France (1.1), the Netherlands (1.1), Denmark (0.9), and Japan (0.9) over this period. Part of the variation across countries reflects differences in the timing of the smoking epidemic: men in the United Kingdom and the United States adopted smoking earlier and have since exhibited declines, whereas the smoking epidemic hit other countries (e.g., Japan, Spain, Italy) much later (see Table 5-1). Thus over this period, the trends for men capture the latter portion of the smoking epidemic (including its waning) for some countries, such as the United Kingdom and the United States, but only the escalating portion for many others.

There was no corresponding drop in smoking among women during this time, and, not surprisingly, smoking had a negative effect on female life expectancy trends from 1950 to 2003 in all 10 countries. The largest decreases in life expectancy at 50 attributable to smoking occurred in Canada (a loss of 1.4 years), Denmark (1.5 years), and the United States (1.6 years). By contrast, there was very little effect on the life expectancy of women in Spain (a loss of 0.1 year), France (0.2 year), Italy (0.3 year), and Japan (0.3 year).

Between 1950 and 2003, the gain in U.S. women's life expectancy trailed the mean gain in the other nine countries by 2.1 years. Preston and colleagues' (2010b) results suggest that 42 percent of this shortfall (0.9/2.11) is attributable to the greater impact of smoking among U.S. women. Correspondingly, gains in life expectancy among U.S. men lagged behind those in the other nine countries by an average of 0.2 year, but differences in smoking-attributable mortality account for only 6 percent of the shortfall.

The effects of smoking on life expectancy trends in the United States are illustrated in Figure 5-4. The solid lines are the actual life expectancy trends, while the dotted lines represent what the trends would hypothetically look like if smoking-related mortality were removed. For men, the difference between the two trend lines widened steadily from 1950 to 1990, increasing from 0.7 year to 3.1 years, but then the gap began closing and had decreased to 2.5 years in 2005. An implication of the figure is that a rise in smoking-attributable mortality is responsible for the leveling off of male life expectancy in the 1960s and early 1970s. For women, on the other hand, the gap remained small until around 1975, when it began increasing rapidly, and by 2005 it had grown to 2.3 years—nearly as large as the gap for men in that year. The gap for women is expected to level off and then begin declining, in concert with lung cancer mortality.

Staetsky (2009)

Staetsky's (2009) study differs from the work of Preston and colleagues (2010b) in that she relied on the original method developed by Peto and

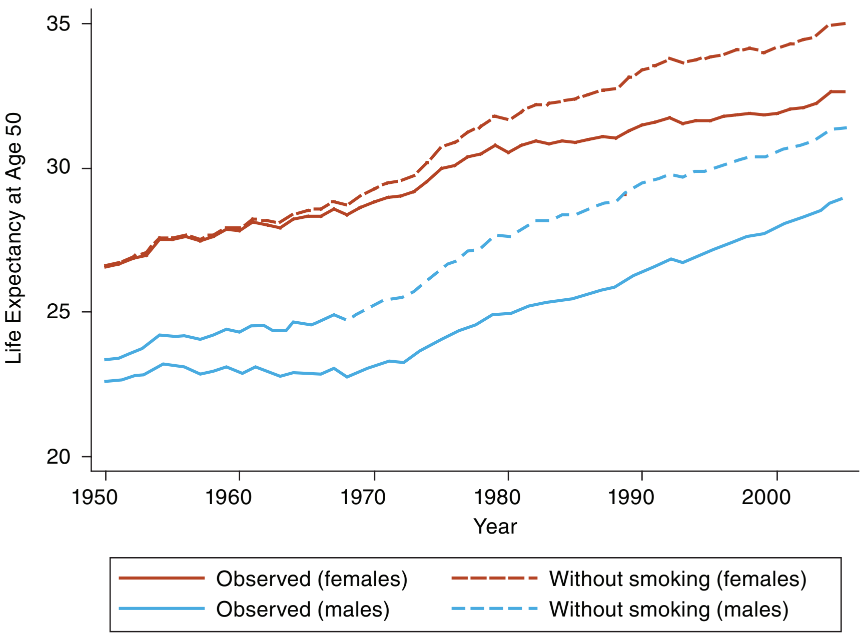

FIGURE 5-4 U.S. trends in observed and estimated life expectancy at age 50 without smoking, by gender.
SOURCE: Preston et al. (2010b, Figure 4-1). Reproduced with permission.

colleagues (1992) to estimate smoking-related mortality. She also looked at 8 high-income countries instead of the 21 that Preston and colleagues worked with, and she focused on women aged 65 and older instead of considering both men and women aged 50 and older as Preston's group did. Her results are very much in line with those of Preston and colleagues—she, too, concludes that a large part of the divergence in female life expectancy trends among various high-income countries can be attributed to smoking patterns—but she offers some additional perspectives that are worth noting.

First, Staetsky observes that the eight countries she studied fall into two obvious clusters, each with similar mortality trends and smoking patterns among women. In the first cluster, consisting of the United States, Denmark, the Netherlands, and England and Wales, a large percentage of women—one-third or more—were smoking during the 1970s. Women in the second cluster, consisting of France, Italy, Spain, and Japan, had much lower rates of smoking. Mortality from lung cancer and other smoking-related diseases was relatively low for women in this second cluster of countries during the 1980s and 1990s, and their life expectancy rose steadily throughout this period. By contrast, women in the United States, Denmark, and England and Wales had much higher smoking-related mortality during this period, and their life expectancy slowed significantly relative to the other cluster of countries. The Netherlands was something of an anomaly, with lung cancer mortality trends falling somewhere between those of the two clusters. The reason, Staetsky concludes, is that women in the Netherlands took up smoking somewhat more slowly than women in the United States and Denmark, although more rapidly than women in the other cluster, so smoking affected their health to a degree falling somewhere between that in the two clusters.

Staetsky also addresses the issue of the apparent mismatch between the high levels of smoking in Europe today and the lower levels of smoking-related diseases relative to the United States. Statistics show that smoking currently is much more common in most European countries than in the United States among both men and women (British Heart Foundation, 2008). So how could smoking explain the fact that life expectancy has been increasing more slowly for U.S. women than for women in most European countries? The answer lies in the 20- to 30-year period between the time people start smoking and the time major health effects appear. In the period from the 1950s to the 1970s, U.S. women were smoking at a much higher rate than women in most European countries, particularly those in Southern Europe, and it is the smoking behavior during that period that affected life expectancy in the 1980s and 1990s. Now that smoking is more common among women in Europe than among those in the United States, the effects are likely to be seen in life expectancy trends over the next couple of decades.

DISCUSSION

While this chapter has focused on the United States in comparison with other countries, it should be noted that smoking has been implicated in the poor performance of other countries as well. In a paper commissioned for this study, Christensen and colleagues (2010a) conclude that smoking is the major factor explaining why Denmark's life expectancy has fallen behind that of neighboring Sweden. Likewise, Juel (2008) used data from 1997–2001 to calculate that nearly all the difference in male life expectancy between Denmark and Sweden and about three-quarters of the difference in female life expectancy could be attributed to smoking- and alcohol-related deaths. Smoking-related deaths, estimated using the Peto/Lopez method, were the more important of the two.

In short, it appears that smoking is responsible for a good deal of the divergence in female life expectancy being examined here. During 1950–2003, gains in life expectancy at age 50 were 2.1 years lower among U.S. women compared with the average of the other nine countries examined in this study (5.7 vs. 7.8 years gained, respectively); Preston and colleagues (2010b) estimate that smoking accounts for 42 percent of this shortfall. In terms of the gap in life expectancy between the United States and other countries in 2003, Preston and colleagues find that differences in the estimated damage caused by smoking account for 78 percent of the 1.6-year gap for women and 41 percent of the 0.8-year gap for men. It appears that smoking has also caused significant reductions in life expectancy in Denmark and the Netherlands, two other countries with relatively poor life expectancy trends. On the other hand, smoking has also had a major negative effect on life expectancy in Canada, where life expectancy trends have been much more favorable. Thus although smoking clearly helps account for the lagging performance of the United States, it is only one of many factors affecting trends in life expectancy.

6

The Role of Social Networks and Social Integration

Over the past 50 years, social epidemiologists have tracked the impacts of social ties on health. Early studies focused on widowhood. By the late 1970s, several investigators had begun to examine the influence of social networks, social support, and aspects of community engagement on a number of health outcomes. After following nearly 7,000 adults in Alameda County, California, over a 9-year period, Berkman and Syme (1979) found that people with fewer social and community ties were significantly more likely to have died. The mortality rate for the men with the fewest ties was 2.3 times that for the men with the most ties, while the mortality rate for the women with the fewest ties was 2.8 times that for the women with the most ties. The effect of social ties on mortality was independent of such factors as the health of the survey participant at the beginning of the study; socioeconomic status; and smoking, drinking, obesity, and level of physical activity.

In the 30 years since the publication of that paper, researchers have studied the effects of social networks on health and mortality from a variety of angles and often with an increasingly rich set of covariates or potential confounders (Holt-Lunstad et al., 2010; House et al., 1982). They have found that various aspects of social ties—including structural characteristics of social networks, such as the size of one's network of friends and family members, and the resources that flow through networks, such as the support one receives from the network—influence health in a number of ways. Recent, more formal analysis of social networks (Christakis and Fowler, 2007) suggests that they transmit a number of both health-promoting and risk-related behaviors capable of mediating many of the relationships between social network structure and health outcomes. Thus, aspects of social networks ranging from structure to function are related to mortality, morbidity, cognitive and physical function, and a range of health behaviors.

As with other factors considered in this volume, while associations between social ties and mortality and health may be strong, it is often difficult to be sure of the causal direction. People who are social isolates may differ from those who are highly socially integrated in many ways. Some of these differences may also be related to their health. In some cases, poor health can be linked to social withdrawal.

The question addressed in this chapter is whether international differences in the distribution of social networks and social support, and the risks related to them, might play a role in the divergence in life expectancy among countries. To answer this question, this chapter first takes a closer look at the pathways by which social networks can affect health and mortality and the evidence for these linkages. It then examines how social networks in the United States compare with those in other countries and considers the evidence that those differences play a role in the divergence in life expectancy trends.

PATHWAYS LINKING SOCIAL NETWORKS TO HEALTH AND MORTALITY

There are a number of mediating pathways by which aspects of social networks might plausibly impact health. Most obviously, the structure of network ties influences health via the provision of many kinds of support, from financial to instrumental and emotional (Berkman and Glass, 2000). Support is often transactional in nature, potentially involving giving as well as receiving, and occurs within a normative framework of exchange over the life course that may vary across countries and cultures. Some exchanges improve access to resources and material goods. For instance, social networks have been shown to be associated with an individual's likelihood of getting a job (Granovetter, 2003). Other types of support, such as emotional support, may impact health by reducing physiological stress responses. Social networks can also impact health through social influence whereby individuals obtain normative guidance about behaviors. Finally, negative interactions leading to conflict, abuse, or neglect can have powerful impacts on subsequent health outcomes via a number of behavioral and biological pathways.

Linking the kinds of social interactions described above to health outcomes logically requires a set of pathways by which the effects of social interaction affect health. These can be pathways that link social interaction to behaviors, psychological states, or more directly to physiological responses tied to health. Previous research has linked aspects of social networks and the resources that flow through them to behaviors related to tobacco and alcohol consumption, physical activity, dietary patterns, and sexual behaviors. By establishing and enforcing normative behaviors, networks may influence work- and school-related behaviors, criminal behaviors, and other social behaviors. Networks may also influence patterns of self-esteem, efficacy, competence, and other conditions leading to mental health outcomes. Finally, increasing evidence suggests that social networks and related functions impact physiological processes directly by several pathways. Invoked most frequently is a stress pathway linked to neuroendocrine regulation, inflammation, and immune function (Gruenewald et al., 2009; Loucks et al., 2006a, 2006b; Uchino, 2006). Berkman (1988) hypothesizes that social isolation or the negative aspects of social ties influence health by accelerating the rate of aging. Social isolation, conflict, or lack of support may be viewed as a chronically stressful condition to which the organism responds by aging more rapidly. This acceleration would be especially evident in cardiometabolic functions that decline with age.

Social Networks and Mortality

Numerous studies from many industrialized countries in North America, Europe, and Asia have shown that aspects of social networks or social support are related to mortality, including mortality from all causes combined (Berkman et al., 2004; Blazer, 1982; Eng et al., 2002; Fuhrer and Stansfeld, 2002; Kaplan et al., 1988; Khang and Kim, 2005; Orth-Gomer and Johnson, 1987; Orth-Gomer et al., 1993, 1998; Penninx et al., 1998; Pinquart and Duberstein, 2010; Pinquart and Frohlich, 2009; Seeman, 1996; Sugisawa et al., 1994). Although all of these studies are longitudinal in the sense of including a mortality follow-up after baseline assessment of social networks, they vary widely in their ability to control for important covariates or to disentangle the extent to which such covariates are mediators along the pathway from social networks to increased mortality risk. Furthermore, networks themselves develop in the context of individual exposures over a life course, some of which may be related to health.

Focusing on some of the more salient aspects of the above-mentioned mortality studies helps identify areas for further work. For instance, it appears that different aspects of social networks may be more important at different ages, or for men or women, or in different countries. In a follow-up to the original Alameda study (Berkman and Syme, 1979), Seeman and colleagues (1987) report that over a 17-year period, the subjects with stronger social networks and community ties were significantly less likely to die. The types of social ties with the greatest effect on mortality differed by age. For adults 60 and younger, marital status had the greatest association with the risk of dying, while for those over 60, the most meaningful relationships for health were those with close friends and relatives. A large-scale prospective study conducted in Japan with more than 11,000 subjects aged 40–69 found important gender differences: for men the key factor related to health was participation in hobbies, clubs, or community groups, while for women the factors that increased risk were being single and having little contact with close relatives (Iwasaki et al., 2002). A 7-year study in Israel found that the two social factors influencing mortality among a group of older Jewish–Israelis were contact with friends and attendance at synagogue (Litwin, 2007). And a 6-year study of 7,500 women from four different communities in the United States found mortality risks to be significantly lower among women with higher social network scores, although the authors conclude that much of the protection older women receive from a large social network is actually due simply to being married (Rutledge et al., 2003).

In a paper prepared for the panel, Banks and colleagues (2010) perform a similar analysis for both males and females using comparable data on the older population in the United States and England. Once again, marriage (including cohabitation) is the element of social networks and interactions found to be protective against mortality. This is strongly the case for both males and females in England, but in the United States the effects are not statistically significant. In England, where the data permit the cleanest analysis, any association of mortality with memberships in clubs and organizations is shown to be simply a consequence of the inclusion of membership in sports and health clubs in the participation measure, so the likelihood is strong that a reverse causal mechanism generated this relationship. In the United States, any overall effect of networks, contact, and participation is shown to be due to a significant protective effect for those who attended religious meetings regularly.

Berkman and colleagues (2004) examined an occupational cohort of employees who were stably employed to minimize the possibility that socially isolated subjects were more likely to also be economically disadvantaged or disabled. They found that socially isolated men had a mortality risk 2.7 times greater than that of the men with the highest level of social integration; the corresponding figure for women was 3.6 times greater (Berkman et al., 2004). The risks were greatest for cancer mortality, a finding at odds with some but not all of the data from the United States. Kawachi and colleagues (1996) examined mortality risks among 32,000 U.S. men aged 42–77 and found that socially isolated men were 1.9 times more likely to die from cardiovascular disease and 2.2 times more likely to die from accidents and suicide than men who had the highest level of involvement in social networks (Kawachi et al., 1996).

There is also evidence that social networks are linked to mortality from breast cancer. In a study of 2,800 women diagnosed with breast cancer between 1992 and 2002, women who had been socially isolated before the diagnosis were more than twice as likely to die from the disease as women with a high level of social support. The researchers conclude that the increased mortality was likely an indirect effect of the lack of social connections and that the reason the socially isolated women had an increased mortality risk was that they did not receive as much aid, care, and support from friends, children, or family members (Kroenke et al., 2006).

The authors of a recent meta-analysis of 87 studies that examines the effects of social support on cancer mortality report that large social networks, positive social support, and being married all are correlated with decreased mortality from cancer. However, the authors conclude that the effects are generally larger for younger patients (Pinquart and Duberstein, 2010). Another recent meta-analysis concludes that the quality of social relationships has an effect on mortality that is comparable to that of quitting smoking and greater than that of other risk factors such as obesity and physical activity (Holt-Lunstad et al., 2010); however, many of the results underlying this study lack statistical controls for some of the factors that are correlated with both mortality and social relationships. Much work remains to be done to understand the links between social networks and mortality. Nonetheless, the preponderance of the evidence indicates that social ties and social support do affect mortality among adults.

Social Networks and Physical and Mental Health

In general, studies that have examined the effects of social networks on physical health have less consistently found evidence of a relationship than those looking at effects on mortality. Nevertheless, a number of studies show a link between social ties and social support and the development of such illnesses as heart disease, stroke, and cancer.

In the above-referenced study of 32,000 U.S. men aged 42–77, Kawachi and colleagues (1996) found that over 4 years, men who were socially isolated—not married, having fewer than six friends and family members, and not a member of any church or social organization—were 121 percent more likely to suffer a stroke than those men with the greatest degree of social connection. However, they were no more likely to suffer a nonfatal heart attack.

Broadly speaking, studies that have looked at the effects of social support on heart disease have had mixed results, but a majority—unlike the work of Kawachi and colleagues (1996)—have found at least some effect. When Lett and colleagues (2005) reviewed the body of research on this issue, they concluded that subjects with low levels of social support were more likely to develop coronary heart disease and to have it worsen than those with high levels of support, and the risk ratio between the two groups appeared to lie between 1.5 and 2.0, depending on the study. The authors note, however, that there was little consistency across studies in the way social support was defined and measured and furthermore, that there was little experimental evidence that increasing social support helps reduce the risk of heart disease.

Banks and colleagues (2010) found no relationship between a summary social network index and the prevalence of high blood pressure or diabetes among older men in either the United States or England. In the United States, men with high levels of social ties had a greater prevalence of heart disease. Among women in both countries, high levels of social ties were related to fewer of these health problems, with the exception of obesity (which is linked to diabetes). The authors also found inconsistent effects of social interaction and social network measures on subsequent mortality in the two countries. Overall, then, the results of this study mirror the highly mixed nature of the existing empirical evidence linking social networks to physical health.

More consistent findings with regard to social networks and domains of health relate to mental functioning rather than morbidity or physical health. Study after study has shown that social networks and social participation delay various types of cognitive decline in older adults, while those older adults with few social ties deteriorate much more quickly. Bassuk and colleagues (1999) followed 2,800 adults aged 65 and older living in New Haven, Connecticut, and found that those with no social ties were significantly more likely to decline cognitively than those who had a large number of such ties. In particular, those with no social ties were 2.2 times as likely to have declined cognitively after 3 years, 1.9 times as likely after 6 years, and 2.4 times as likely after 12 years (Bassuk et al., 1999). A more recent study shows social integration to be inversely related to memory decline among Health and Retirement Study (HRS) participants (Ertel et al., 2008).

Similar results have been found in other countries. Fratiaglioni and colleagues (2000, 2004) report an association between limited social networks and increased risk of incident dementia. Zunzunegui and colleagues (2003) found social isolation to be related to cognitive decline in an older Spanish sample. One prospective study in Taiwan that followed nearly 2,400 older adults over 7 years found no relationship between social networks and cognitive functioning but did find a clear effect of social activities on tests of cognitive function. Subjects who reported participating in one or two social activities and in three or more such activities failed 13 and 33 percent fewer of the cognitive tasks, respectively, than those who reported participating in no social activities (Glei et al., 2005).

Given the evidence that various aspects of social ties and networks and the functions of such networks are consistently related to mortality and often to other health outcomes as well, a natural question is whether differences in the distribution or risk of social networks might help explain cross-country differences in life expectancy.

INTERNATIONAL COMPARISONS OF SOCIAL NETWORKS AND EFFECTS ON HEALTH AND MORTALITY

Few if any studies directly address the question of whether social factors might explain some of the differences in life expectancy among various high-income countries. However, a great deal of research compares social networks among various countries, and some of that research also includes information on the connection between social networks and mortality in the countries under consideration. Ideally, one would wish to assess the variability in the distribution of social networks and support in many countries. Second, one would like to identify whether risks associated with social isolation and various health outcomes are the same within each country. For social networks and support to help explain cross-country differences in life expectancy, at least one of two conditions must be met. First, a different fraction of the population needs to be exposed to risk factors across countries. Alternatively, the health risk ("toxicity") associated with risk factors might differ among countries. For common risk factors, even small differences in toxicity could have large population health effects. Differences in toxicity could occur if population differences in exacerbating or compensatory factors influenced the risk of disease. For instance, if countries had public policies protecting citizens against the deleterious health effects of extreme poverty, those health effects might not manifest themselves even though poverty was present.

The United States and England

Perhaps the most directly relevant study on these issues is the report prepared for the panel by Banks and colleagues (2010) comparing the effects of social networks and social integration in the United States and the United Kingdom. The investigators compared data from the HRS in the United States and the English Longitudinal Study of Ageing (ELSA) in the United Kingdom. Exploiting the relative comparability of the data items, they derived a social network index combining information on the presence of a spouse or partner; the frequency of meeting up with children, family, and friends; and membership in clubs or organizations. In addition, they were able to derive comparable measures of both negative and positive social support from children, close family members, and friends.

One key finding was the remarkable similarity in the distribution of social support and networks among older adults in the United States and England (see Figure 6-1). The differences that did appear were second order,

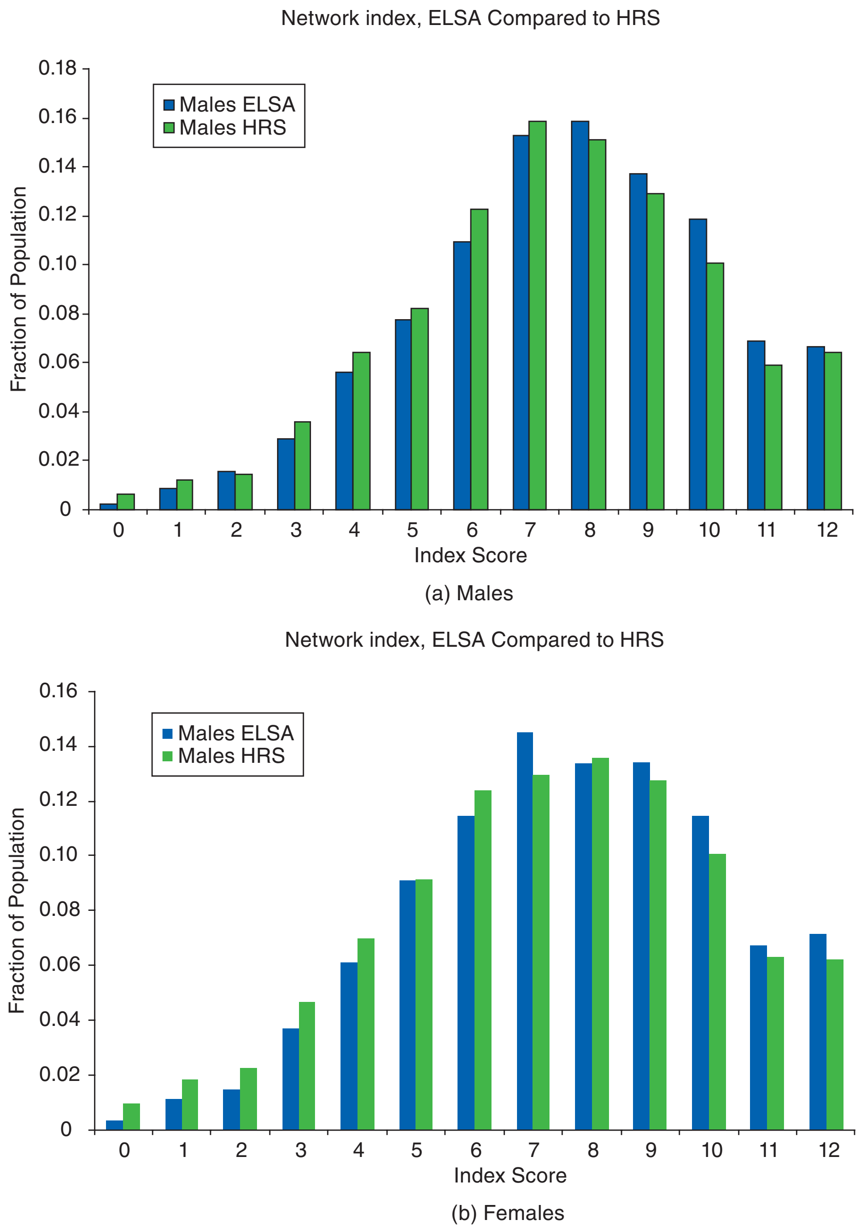

FIGURE 6-1 Distribution of scores of the index of social networks in England and the United States among men (a) and women (b).
NOTE: ELSA = English Longitudinal Study of Ageing; HRS = Health and Retirement Study.
SOURCE: Banks et al. (2010, Figures 8-1A and 8-1B). Reproduced with permission.

somewhat nuanced, and not all indicative of weaker networks or less support in the United States. As an example, American men and women receive more positive support from their children than do their British counterparts, but also more negative support (Banks et al., 2010), a finding similar to that reported in a recent international study (Silverstein et al., 2010).

Given the similarities in the levels and distribution of social support and networks in these two populations, rather large differences would have to exist in the health consequences of these social circumstances for this to be a candidate explanation for differences in morbidity between the two countries. But the authors also found very little consistent or compelling association between levels of social networks and the prevalence of a variety of physical health measures, and only a weak association between social networks and subsequent mortality; what effects were found were associated primarily with the presence of a spouse/partner. The authors conclude that differences in morbidity and mortality between these two countries cannot be explained by current differences in social ties, support, and networks. By extension, the same argument would hold true for life expectancy.

Other International Comparisons

Given the similarity of the distribution of social ties and networks between the United States and England, more powerful evidence might be expected to come from other international comparisons where variation in these social risk factors is greater. A small number of studies have compared social ties in the United States with those in other countries and looked at how differing social networks may affect health and mortality in those countries.

Japan is a particularly interesting country to compare with the United States, both because it has significantly higher life expectancy and because the countries have very different cultures. Janevic and colleagues (2000) examined the relationships between social ties and health in Japan and the United States, looking in particular for any differences between men and women. They found relatively few national differences, and those differences did not appear to play a major role in the relationship between social ties and health, leading the authors to conclude that this relationship may vary little from country to country. Their data did indicate that older people in the United States receive more emotional and instrumental support from their networks than do older Japanese, but Americans also have more negative social relationships. The authors note that it was the type and quality of support received, rather than the particular structure of the social networks, that had the largest effect on health.

Antonucci and colleagues (2001) compared the relationship between social networks and health in four countries: the United States, Japan, France, and Germany. In particular, they were interested in what happens to the social networks of older adults when they become ill or widowed. One might expect that becoming ill or losing a spouse would change a person's social network in various ways. The network might shrink, for example, as contact faded with friends and even family members. The data showed that network structure did indeed change in various ways in response to illness or losing a spouse, but only in three of the countries; the social networks of older adults in the United States remained stable in the face of such losses. The authors conclude that older adults in the United States may be somewhat more protected from the effects of illness and loss of a spouse because of the stability of their social networks in the face of such losses.

The potential power of a multicountry comparison is further evidenced by the final section of the Banks et al. (2010) paper. Using data from the 2006 and 2007 Gallup World Poll, the authors document differences in a variety of social integration and participation measures across nine of the countries considered in this study (see Table 6-1). Once again, the implications of their findings for explaining the life expectancy and health disadvantages of the United States are rather mixed. The United States has a relatively low rank with respect to marriage or living with a partner, although not as low as England, while Japan is the one country with notably higher levels of marriage among older persons. The indicator of number of hours spent in the last day with family and friends is not available for the United States, but the hours are longer in Japan than in other countries. On the other hand, on two other indicators of community integration—religious participation and volunteering—the United States ranks highest.

One can also examine international differences in some of the psychosocial outcomes that have been linked to social integration using the same Gallup data (see Table 6-2). In the Gallup poll, people report their levels of stress, worry, sadness, depression, and anger in the last day—all states that would potentially be buffered by strong social relationships. No one country stands out as reporting poorer psychosocial well-being, and differences in reports of these states vary markedly across countries. People in the United States reported the most stress, people in Japan the most depression, and people in France the most anger, while people in Denmark and the Netherlands reported relatively low levels of most of these states. The variation exhibited in these measures across countries suggests that a more sophisticated and in-depth multicountry analysis exploiting such data might yield useful evidence in the future.

Change Over Time in Social Networks

Finally, it is useful to look at differential trends in social integration across countries. Living alone is one indicator of social integration that can

TABLE 6-1 Social Network Measures by Country: Gallup World Poll, 2006–2007

Country	Proportion Married or Living with Partner	Proportion Attended Religious Services in Past Week	Hours Spent with Friends and Family Yesterday	Proportion Volunteered Time to an Organization in Past Month
		Males		
United States	0.58	0.46	N.A.	0.43
Canada	0.60	0.29	N.A.	0.33
Denmark	0.59	0.14	7.08	0.23
France	0.61	0.14	6.86	0.29
Italy	0.60	0.51	8.41	0.22
Japan	0.66	0.21	7.55	0.26
Netherlands	0.57	0.21	6.60	0.36
Spain	0.57	0.23	7.46	0.13
United Kingdom	0.54	0.20	7.16	0.21
		Females		
United States	0.51	0.46	N.A.	0.43
Canada	0.63	0.33	N.A.	0.42
Denmark	0.64	0.21	7.26	0.25
France	0.55	0.19	6.50	0.28
Italy	0.62	0.59	8.66	0.21
Japan	0.67	0.23	10.75	0.24
Netherlands	0.59	0.26	8.33	0.38
Spain	0.59	0.33	7.83	0.16
United Kingdom	0.45	0.29	7.53	0.25

SOURCE: Adapted from Banks et al. (2010, Tables 8-7 and 8-8). Reproduced with permission.

be tracked across time for many countries. The likelihood of living alone among older people increased markedly in Europe and the United States after 1950 and particularly from 1970 to 1990, but this trend has stabilized or reversed in many countries since then. In 2000 older women in the United States were less likely to live alone than those in many Northern European countries (e.g., Great Britain, the Netherlands, Sweden, Germany, Austria) (Tomassini et al., 2004).

Whether one lives alone or with others in old age is determined by marriage rates, mortality rates, past fertility rates, income levels, and policies on providing both income and housing for older persons (Macunovich et al., 1995; Wolf, 1995). Decreases in the death of a spouse have generally increased the likelihood of living with a spouse, but in many countries these increases have been offset by increases in divorce rates. Because the Japanese have both lower mortality and lower divorce rates, they are most

TABLE 6-2 Psychosocial Measures[a] and Availability of Social Support[b] Among Those Aged 50+: Percentage Responding Yes to Questions, Gallup World Poll, 2006–2007

Country	Stress	Worry	Sadness	Depression	Anger	Support Available
United States	35	28	19	11	12	96
Italy	31	44	29	13	17	86
Canada	31	27	16	8	12	95
Australia	30	26	20	11	10	93
United Kingdom	27	28	29	14	10	97
Japan	24	26	11	15	20	92
France	23	32	25	6	31	89
Denmark	14	22	15	6	11	94
Netherlands	17	35	20	5	7	89

[a]Questions asked:
Did you experience stress during a lot of the day yesterday?
Did you experience worry during a lot of the day yesterday?
Did you experience sadness during a lot of the day yesterday?
Did you experience depression during a lot of the day yesterday?
Did you experience anger during a lot of the day yesterday?
[b]Question asked:
If you were in trouble, do you have relatives or friends you can count on to help you whenever you need them, or not?
SOURCE: Data from Gallup World Poll Data. See http://www.gallup.com/video/106357/introducing-gallup-world-poll.aspx [accessed January 12, 2011].

likely among the populations of the countries studied here to be married in old age; clearly, however, cultural differences are the reason older people in Japan are less likely to live alone than those in any of the other countries (Palloni, 2002). The past high fertility of U.S. cohorts relative to those in the other countries adds to the likelihood that older Americans will live with a child and is one reason they have both a relatively low level of and recent reductions in solitary living. Thus, the available evidence does not support the hypothesis that social networks among the U.S. elderly weakened sharply in the 1980s and 1990s while remaining strong in other countries.

Discussion

Data do not currently exist with which to test detailed hypotheses relating to differences in the causal effects of social ties and networks across multiple countries, or even to document the distribution of such ties and networks on a detailed and fully comparable basis. Furthermore, almost no information is available concerning trends in social networks and their effects on health and mortality. Most of the data concern social networks at one point in time, generally near the present. Nonetheless, at this point there appears to be little reason to believe that social networks played a role in the divergence in life expectancy trends among high-income nations from 1980 to 2005. As for explaining the current gap in life expectancy, the details of the networks may vary from country to country, but countries appear to differ relatively little in the overall level of support individuals receive from their social networks. Thus at present, the available data do not support the notion that social networks play an important role in international variations in longevity.

7

The Role of Health Care

The U.S. health care system differs from the systems of other countries in a number of ways that could conceivably lead to differences in life expectancy. Social and health care policies are generally better integrated in the other countries considered here, for example, and access to health care is not as limited by the ability to pay. Health insurance is almost universal in Europe, Canada, Australia, and Japan, whereas 50.7 million people in the United States did not have health insurance in 2009 (DeNavas-Walt et al., 2010). Another way in which European health systems may differ from the system in the United States is related to their orientation toward patient services. It is sometimes argued that European health care systems have a stronger focus on primary care as compared with a greater emphasis on specialist care in the United States. Evidence on this matter is mixed. Organisation for Economic Co-operation and Development (OECD) data indicate that the percentage of physicians (36 percent) who are specialists in the United States is the same as the average for other OECD countries (McKinsey Global Institute, 2007, Exhibit 37). However, the United States scores in the bottom group of OECD countries (6 out of 18) on a scale of the adequacy of primary care (Macinko et al., 2003). This scale is built from items relating to policy, finance, and personnel.

The adequacy of primary care is likely to be related to disease prevention. On several indicators of actual performance in preventive medicine for the older population, the U.S. performance is mixed. The United States ranks ninth among 23 OECD countries in the proportion of the population above age 65 offered an annual influenza vaccination (Organisation for Economic Co-operation and Development, 2007), although the proportion actually receiving one is not exceptionally high (see Table 7-1). On the age-standardized death rate above age 50 from influenza, the United States ranks sixth among 16 OECD countries (Preston and Ho, 2010). The proportion of individuals having their blood pressure checked in the past year is higher in the United States than in four other English-speaking countries (Schoen et al., 2004, Exhibit 6). In this study, however, U.S. physicians were less likely to send out reminders for preventive care than physicians in the other countries (Schoen et al., 2004, Exhibit 6). Eighty percent of Americans have a physician they see regularly, a lower percentage than that in six other OECD countries (Schoen et al., 2007). On screening for major cancers, a form of preventive medicine, the United States ranks first among OECD countries (Howard et al., 2009).

Efforts to identify early stages of a disease—for example, through screening—are sometimes termed "secondary prevention" and are a principal responsibility of the health care system. One could take a broader view of the responsibilities of the health care system and include among them the prevention of harmful personal behaviors such as smoking, lack of exercise, and excess calorie consumption (Murray and Frenk, 2010), sometimes termed "primary prevention." From this vantage point, as noted in previous chapters, the U.S. health care system performs poorly. This report addresses these behaviors individually, however, and this chapter focuses more narrowly on the health care system—the array of hospitals, physicians, and other health care professionals; the techniques they employ; and the institutions that govern access to and utilization of these resources. Efforts to identify early stages of a disease, for example, through screening, is sometimes called "secondary prevention" and is a principal responsibility of the medical system.

ACCESS TO HEALTH CARE

Access to health care in the United States is limited by the availability of health insurance, with 16.7 percent of the resident population lacking coverage (DeNavas-Walt et al., 2010). The young—both adults and children—are most likely to lack health insurance. Only 10 percent of the uninsured are aged 55 or older; only 2 percent of those 65 and over are uninsured, compared with 13 percent of those 55–64.

Data from the National Health and Nutrition Examination Survey (NHANES), 2003–2006, for those aged 55–64 reveal that uninsured and insured adults do not differ significantly in the prevalence of many health conditions and risk factors. The two groups are similar in levels of ever having had cancer (uninsured 10.2 percent, insured 10.5 percent) or a heart attack (4.7 and 4.6 percent), although the insured report a somewhat higher prevalence of stroke (1.9 versus 3.2 percent), diabetes (10.2 versus

TABLE 7-1 Indicators of Health Care Costs, Health Care Access, Appropriate Use of Services, and Health Care System Efficiency Across Selected Countries

Indicator	United States	Canada	France	Germany	Netherlands	United Kingdom	Japan	Australia
Per capita health care expenditures, 2005 ($U.S.)[a]	6,347	3,460	3,306	3,251	3,192	2,580	2,474	
% of population >65 receiving flu shot, 2004[b]	65	62	68	48	73	71	43	
% primary care MD use of electronic records, 2005[c]	28	23		42	98	89		79
% chronically ill skipping care because of costs, 2007[c]	42	14		20	5	9		26
% records of test results not available	22	18		12	9	17	14	17
% went to emergency room when not appropriate	21	19		6	8	11	8	16
Administrative costs, 2004 ($U.S.)[d]	465	131	238	172	132	57	52	
Practicing MDs, 2006 (per 1,000)[a]	2.4	2.1	3.4	3.8	2.5	2.1	2.0	
Acute hospital beds (per 10,000), 2005[a]	2.7	2.8	3.7	6.4	3.1	2.3	8.2	

Prescription drugs, 2005 (grams per capita relative to U.S. = 100)[e]	100	146	171	85		94	56
MRIs, 2006 (per 1 million)[a]	26.5	6.2	5.3	7.7	6.6[f]	5.6	40.1[f]
% waited >6 months for elective surgery, 2007[c]	4	14		3	2	15	
% MD recommended treatment w/o benefits, 2007[c]	20	12		20	13	10	
Generalist MD annual remuneration, 2004 (in thousands of $U.S.)[g]	161	107	92	[77][h]	117	118	

NOTES:
[a]Data from Organisation for Economic Co-operation and Development (2008). Exchange rate determined using OECD measure of purchasing power parity (PPP).
[b]Data from Cylus and Anderson (2007).
[c]Data from Schoen et al. (2007).
[d]Expenditures on health administration and insurance by private insurers and central and local authorities.
[e]Data from Danzon and Furukawa (2008).
[f]2005 data.
[g]Data from Peterson and Burton (2007).
[h]Specialist income; likely an upper bound on generalist income.
SOURCES: Garber and Skinner (2008), except for % test results of records not available; % went to emergency room when not appropriate; and data for Australia, which are from Commonwealth Fund National Scorecard on U.S. Health System Performance (Commonwealth Fund, 2008).

12.5 percent), and obesity (36.6 versus 39.5 percent). On the other hand, a recent review of the effects of lack of insurance by the Institute of Medicine (2009) concludes that uninsured men and women are much less likely to receive clinical preventive services (primarily secondary prevention) that have the potential to reduce unnecessary morbidity and premature death. Moreover, uninsured chronically ill adults are more likely to delay or forgo visits with physicians and clinically effective therapies, including prescription medications. Uninsured adults are more likely as well to be diagnosed with later-stage cancers that are detectable at earlier stages by screening or by contact with a clinician who can assess worrisome symptoms. Without health insurance, adults also are more likely to die from trauma or other serious acute conditions, such as heart attack or stroke.

The Institute of Medicine (2002) has estimated that 18,000 people aged 25–64 die each year because they lack health insurance. This calculation assumes a mortality rate for the uninsured that exceeds that of the insured by 25 percent. A recent update of this analysis found that those without health insurance had 40 percent higher mortality than the insured in the age range 17–64 (Wilper et al., 2009). An assumption of 40 percent higher mortality would result in 45,000 excess deaths in this age range attributable to a lack of health insurance. This estimate suggests that only a small number of total deaths over age 50 are likely to result from a lack of insurance: if 13 percent of those aged 50–64 are uninsured, and the excess mortality for this group is 40 percent, the excess mortality among all persons aged 50–64 due to a lack of insurance is about 5 percent.

Access to health care in the United States also is affected by the ability to pay for services not covered by insurance. Even those with insurance can find it difficult to pay the high costs of copayments and uncovered drugs. The percentage of adults in the United States who say that they have had an access problem because of costs is far higher than that in other high-income countries (see Table 7-1). In the United States, for example, 42 percent of chronically ill adults indicate that they have forgone some care because of costs in the past year, while this is true of only 5 percent of chronically ill people in the Netherlands.

EFFICIENCY AND COST OF CARE

The United States spends 16 percent of its gross domestic product (GDP) on health care, a higher figure than for any other country. Japan and France, two countries with substantially higher life expectancies, spend only 8 percent and 11 percent of their GDP on health care, respectively (Organisation for Economic Co-operation and Development, 2008). One factor in the higher U.S. costs is a high level of expenditure on administration of services. Table 7-1 shows that administrative costs per capita in the United

States are 9 times those in Japan and the United Kingdom and 3.5 times those in the Netherlands. Also contributing to the high costs in the United States is the high prevalence of major illnesses, described in Chapter 2, and the high proportion of the U.S. population diagnosed with a disease that is being treated for it (e.g., Thorpe et al., 2007). This combination produces a high usage of physician services in the United States. Survey data on physician visits for the population aged 50+ in Europe and the United States show that the United States in 2004 ranked fourth among 12 countries on the proportion of this population who had visited a physician in the past year. Some of the high treatment costs in the United States also are undoubtedly driven by physicians' incentives under a predominantly fee-for-service health care system (Garber and Skinner, 2008). And physicians earn substantially higher salaries in the United States (see Table 7-1).

On several other indicators of efficiency that may also be related to survival—use of information technology, appropriate use of emergency rooms, and appropriate availability of medical records—the United States ranks very poorly (see Table 7-1). It is interesting to note, however, that the Netherlands, which ranks as extremely efficient on all of these measures, is one of the other countries that in the past has had relatively poor life expectancy trends.

INTERNATIONAL COMPARISONS QUALITY OF HEALTH CARE AND IMPLICATIONS FOR LIFE EXPECTANCY

Costs and efficiency aside, how does the U.S. health care system compare with those of other countries in preventing death from various diseases? Mortality rates are determined by disease incidence, detection, and treatment. Incidence reflects not just the performance of a health care system but also a variety of other characteristics affecting population health, including behavioral, social, and genetic factors. These characteristics are not unrelated to the health care system but are perhaps less directly a product of that system than disease identification and treatment. This section considers how the U.S. health care system compares with those of other countries in detecting and treating specific diseases and conditions.

International Comparisons of Detection and Treatment of Cancer

The United States compares well with other countries on both identifying and treating cancer (Preston and Ho, 2010). First, in international comparisons of the frequency of cancer screening, the United States scores consistently higher than any other country. Howard and colleagues (2009) compare U.S. data from the Health and Retirement Study (HRS) and the 2004 Medical Expenditure Panel Surveys with data on 10 countries from the Survey of Ageing, Health and Retirement in Europe. The frequency of screening was much higher in the United States than in the European composite. The European/U.S. ratio for frequency of screening for ages over 50 ranged from 0.22 to 0.60 for mammograms, 0.36 to 0.49 for colon cancer screening, 0.55 to 0.88 for pap smears for cervical cancer, and 0.56 to 0.64 for PSA tests for prostate cancer. In most of the comparisons of screening by age, the United States had a higher frequency than any other country (Garcia, 2010; Howard et al., 2009). Preston and Ho (2010) show that the international differences in screening frequency for prostate and breast cancer were present in earlier years as well. Given this higher rate of screening, one would expect higher cancer incidence rates in the United States because a greater percentage of those with cancer are actually identified (Crimmins et al., 2010; Preston and Ho, 2010). Higher levels of screening should also lead to earlier detection and increased survival with treatment.

In terms of cancer survival, the United States compares quite well with Europe; however, some or all of this survival advantage may be a reflection of earlier detection. On the other hand, early detection itself offers survival benefits. During the late 1980s, 5-year survival rates in the United States were higher than those in all of the 18 European countries surveyed for each of the major cancers: lung, breast, prostate, colon, and rectal (Gatta et al., 2000). A more recent study examining survival rates during the period 2000–2002 led to a similar conclusion: 5-year survival was higher in the United States than in a European composite for all major types of cancer (Verdecchia et al., 2007). As can be seen in Table 7-2, when all cancers are included, 66.3 percent of American men survived for at least

TABLE 7-2 Five-Year Relative Survival Rates for Various Cancers

	5-Year Survival Rate (%)	
Site	United States	Europe
Prostate	99.3	77.5
Skin melanoma	92.3	86.1
Breast	90.1	79.0
Corpus uteri	82.3	78.0
Colorectum	65.5	56.2
Non-Hodgkin's lymphoma	62.0	54.6
Stomach	25.0	24.9
Lung	15.7	10.9
All malignancies (men)	66.3	47.3
All malignancies (women)	62.9	55.8

NOTE: Data based on period survival data for 2000–2002 from U.S. and European cancer registries.
SOURCE: Data from Verdecchia et al. (2007).

5 years compared with 47.3 percent of European men, and 62.9 percent of American women survived for 5 years compared with 55.8 percent of European women. The advantage among men was much larger than the advantage among women mainly because of high U.S. survival rates from prostate cancer.

Recommended levels of screening for breast and prostate cancer are controversial. Most of the controversy relates not to the survival advantages of frequent screening but to the occurrence of false positives and the side effects of biopsy and treatment. Evidence that frequent screening and early detection influence survival from breast and prostate cancer is reviewed by Preston and Ho (2010). Most of the evidence indicates that early detection of cancer followed by the typical treatment regimen can alter the clinical course of the disease and produce a survival advantage. One exception is a randomized U.S. trial of expanded prostate cancer screening that found no survival advantage in the first 8 years of the trial among the group offered expanded screening (Andriole et al., 2009). This trial, however, was conducted in a country in which 59 percent of men over age 65 are already receiving an annual PSA test (Howard et al., 2009). This factor, clearly reflected in the control group and in pretrial conditions, made it more difficult to identify a survival effect. A larger trial in Europe, where routine testing is less frequent, showed a significant survival advantage for those offered expanded screening (Schröder et al., 2009).

Early detection of cancer would not produce survival advantages unless effective methods of treatment were employed. Randomized trials of radiation and surgical removal for prostate cancer demonstrate their survival benefits relative to "watchful waiting," a particularly common strategy in Scandinavia. Treatment appears to be unusually aggressive in the United States once prostate cancer has been detected, although the data are less abundant on treatment than on screening (Preston and Ho, 2010).

Has the combination of extensive screening and aggressive treatment reduced mortality due to prostate cancer in the United States relative to other countries? Preston and Ho (2010) compare age-standardized mortality rates from prostate cancer from 1980 to 2005 in the United States and a set of OECD countries (Australia, Austria, Canada, Finland, France, Germany, Greece, Italy, Japan, the Netherlands, Norway, Spain, Sweden, Switzerland, and the United Kingdom). The United States saw a significantly faster decline in prostate cancer mortality over this period, which included approval of PSA testing by the Food and Drug Administration in 1986 (see Figure 7-1). By 2003, the mortality rate for prostate cancer in the United States was 20.4 percent lower than the average for the other countries. One population model suggested that two-thirds of the drop in prostate cancer mortality from 1990 to 1999 in the United States was attributable to increased PSA testing and one-third to improved treatment (Etzioni et al., 2008).

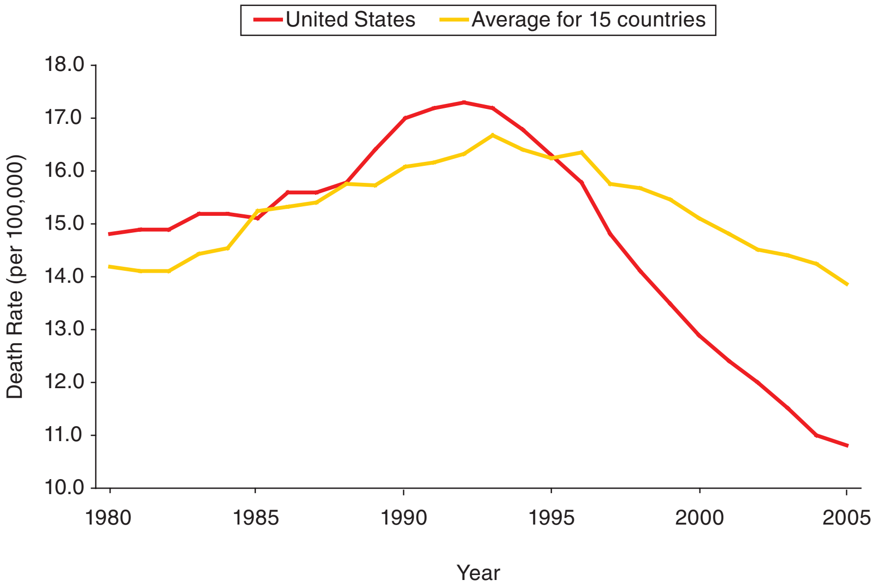

FIGURE 7-1 Age-standardized death rates from prostate cancer, 1980–2005, in the United States and 15 OECD countries.
SOURCE: Preston and Ho (2010, Figure 9-3). Reproduced with permission.

Breast cancer appears to present a similar picture (Preston and Ho, 2010). In contrast with prostate cancer, however, its incidence is affected by a number of risk factors, such as childlessness, delayed childbearing, obesity, and hormone replacement therapy. This means mortality trends cannot be interpreted unambiguously for this form of cancer in terms of health care practices.

As noted above, the United States uses mammograms to screen for breast cancer more frequently than do European countries. Probably as a result, breast cancer is caught, on average, at an earlier stage in the United States than in Europe (Sant et al., 2004). Once detection occurs, there appear to be no large differences in treatment regimens between Europe and the United States, although treatment has tended to be somewhat more aggressive in the United States, and U.S. doctors may have adopted new treatments somewhat more quickly than doctors in other countries (Preston and Ho, 2010). Studies of women diagnosed with breast cancer between 1990 and 1992 (Sant et al., 2004) and between 2000 and 2002 (Verdecchia et al., 2007) found that the 5-year survival rate in the United States was about 10 percentage points higher than that in Europe in both periods. The researchers who made these comparisons concluded that the U.S. advantage in survival rates was due to earlier diagnosis and more aggressive treatment of the cancer once it had been detected.

As Figure 7-2 shows, the United States has also seen a more rapid (and statistically significant) drop in breast cancer mortality since 1990 relative to other OECD countries, although breast cancer mortality has been declining in all high-income countries. This decline is not likely to be due to improvements in risk factors as the risk factors for breast cancer have, if anything, worsened; obesity has risen, and women have been bearing children increasingly later in life. The one exception is the decrease in the use of hormone therapy after 2002 (see Chapter 8). Thus it appears likely that the decreases in breast cancer deaths are attributable to improved screening and treatment. Berry and colleagues (2006) conducted a careful simulation of the decline in breast cancer mortality in the United States and concluded that about two-thirds of the decline from 1990 to 2000 was attributable to increased use of adjuvant therapy and one-third to screening. Das and colleagues (2005) supported this conclusion with a study showing that those states with higher levels of screening had lower levels of cancer mortality when other factors were taken into account. As with prostate cancer, the U.S. health care system may have outperformed the health care systems of

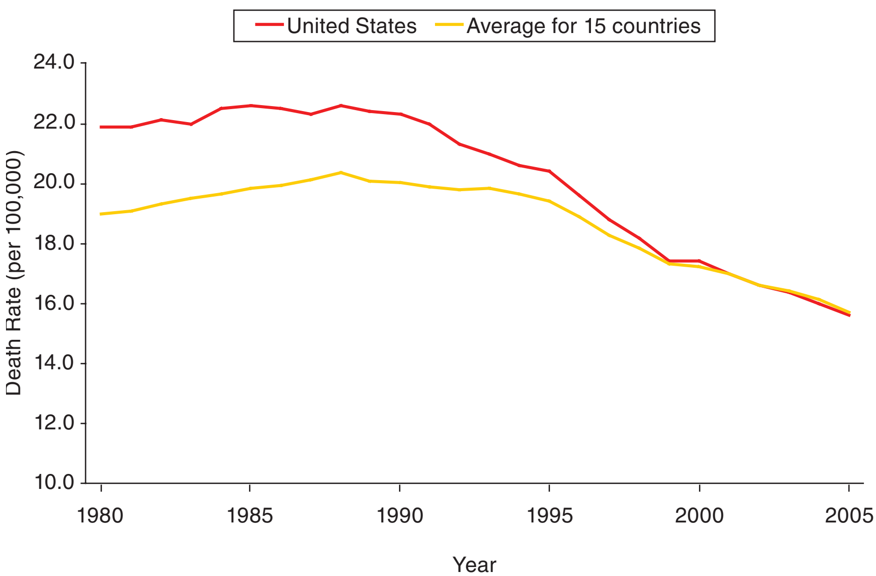

FIGURE 7-2 Age-standardized death rates from breast cancer, 1980–2005, in the United States and 15 OECD countries.
SOURCE: Preston and Ho (2010, Figure 9-4). Reproduced with permission.

other high-income countries in preventing death from breast cancer. This successful performance may be one reason why Glei and colleagues (2010) find that cancer (apart from lung cancer) has had less of an effect on life expectancy trends in the United States than in most other countries.

International Comparisons of Detection and Treatment of Cardiovascular Disease

It is more difficult to compare the effectiveness of health care systems in dealing with cardiovascular disease than to do so for cancer because there are no national registries for heart disease and stroke as there are for cancer. Still, data are available on both treatment and survival rates that allow some country-to-country comparisons.

Two major risk factors for cardiovascular disease are high serum cholesterol and high blood pressure. A relatively large percentage of people in the United States have been diagnosed with both conditions (see Chapter 2). Table 7-3 indicates the proportion of individuals aged 50+ reporting having been diagnosed with high cholesterol and receiving medication for this condition. The table shows that among those diagnosed with high cholesterol, a higher proportion of both males and females in the United States are treated for the condition than is the case in any of the other 11 countries listed, with the exception of older French women. Use of medication among

TABLE 7-3 Percentage Taking Cholesterol-Lowering Medications Among Those Reporting They Have Been Diagnosed with High Cholesterol

	Ages 50+		Ages 65+	
Country	Males	Females	Males	Females
Austria	56.8	55.4	66.8	60.4
Belgium	53.3	60.1	64.1	68.0
Denmark	63.8	60.2	80.7	65.2
France	80.3	79.9	87.7	88.3
Germany	58.0	54.3	69.7	58.7
Greece	61.3	63.0	68.7	67.3
Italy	55.7	53.4	65.3	56.2
Netherlands	65.3	69.8	80.5	76.3
Spain	59.7	58.0	67.1	62.6
Sweden	59.7	58.5	67.6	68.0
Switzerland	64.2	62.3	74.6	70.2
United States	85.0	80.6	89.3	82.2

SOURCES: National Health and Nutrition Examination Survey (NHANES) (1999–2006) for United States; Survey of Health, Ageing, and Retirement in Europe (SHARE) (2004) for remaining countries. More information on these surveys is available from http://www.cdc.gov/nchs/nhanes.htm and www.share-project.org [accessed December 20, 2010].

those diagnosed with high blood pressure is less variable across countries. Table 7-4 shows that, for men reporting having been diagnosed with high blood pressure, the United States is in the middle of the group of 13 countries listed in terms of frequency of receiving medication; for women, the United States ranks third. The combination among Americans of high prevalence of hypertension and relatively high drug use among those diagnosed means that they are the most likely to be using antihypertensives. It is likely that other countries have only recently begun to treat hypertension as aggressively as the United States. Wolf-Maier and colleagues (2004) used data from the 1990s to compare frequency of treatment for hypertension in the United States, Canada, and five European countries (Germany, Spain, England, Sweden, and Italy). Of those aged 35–64 who had measured high blood pressure or were receiving medication for the condition, 77.9 percent were being treated in the United States, compared with a range of 41.0–62.4 percent in the other six countries.

When judged according to survival rates, the U.S. health care system's handling of cardiovascular events is near or slightly above average. In a study of survival rates 1 year after an acute myocardial infarction among people in seven countries (Australia, Canada, Denmark, Finland, Sweden, Great Britain, and the United States), the United States had the third-

TABLE 7-4 Percentage Taking Antihypertensive Medications Among Those Reporting They Have Been Diagnosed as Hypertensive

	Ages 50+		Ages 65+	
Country	Males	Females	Males	Females
Austria	88.7	90.8	92.1	92.8
Belgium	65.7	67.4	73.2	73.8
Denmark	82.2	83.2	89.1	88.5
England	77.0	77.1	84.9	84.9
France	92.2	94.3	95.7	92.3
Germany	90.4	89.6	93.6	90.2
Greece	92.0	89.8	92.0	91.7
Italy	86.1	90.1	91.4	92.5
Netherlands	79.7	83.5	88.3	93.0
Spain	81.9	86.7	86.0	90.5
Sweden	86.5	88.8	89.4	94.5
Switzerland	94.0	91.8	90.5	93.0
United States	88.1	91.5	91.0	93.1

SOURCES: Survey of Health, Ageing, and Retirement in Europe (SHARE) (2004), Health and Retirement Study (HRS) (2004); English Longitudinal Study of Aging (ELSA) (2002). More information on these surveys is available from the following websites: http://www.share-project.org, http://hrsonline.isr.umich.edu/, and http://www.ifs.org.uk/elsa/ [accessed December 20, 2010].

highest survival rate for men aged 40–64 and the second-highest for men aged 85–89; for women in the same age groups, the United States had the fourth-highest and highest survival rates, respectively (Moise, 2003). Preston and Ho (2010) suggest that one reason for the relatively high survival rates in the United States may be the tendency to respond to heart attacks with aggressive treatment regimens. For instance, a larger percentage of U.S. patients underwent revascularization operations relative to those in any other country.

Evidence on survival after ischemic strokes is more mixed. Generally speaking, the United States does well on short-term survival rates. In one study comparing stroke survival rates among nine countries, the United States ranked third on 7-day survival rates for ages 65–74 and second for ages 75+; on 30-day survival rates, U.S. men and women both ranked second for ages 65–75, while U.S. men ranked first and U.S. women ranked second among those 75+. However, 1-year survival rates represent a broader-gauged measure of success. When these rates were compared, the United States ranked in the bottom half of the countries surveyed (Organisation for Economic Co-operation and Development, 2003).

Again, the survival rates in the United States may be boosted by a tendency toward more aggressive treatment. For example, carotid endarterectomy, a technique used to prevent stroke by surgically removing plaque from inside the carotid artery, is used much more often by physicians in the United States than by those in any of 11 OECD countries examined in one study (Organisation for Economic Co-operation and Development, 2003).

International Comparisons of Detection and Treatment of Diabetes

Diabetes has been identified as a "tracer" condition indicating quality of health care (Nolte et al., 2006). Diabetes differs from cancer in that it requires regular monitoring and compliance. In the Nolte et al. study, the United States had a high ratio of diabetes deaths to incident cases among people younger than 40, implying that treatment of the disease is relatively poor. Unlike the survival rates for cancer and cardiovascular disease cited above, however, the incidence and survival data for diabetes are not drawn from prospective studies of a cohort but from two different data sources. The coding of deaths from diabetes also is subject to considerable variation because of the multiple morbid conditions typically present at death.

Some support for the conclusion of Nolte and colleagues is supplied by an earlier detailed investigation of diabetes treatment in the United States and the United Kingdom (Organisation for Economic Co-operation and Development, 1996). The study found that superior treatment in the United Kingdom, particularly through diabetes clinics, was associated with an additional 1.35 quality-adjusted life years for diabetics in that country.

A more recent study (Organisation for Economic Co-operation and Development, 2007) considered five measures related to diabetes treatment but rejected four of them as "not fit for international comparisons." On the one measure that passed muster, the frequency of retinal exams among diabetics, the United States ranked fourth in frequency among 12 countries. Among older people reporting a diagnosis of diabetes, the proportion who reported being treated for the disease was virtually the same in the United States (81.3 percent based on HRS data) and in a composite of 10 European countries (81.5 percent based on Survey of Health, Ageing, and Retirement in Europe [SHARE] data) (Thorpe et al., 2007).

For the most important causes of mortality among the aged—heart disease, cancer, and stroke—the U.S. health care system appears to offer high-quality detection and treatment. The evidence is most clearcut for cancer and much less abundant for cardiovascular disease. By contrast, diabetes may represent a weakness in the U.S. health care approach and is one of the causes of mortality that has shown adverse trends in the United States relative to other countries, although these trends may be influenced by the faster growth of obesity in the United States (see Chapter 3).

Discussion

On the basis of the evidence presented here, it appears unlikely that weak performance by the U.S. health care system is responsible for the country's poor longevity ranking at older ages. Any policy lessons to be drawn from this conclusion would, of course, need to account for the fact that the preponderance of deaths and of episodes of illness above age 50 occur at ages over 65, when individuals are covered by Medicare.

LESSONS FROM RECENT TRENDS IN LIFE EXPECTANCY IN DENMARK AND THE NETHERLANDS

As discussed earlier, the increase in life expectancy slowed at around the same time in the United States, Denmark, and the Netherlands. There is some evidence of a common cause for the slowdown in all three countries—smoking (see Chapter 5). Both Denmark and the Netherlands have now emerged from their period of stagnation and have seen improvements in life expectancy—Denmark beginning around 1995 and the Netherlands around 2002. Yet life expectancy increases remain weak in the United States. What can we learn about the causes of recent improvements in Denmark and the Netherlands?

Christensen and colleagues have suggested that Denmark's renewed growth in life expectancy came about because of lifestyle improvements in combination with enhanced medical and surgical treatments (Christensen et al., 2010a). Mackenbach and Garssen (2010) argue that the Netherlands emerged from the period of stagnation because of improved funding of health care, which contributed to more appropriate use of health care.

Mackenbach and Garssen (2010) report that after 2002, the mortality rate in the Netherlands dropped steadily in all older age groups with the exception of the very oldest men, those over 90. The authors eliminate a number of potential causal factors—prevalence of disease and disability, environmental factors such as air pollutants and winter temperatures, health behaviors, and poverty rates—because they did not improve during the appropriate time period. However, substantial changes occurred in health care in the Netherlands during this period. These included modest increases in the percentage of the elderly receiving influenza vaccinations, seeing medical specialists, and using prescribed drugs, as well as sharp increases in the numbers of older men and women admitted to hospitals. There was also a significant drop in the percentage of older adults who died within a year of being admitted to the hospital. These improvements in various health care factors accompanied—and were, presumably, the product of—sharp increases in health care spending in the Netherlands, where health care expenditures per person, in nominal prices, grew by more than 40 percent between 1999 and 2003. Changes in health care organization also occurred during this time. For instance, more aggressive treatment of stroke became common as specialized stroke units became available on a large scale beginning around 2000. There is evidence as well that end-of-life practices in the Netherlands changed significantly within a short time. From 2001 to 2005, euthanasia, assisted suicide, and the withholding or withdrawing of life-prolonging treatment became less common, and the alleviation of symptoms and the use of continuous deep sedation became more common. Correspondingly, the percentage of deaths in which life-prolonging treatment was withheld or withdrawn fell (Mackenbach and Garssen, 2010).

It should be noted that evidence for the conclusion drawn by Mackenbach and Garssen (2010)—that the most likely explanation for why life expectancy accelerated in the Netherlands beginning around 2002 was increased use of the health care system due to a sharp increase in government spending on health care—is mainly circumstantial. It is based on excluding other possible explanations and on how well the health care explanation fits the evidence.

The implications for the United States are not at all clear. Since U.S. health care expenditures are already substantially higher than those of the Netherlands and Denmark, increased spending or emphasis on health care at older ages in the United States would not necessarily result in an acceleration of life expectancy.

DISCUSSION

The lack of universal access to health care in the United States undoubtedly increases mortality and reduces life expectancy. It is a smaller factor above age 65 than at younger ages because of Medicare, although health impairments that begin below age 65 will often carry over into that age interval. For the main causes of death at older ages—cancer and cardiovascular diseases—available measures do not suggest that the U.S. health care system is failing to prevent deaths that elsewhere would be averted. In fact, cancer detection and survival appear to be better in the United States than in other OECD countries.

Relatively high proportions of people in the United States with diagnosed high cholesterol and high blood pressure are receiving treatment. Survival rates following heart attack and stroke are also favorable in the United States, although 1-year survival rates following stroke are not above average. Treatment of diabetes, on the other hand, may represent a weakness in the U.S. health care system.

These facts relate to the performance of the health care system after a disease has already developed; they say nothing about disease prevention. Thus it is possible that the U.S. health care system does a much poorer job at primary prevention than the systems of other countries. The panel reviewed scattered evidence on preventive medicine in the United States relative to Europe, and it is not conclusive. Certainly the high prevalence of cardiovascular disease in the United States (see Chapter 2) is consistent with a widespread failure of preventive medicine. But it is also consistent with a high prevalence of smoking, obesity, and physical inactivity among Americans, or with a medical system that may be unusually effective at identifying and treating cardiovascular disease. Until international data systems are better designed to identify cases of cardiovascular disease and to follow them through treatment, survival, and death, it is impossible to identify confidently the roots of international differences in the prevalence of and mortality from cardiovascular disease. Cancer data systems are better developed and allow a more robust comparative assessment of the U.S. health care system. Whether the comparisons observed for cancer can be generalized to other diseases is, however, unclear.

8

The Role of Hormone Therapy

As discussed in Chapter 1, the slowdown in life expectancy in the United States versus other high-income countries during the period 1980–2005 was particularly pronounced among U.S. women. Thus it makes sense to look for a phenomenon that affects women but not men.

One possibility is the use of hormone therapy (HT) or, as it is often called, hormone replacement therapy. In the early 1980s, HT was prescribed for perimenopausal and postmenopausal women to combat various symptoms of menopause. Through 2002, it was prescribed increasingly often and to increasingly older women to provide protection against bone loss and cardiovascular disease (Goldman, 2010a; Kim et al., 2007). By 1995, about 40 percent of women between the ages of 50 and 74 were on HT, and the number peaked after 2000, when 92 million prescriptions were written in the United States (Hersh et al., 2004).

In 2002, however, researchers directing the Women's Health Initiative announced that they were halting a randomized controlled trial that was looking at the effects of estrogen plus progestin in healthy postmenopausal women. The researchers had observed that women taking the combination of the two hormones had higher rates of breast cancer, coronary heart disease, stroke, and other diseases than women who had been receiving a placebo (Nelson et al., 2002; Writing Group for the Women's Health Initiative Investigators, 2002). A second trial that was testing estrogen-only therapy against a placebo was halted in 2004 after data showed that the women receiving the hormone were more likely to suffer a stroke (Women's Health Initiative Steering Committee, 2004).

Given the widespread use of HT in the United States and the findings that it increased the risks of developing certain diseases, including coronary heart disease, breast cancer, and stroke, it is natural to ask whether HT might have contributed to the divergence in life expectancy trends between U.S. women and women in many other high-income countries. The question can be broken down into two parts: Does HT increase mortality risk? and Was the use of HT significantly more common in the United States than in other high-income countries? Goldman (2010b) examines both of those questions in a paper prepared for the panel.

DOES HORMONE THERAPY INCREASE MORTALITY RISK?

The increased risk for coronary heart disease that the Women's Health Initiative found among older women receiving HT was a surprise because earlier observational studies had found just the opposite (Goldman, 2010b). These earlier studies—which were based on observations of women given HT as part of normal medical practice rather than in randomized controlled trials—showed that women taking HT were generally from 35 to 50 percent less likely to develop heart disease than those not taking HT (Grodstein et al., 2000, 2006; Manson and Bassuk, 2007; Prentice and Anderson, 2008). For example, one meta-analysis of 32 previous observational studies calculated that women who had been treated with estrogen at some point had a 35 percent lower risk of developing coronary heart disease than women who had never been given estrogen (Grady et al., 1992).

By contrast, the Women's Health Initiative and at least two other randomized controlled trials found an increased risk of coronary problems among women who were given HT. The results of the Women's Health Initiative were particularly compelling as it involved 27,500 postmenopausal women and thus assembled a very large amount of data from which to draw conclusions about the effects of HT. The controlled trials reinforced some of the findings of the earlier observational studies—the benefits of HT in reducing the risk of colorectal cancers and hip fractures, for example, and an increased risk of breast cancer—but the new finding that HT increased the risk of coronary heart disease and stroke changed medical opinion on HT. Based on the judgment that the risks of HT appeared to outweigh the benefits, guidelines in the United States were modified to recommend against using HT for the prevention of cardiovascular disease in postmenopausal women. As a result, the use of HT has decreased dramatically since 2002 in the United States and other countries around the world (Barbaglia et al., 2009; Guay et al., 2007; Hersh et al., 2004).

Despite the evidence from the controlled trials, however, it appears unlikely that HT resulted in a significant increase in mortality among women in the United States. There are two reasons for this conclusion.

First, although the data indicate that HT—and the estrogen–progestin regimen in particular—may have caused an increase in heart attack and stroke, there is no evidence that it actually led to an increase in overall death rates. Instead, the overall mortality rate was similar among women who were given the hormones and those who were not. For example, when the data from the Women's Health Initiative were analyzed, the risk of death among women who were given estrogen–progestin HT was actually 2 percent less than for women who were given the placebo, although the difference was not statistically significant (Writing Group for the Women's Health Initiative Investigators, 2002). A meta-analysis of the data from other randomized controlled trials pointed to a similar conclusion (Salpeter et al., 2004).

The second reason is that it now appears that the findings from the Women's Health Initiative were likely to have been related to the timing of HT initiation in the trial. In the earlier studies based on observation of women receiving HT prescribed by their physicians, most of the women received treatment starting in early menopause. For example, 80 percent of the participants in the Nurses' Health Study began HT within 2 to 3 years after beginning menopause (Manson and Bassuk, 2007). Since women in the United States begin menopause, on average, at age 51 (Manson et al., 2007), a large majority of the women in that study would have started HT by the time they were 53 or 54. By contrast, the average age of the women starting HT in the Women's Health Initiative was 63, and most of the women in the study had begun menopause at least a decade before joining the study (Grodstein et al., 2006). However, these older women may have been more representative of the age group for which HT was being prescribed in later years to prevent fracture and cardiovascular disease.

One possible explanation for the different effects of HT at different ages is that estrogen supplements may have varying effects on the heart depending on the stage of atherosclerosis. Some researchers have hypothesized that in the early stages of atherosclerosis, estrogen may have a beneficial effect because it improves lipid and endothelial function, but in the later stages, when the arteries have developed more serious lesions, the estrogen may cause clotting or a rupturing of the plaque in the arteries (Manson and Bassuk, 2007). If so, the timing of the HT becomes critical.

Since the release of the Women's Health Initiative findings, a number of studies have examined this possibility. In general, these studies have reanalyzed the data from previous reports by looking at the differences in how HT affected women at different ages, specifically those who started the treatment around the time of menopause versus those who started much later. Most of these reanalyses suggest that while women who begin HT well after menopause may have an increased risk of heart disease and stroke, those who start around the time of menopause do not, and for them the HT does appear to protect somewhat against heart disease (Goldman, 2010b).

However, at least one recent analysis did not find a significant difference in rates of coronary disease or in overall mortality between women who started HT near menopause and those who started later (Prentice et al., 2009), so questions remain about the exact role of timing of HT.

The news is not all good. The data do imply that HT increases certain risks for women, such as the risk of breast cancer, and this is true among women of every age. And indeed, when HT use was cut dramatically after the results of the Women's Health Initiative were announced, the incidence of breast cancer dropped in the United States, as well as a number of other countries. However, the decreases were relatively small—a 7 percent drop in the United States, for example (Ravdin et al., 2007)—and even if HT was responsible for an increase in breast cancer deaths, those deaths were likely offset, at least in part, by a decline in deaths from other causes, such as colon cancer.

Thus, Goldman concludes, there is to date little evidence that women who start HT around the time that menopause begins are at greater risk of developing heart disease or that they are more likely to die when all causes of death are considered. Thus, it appears unlikely that HT played a role in the diverging life expectancies examined in this report. Still, for the sake of completeness, it is worthwhile to examine the second question: Was HT use significantly higher in the United States than in other countries?

RATES OF HORMONE THERAPY IN DIFFERENT HIGH-INCOME COUNTRIES

In the early 1980s the World Health Organization began its MONICA, or Multinational Monitoring of Trends and Determinants in Cardiovascular Disease, project. As part of that project, women aged 45–64 from 32 separate populations in 20 countries were asked whether they had used HT in the previous month. The lowest percentage—0 percent—was found in Moscow, and the highest—42 percent—in Newcastle, Australia, and Halifax, Canada. The average among women from four communities in the United States was 38 percent—above the average in this data set, but below the numbers for Australia and Canada and approximately equal to those for France, Germany, and Iceland (Lundberg et al., 2004).

Various other studies have also indicated that, while a large percentage of U.S. women have used HT, the percentage of women in several other countries has been comparable. One study of French women aged 50–69 found that more than half of the women used HT (Gayet-Ageron et al., 2005), while a second study reported that, for the period 1998–2001, the percentage of French women using HT was twice that of U.S. women (Schneider, 2002). Another study showed that women in the United Kingdom received HT at about the same rate as women in the United States

(Townsend and Nanchahal, 2005). And while the women in some countries, such as Japan, did receive HT at a much lower rate than those in the United States, there clearly were a number of countries with both extensive HT usage and a rapid growth in female life expectancy during the crucial 1980–2005 period (Goldman, 2010b).

The cross-country comparisons are not definitive because of various issues with the data, as well as the fact that HT is administered differently in different countries—orally versus via a transdermal patch or gel. Some Europeans are much more likely to use the latter alternatives. For example, estimates are that 70–80 percent of women in France use these methods (Canonico et al., 2007; Ringa et al., 2005; Varas-Lorenzo et al., 1998). The recent literature suggests that orally administered estrogens are more likely to result in cardiovascular risk (e.g., elevated C-reactive protein [CRP] levels or an increase in triglycerides) than nonorally administered estrogens (L'Hermite et al., 2008; Vrablik et al., 2008). Evidence also suggests that orally but not transdermally administered HT is related to a higher risk of thrombolytic events in postmenopausal women (Scarabin et al., 2003). These findings open up the possibility that HT could have had more negative health consequences in the United States than in other countries, but the evidence is not strong enough to draw any firm conclusions (Goldman, 2010b).

Still, Goldman concludes that there is little evidence supporting the hypothesis that HT played a part in the divergence of life expectancy trends among high-income countries. She bases her conclusions on three factors. First, the data indicate that HT does not appear to increase all-cause mortality risk. Second, when HT is timed as it typically is—that is, when it is begun near the onset of menopause—it does not appear to increase the risk of heart disease and may actually decrease the risk for some women. And third, HT does not appear to have been any more common among U.S. women than among women in several other countries where life expectancy continued to increase steadily throughout the second half of the 20th century (Goldman, 2010b).

9

The Role of Inequality

Not all people in a country have the same risk of mortality or life expectancy at a given age. It has long been recognized that people of higher social status typically have better health, lower mortality rates, and higher life expectancy (see, for example, Lynch et al., 2004). Social inequality differs from the factors discussed in the preceding chapters of this volume in that it has been described as a "fundamental" cause of differences in exposure to, and experience of, risk for poor health outcomes (Link and Phelan, 1995; Phelan et al., 2010). The fundamental cause idea emphasizes that fact that there are many mechanisms through which social status creates social inequality in health. These mechanisms affect many aspects of life and are present at all times and in all countries, although the mechanisms and their importance may vary somewhat over time and place. Psychosocial differences—including stress; depression; and feelings of discrimination, mastery, and competence—are among the numerous mechanisms assumed to differ by social status that have not been considered specifically in this volume. Other unconsidered mechanisms include a wide range of living and working conditions throughout life. Still other mechanisms include factors already considered in some detail in previous chapters, such as health behaviors (e.g., obesity, physical activity, and smoking) and access to and utilization of health care (Braveman et al., 2011).

While socioeconomic differences in health tend to occur in all countries, the magnitude of the differentials in health and mortality can vary across countries with economic, political, social, and policy differences. The United States, for example, is thought to have greater inequality in health than Japan and some European countries (Avendano et al., 2010; Martikainen et al., 2004). Two examples of mortality differentials in the United States that reflect largely socioeconomic differences are the substantially higher mortality among the black relative to the white population and the large geographic inequalities in health (Arias, 2010; Murray et al., 2006; Williams and Collins, 1995).

This chapter describes the gradient in mortality by socioeconomic status in the United States and other countries. It examines whether the relative size of the mortality disparity by socioeconomic status in some of this study's comparison countries could account for the current disparities in life expectancy. It also examines whether the magnitude of the mortality gradient with socioeconomic status has changed over time and how these changes could contribute to disparities in survival.

MEASURING THE ASSOCIATION BETWEEN SOCIOECONOMIC INEQUALITY AND MORTALITY

The association between indicators of socioeconomic status, such as income and education, and mortality implies that the distribution of socioeconomic status within a country could affect mortality—in particular, that two countries with the same average income or education could have differences in health and mortality if income or education were differentially distributed. For instance, a country with greater income inequality—with more wealthy but also more poor people—may have worse average health and greater average mortality because the health benefits to the wealthy from their extra income are outweighed by the health deficits experienced by the poor. This is possible because the marginal benefits of additional income are greater for the poor than for the wealthy—an extra $10,000 per year can make a much greater difference to the health of a person earning $20,000 a year than to that of someone earning $200,000 a year. Thus when inequality is great, the decrease in life expectancy among those of lower socioeconomic status can outweigh the increase in life expectancy among those of higher socioeconomic status, leading to a life expectancy below that likely to be seen in a country with the same average level of the social indicator but less inequality (Preston, 1975; Rodgers, 1979).

Over time, a number of hypotheses have been offered concerning the precise relationship between inequality and health. The most straightforward of these, the absolute level hypothesis, holds that inequality plays no role beyond the simple one described in the previous paragraph. That is, an individual's health is affected by his or her own socioeconomic status, but is not further affected by how the status of everyone else in the society is distributed (Kawachi et al., 2010; Lynch et al., 2004). Others have suggested that the presence of inequality itself may lead to poorer health and increased mortality for at least some of the population. Most of the proposed explanations along these lines focus on the social and psychological costs of inequality. Being in a lower socioeconomic class in a society with differences in status might, for example, lead to shame, distrust, or other negative emotions, which could have direct physiological effects on health through stress hormones, as well as indirect costs due to psychologically influenced behavior differences, such as stress leading to smoking (Kawachi et al., 2010; Lynch et al., 2000). Some have even suggested that the effects of inequality on a population are so pervasive that a lessening of inequality would improve health and decrease mortality for everyone (Mellor and Milyo, 2002; Wilkinson and Pickett, 2009). For a skeptical review of the evidence supporting this position, see Deaton (2003). Identifying the causal paths linking socioeconomic status to health and mortality remains an important objective for determining appropriate policy to address differentials in health and mortality, but this objective is beyond the scope of this volume (for extended discussion, see Kawachi et al., 2010).

Social inequality in health and mortality can be studied using a variety of indicators of social status, including education, occupation, income, and wealth, which are used as proxies for the complex web of mechanisms described above. All of these indicators can reflect the differential demands on and resources available to persons of different social classes that would affect their health and mortality; however, the choice of which measure is used in examining the role of social inequality in health and mortality can affect observed differences. This disparity may be especially evident when one is comparing people across a wide span of ages and across countries.

Education is the only measure of socioeconomic status that remains reasonably consistent across much of the life span and for which everyone can be classified. It is an indicator that precedes chronologically most of the health events of interest in this study and influences many of the more downstream mechanisms by which socioeconomic status affects health. On the other hand, education does not capture changes in socioeconomic status over the latter part of the life course and may not be as sensitive to state welfare policies aimed at mitigating socioeconomic differences, which differ between the United States and Europe (Avendano et al., 2010). Occupation is an indicator of social status that can be quite variable over the life cycle; many older persons, for example, may not have a current occupation. Moreover, some people, such as housewives, may never have had a formal occupation. Income and wealth vary over the life cycle as well. This variation may accurately reflect changes in economic capacity but can also reflect marital status, family status, and retirement status.

The bidirectional paths between socioeconomic status and health have been emphasized by economists (Smith, 2007), and economic measures are more likely than education to be affected by health rather than the other way around. Bidirectionality of causation is especially characteristic of older ages, when health is an important determinant of work ability. In addition, income and wealth can be more affected by health in countries where disability and retirement benefits are less generous. Because of the link between one's job and one's health insurance in the United States, job loss in the United States can affect not only one's income but also one's access to health insurance. Paying for health care or health insurance after loss of a job, or because one does not have good health insurance, can reduce wealth. So in some circumstances, social inequality can be both a cause and a result of poor health. Forces in both directions may differ across countries, but in general, there should be less of a link between health and social status in countries with substantial social service networks and universal health insurance.

RELATIONSHIP BETWEEN OBSERVED SOCIOECONOMIC INEQUALITY AND HEALTH AND MORTALITY

Many studies have looked at the relationship between socioeconomic status and health and mortality in either one or a number of countries. They have almost invariably found that people at lower socioeconomic levels have poorer health on many dimensions (see the review in Elo, 2009). The Whitehall studies of British civil servants, for example, demonstrated a powerful link between occupational status and risk of death (Marmot et al., 1984). Likewise, in a large prospective study, Wolfson and colleagues tracked half a million Canadian men and compared their average income between the ages of 45 and 65 with their mortality rates from age 65 to 70. The researchers found a clear gradient, with men in each income bracket being less likely to die than those in the brackets below them (Wolfson et al., 1993). A study of 3 million men and women from Finland found that all-cause mortality rates among the 10 percent with the lowest income were 73 percent higher among women and 137 percent higher among men compared with the 10 percent with the highest income (Martikainen et al., 2001a). A study by Kitagawa and Hauser (1973), based on data from 1960 for the United States, was a ground-breaking work linking individual socioeconomic status to mortality. The authors found differentials in U.S. mortality by both family income and education for both whites and nonwhites aged 25–64.

Many studies examining differentials in mortality by socioeconomic status focus on mortality before age 65, when these differentials tend to be larger than at older ages. Kitagawa and Hauser (1973) looked at both younger and older adults and found that the differentials in the United States were much smaller above age 65. A number of more recent studies likewise have found fewer differentials in both health and mortality by socioeconomic status at higher ages (Antonovsky, 1967; Crimmins et al., 2009; House et al., 1994; Marmot and Shipley, 1996; Rogot et al., 1992). This difference by age needs to be kept in mind in reviewing the results of many studies of inequality in health and mortality by socioeconomic status that cover different age ranges.

Specific causes of mortality also have been linked to socioeconomic status. For example, one massive study looked at mortality from ischemic heart disease in millions of people in 10 Western European populations. Among those aged 60+, men of lower socioeconomic status were 22 percent more likely to die from heart disease than men of higher socioeconomic status, and women of lower socioeconomic status were 36 percent more likely to die from heart disease than women of higher socioeconomic status (Avendano et al., 2006). A study in Sweden of 5,000 patients who had suffered heart attacks found that those from less affluent areas had an average survival time significantly lower than that of patients from more affluent areas (Tyden et al., 2002).

An estimation of U.S. differences in life expectancy at the end of the 1990s for three educational groups across the adult age range indicates substantial differences in the expected average length of life at all ages and for both sexes, although the differences are smaller at older ages (see Table 9-1). At age 50, men in the high education group could expect to live 5.6 more years than those with low education; for women at this age, the difference is 3.9 years. At age 80, the difference is about 1 year for men and 1.5 years for women. Thus there is no question that life expectancy in the United States would be higher if no one experienced the levels of life expectancy of the lower education groups. But is the difference in life expectancy by education greater than in other countries? This question is taken up later in the chapter.

TABLE 9-1 Life Expectancy by Age and Years of Education for the United States at the End of the 1990s

	Males Years of Education			Females Years of Education			Both Sexes Combined Years of Education		
e_x	0–8	9–12	13+	0–8	9–12	13+	0–8	9–12	13+
20	51.2	52.0	59.4	57.7	58.4	62.7	54.2	55.4	61.0
30	42.5	43.0	49.7	48.2	48.8	52.8	45.2	46.2	51.2
40	33.6	34.1	40.2	38.9	39.5	43.1	36.1	37.0	41.6
50	25.3	25.8	30.9	29.8	30.5	33.7	27.4	28.4	32.2
60	18.0	18.4	22.2	21.6	22.1	24.6	19.8	20.5	23.4
70	12.2	12.2	14.6	14.6	14.6	16.4	13.5	13.7	15.5
80	7.6	7.5	8.5	8.6	8.5	9.1	8.2	8.1	8.8

SOURCE: Data from Molla et al. (2004).

The above discussion provides some idea of the current gap in life expectancy by socioeconomic status in the United States, but what has been the time trend in these mortality differentials? In the United States, studies of the period 1960–1980 found that educational differentials in mortality increased, but the increase occurred primarily among men. There was actually a decrease in mortality differentials by education among working-age women (Pappas et al., 1993; Preston and Elo, 1995). A narrowing of educational differentials in mortality for white women aged 30 and older from 1970 to 1990 resulting from very small gains in life expectancy among those with the highest education also has been reported (Crimmins and Saito, 2001).

Several researchers who have examined the period 1980–2000 report a widening of mortality differentials for both men and women due generally to larger increases in life expectancy among those with higher education and stagnation or decreases in life expectancy among the lowest education group (Jemal et al., 2008; Meara et al., 2008). Meara and colleagues (2008) found that the educational differential in life expectancy at age 25 increased by about 30 percent from the 1980s to the 1990s. They also found that most of the increase in the differential was due to mortality change above age 45. Among women, there were increases in the educational differences in mortality from cancer, heart disease, and chronic obstructive pulmonary disease (COPD). A study of U.S. males aged 60+ covered by social security found increases in mortality differentials from 1972 to 2001 when the men were classified by their incomes at ages 45–55; improvements occurred more rapidly among men in the higher income group relative to those in the lower income group (Waldron, 2007). Thus, increasing socioeconomic inequality in mortality within the United States appears to have influenced overall U.S. mortality trends in recent decades. Life expectancy would have increased more rapidly if it had increased in all socioeconomic groups at the same rate as in the highest socioeconomic group.

WHAT CAN BE LEARNED FROM TRENDS IN RACIAL INEQUALITY IN MORTALITY IN THE UNITED STATES?

As indicated at the beginning of this chapter, blacks have much higher mortality than whites in the United States. For ages above 50, a number of researchers have concluded that racial differences in health and mortality in the United States are attributable primarily to racial differences in socioeconomic status (Hayward et al., 2000; Preston and Taubman, 1994; Smith and Kington, 1997; Williams and Collins, 1995). Because racial differences in mortality reflect largely socioeconomic differences and because more data are available in the United States by race than by socioeconomic status, an examination of mortality trends in the United States for blacks and whites may provide further insight into differential trends in life expectancy by socioeconomic status.

Racial differences in mortality, like socioeconomic differences, are quite large over most of the life cycle but are smaller at older ages. In fact, many researchers have found a crossover between white and black mortality at the oldest ages (Johnson, 2000; Manton and Stallard, 1997), although whether there is a crossover and at what age it occurs may be related to the quality of mortality data for blacks at the oldest ages (Hill et al., 2000; Preston et al., 1996). Yet while data quality may be important in assessing mortality at very old ages, such data problems would have little effect on either the racial differences or trends in those differences discussed here.

In 2006, life expectancy in the United States at age 50 was 32.6 years for white women and 30.2 years for black women; white men at age 50 could expect to live 29.0 years on average and black men 25.2 years (see Figure 9-1). Between 1980 and 2006, life expectancy at age 50 increased by 3.6 years for black men and 3.8 years for white men. Life expectancy at age 50 for black women increased by 2.9 years and for white women by 1.7 years. Thus the racial difference in life expectancy for men is almost the same at present as it was in 1980 (see Figure 9-2). For women, however, the racial difference in life expectancy has grown smaller because of the slower growth in life expectancy for white women. These differences in life expectancy by race indicate that the slowdown in the increase in U.S. life expectancy appears to characterize women, and white women in particular. In addition, even though there appears to have been a growing inequality in mortality in the United States by socioeconomic status in recent years, this does not appear to be due to a widening of inequality by race.

The findings of two recent studies of mortality trends reinforce these conclusions. Meara and colleagues (2008) report that increasing educational disparities in mortality do not reflect growing racial disparities. Jemal and colleagues (2008) note that for the period 1993–2001 for the U.S. population aged 25–64, the annual percentage decline in age-standardized mortality was highest for black men and lowest for white women. Furthermore, among white women, those with the lowest education experienced increases in mortality rather than decreases over the period. Thus, the evidence suggests that while black/white mortality differentials are important in determining overall levels of life expectancy and explain part of the gap between the United States and other countries, changes in race differentials do not explain the trend in U.S. life expectancy.

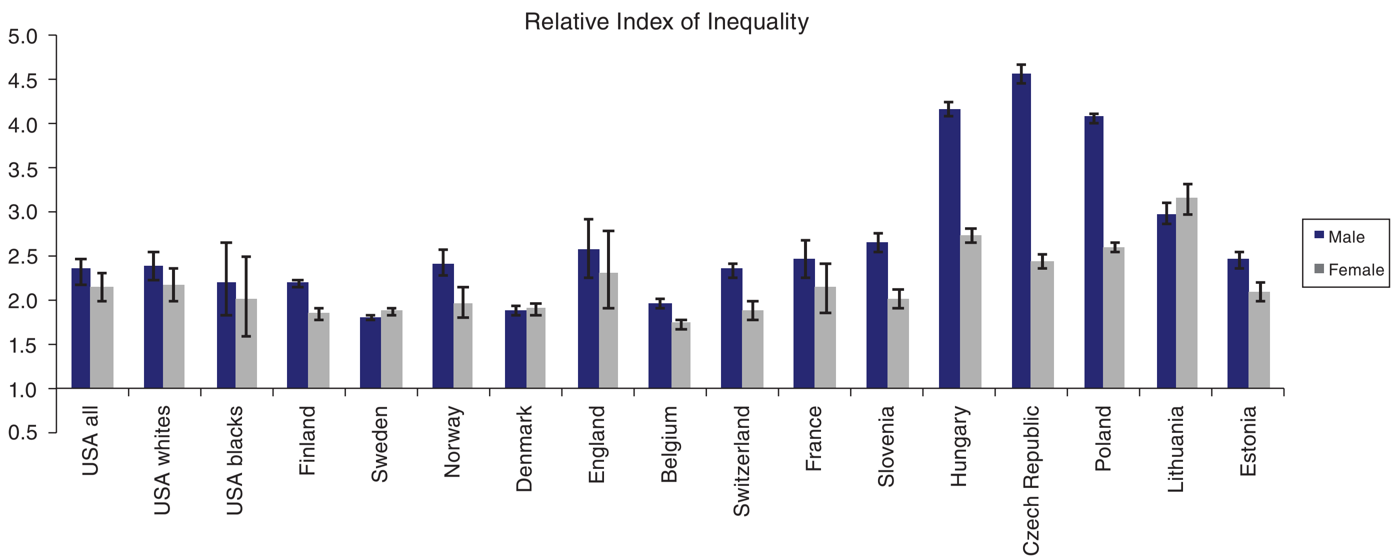

FIGURE 9-1 U.S. life expectancy at age 50 by race and gender, 1980–2006.
SOURCES: Data from Anderson (1998, 1999, 2001); Anderson and DeTurk (2002); Arias (2010); Arias et al. (2010); National Center for Health Statistics (1984, 1985, 1986, 1987, 1988, 1989, 1990, 1991, 1992, 1994, 1995, 1996, 1997, 1998a, 1998b).

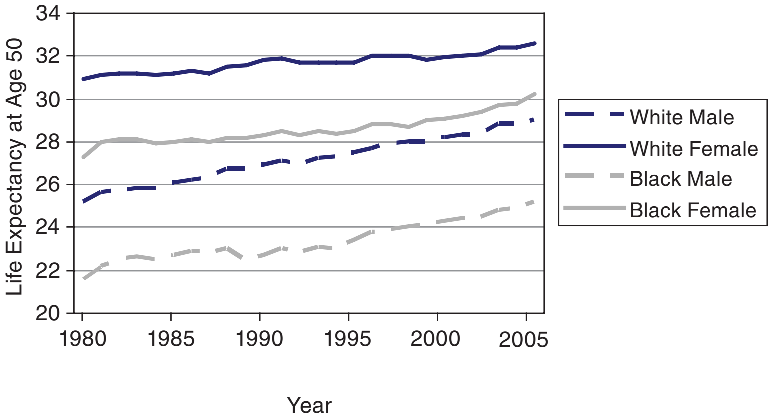

FIGURE 9-2 Racial differences in life expectancy at age 50 for U.S. men and women, 1980–2006.
SOURCES: Data from Anderson (1998, 1999, 2001); Anderson and DeTurk (2002), Arias (2010); Arias et al. (2010); National Center for Health Statistics (1984, 1985, 1986, 1987, 1988, 1989, 1990, 1991, 1992, 1994, 1995, 1996, 1997, 1998a, 1998b).

INTERNATIONAL DIFFERENCES IN THE LINK BETWEEN SOCIOECONOMIC STATUS AND HEALTH AND MORTALITY

A variety of studies have examined differences in the relationship between socioeconomic status and health and mortality across countries. An examination of self-reported health and mortality versus socioeconomic status in 22 European countries found that in almost every country, lower socioeconomic status was associated with poorer health and higher mortality. However, the size of the differences varied greatly from country to country. Differences in mortality rates tended to be larger in Northern European countries and smaller in Southern European countries, for example, but very large in Eastern Europe and the Baltic region (Mackenbach et al., 2008). An earlier study of differences in mortality due to ischemic heart disease by occupation across a group of European countries and the United States found higher gradients in the north of Europe and smaller gradients in the south, with the United States in between (Kunst et al., 1999).

A recent paper that looked at the relationship between socioeconomic status and disease in the United States and England among persons in late middle age found that in both countries, people of lower socioeconomic status had significantly higher rates of diabetes, hypertension, heart attack, stroke, lung disease, and cancer. However, people in the United States had significantly higher rates of disease than those in England across all socioeconomic groups (Banks et al., 2006). An additional study comparing health differences between rich and poor Americans and between rich and poor Europeans aged 50–74 found that at all wealth levels, Americans had more health problems than Europeans. However, the differences were most pronounced at lower levels of wealth and largely disappeared when the wealthiest Americans were compared with the wealthiest Europeans (Avendano et al., 2009).

Researchers have reported a widening of inequalities in mortality by socioeconomic status in Europe from the 1970s through the 1990s (Harding, 1995; Hemström, 2000; Mackenbach et al., 2003; Martikainen et al., 2001b; Valkonen et al., 2000). The same widening of differentials has been reported in a number of individual countries as well, as in a study of six Western European countries by Mackenbach and colleagues (2003). In those six countries, the widening of differentials was primarily the result of faster mortality decline among the most advantaged. Thus it appears that at least some European countries, like the United States, saw less mortality improvement than they would have if the least advantaged had had the experience of the most advantaged.

Japanese socioeconomic differentials in health and mortality have historically been smaller than those in the United States (Marmot and Davey Smith, 1989). However, studies of longitudinal data on the older Japanese population indicate some differentials, including higher mortality among those of low economic and educational status (Liang et al., 2002). From the early 1960s to the late 1980s, Japan had the narrowest income differentials among all industrialized countries, and it has been suggested that smaller differentials in health by socioeconomic status in Japan may have resulted from this low level of inequality (Marmot and Davey Smith, 1989; Shibuya et al., 2002; Wilkinson, 1994). There is also some evidence of increasing inequality in socioeconomic status and associated differentials in health in Japan (Fukuda et al., 2004; Martikainen et al., 2004; Nishi et al., 2004).

Comparable date for Europe and Japan on differences in life expectancy at age 50 by socioeconomic status are not available. However, a recent analysis provides data on life expectancy at age 65 for three educational groups in 10 European countries that can be compared with data on life expectancy for the three groups at age 65 in the life tables of Molla and colleagues (2004) described previously (Majer et al., 2010). While this comparison provides an opportunity to examine the relative size of differentials in life expectancy in some of the European countries examined in this study, the educational groupings are only roughly comparable in Europe and the United States, as the boundaries of the categories for the United States are at somewhat lower education levels.

The U.S. spread in the range of life expectancy from the high to the low education group is somewhat larger than the average European spread for both men and women (see Table 9-2). For men this occurs because average life expectancy for U.S. men in the highest education group is higher than that in the European countries, while life expectancy in the lowest education group is identical. Women in each educational grouping in the United States have lower life expectancy than the average for European

TABLE 9-2 Life Expectancy at Age 65 (Years) by Level of Education in Selected European Countries and the United States

Country	High Ed.	Middle Ed.	Low Ed.	High-Low/ Middle-Low
		Males		
Finland	15.7	14.6	14.2	1.5/0.3
Denmark	15.8	14.5	13.8	2.1/0.7
Ireland	17.8	16.0	14.1	3.7/1.9
Austria	17.5	16.3	13.6	3.8/2.7
Belgium	16.2	15.2	13.4	2.8/1.8
Greece	19.2	17.2	15.8	3.4/1.4
Italy	19.0	15.3	16.7	2.3/-1.3
France	19.4	18.5	16.4	3.0/2.1
Spain	19.4	18.4	16.4	2.9/2.0
Portugal	18.7	16.7	14.8	3.8/1.9
European Average	17.9	16.3	14.9	2.9/1.3
United States	18.3	15.1	14.9	3.4/0.2
		Females		
Finland	18.9	18.6	18.3	0.6/0.3
Denmark	17.9	17.4	17.2	0.8/0.3
Ireland	21.0	20.1	18.3	2.7/1.8
Austria	21.4	21.1	18.4	3.0/2.7
Belgium	20.8	20.7	19.1	1.7/1.6
Greece	20.6	19.4	18.1	2.5/1.3
Italy	22.1	19.6	20.8	1.3/-1.2
France	23.8	23.9	21.7	2.1/2.2
Spain	22.3	22.0	20.4	1.9/1.6
Portugal	21.4	20.6	18.5	3.0/2.2
European Average	21.0	20.4	19.1	1.9/1.3
United States	20.4	18.2	17.9	2.5/0.3

NOTES: Educational classification: For Europe, low is lower secondary education; middle is upper secondary education; high is tertiary or vocational and university education. For the United States, low is 0–8, middle is 9–12, and high is 13+ years. The European equivalent categories would be 0–11, 9–15, and 16+ years.
SOURCES: Data for European countries from Majer et al. (2010); data for United States from Molla et al. (2004).

women in the comparable groups. It should be noted that there is considerable variation in inequality in life expectancy by education within Europe. Denmark shows relatively low inequality, particularly among women, while France shows higher than average inequality. Looking only at the lowest educational group, the United States has higher life expectancy for males than 6 of the 10 European countries; among females, however, the U.S. level exceeds only that of Denmark.

The results of these studies suggest that economic inequality could explain some of the differences in life expectancy between the United States and other countries, but none of the studies address that issue explicitly, nor do they address the role of trends in inequality. Two of the studies prepared for the panel attempt to do so.

THE ROLE OF SOCIOECONOMIC INEQUALITY IN DIFFERENCES IN LIFE EXPECTANCY

Avendano and colleagues (2010) examined mortality rates for different socioeconomic classes in the United States, for blacks and whites as well as the total population, and in a number of European countries, including Denmark, England, and France, using data from the U.S. National Health Interview Survey (NHIS) and a variety of European data sets (Avendano et al., 2010). They studied men and women who were aged 30–74 between 1990 and 2003; they also examined differences for white and black Americans. Educational level was used as a measure of socioeconomic status.

The authors chose to use education as the basic index of socioeconomic status because it is relatively easy to measure, it can be made closely comparable from country to country, and it is much less susceptible to the problem of reverse causation than income or wealth. The authors used comparable levels of education in each country to divide people into low, middle, and high levels of education. These three levels correspond roughly to having 11 years of education or less in the United States, 12–15 years of education, and a bachelor's degree or more. The authors caution that the study's findings on the relationship between education and mortality in different countries may not be generalizable to other measures of socioeconomic status or to other classifications of education.

The authors found that at ages from 30 to the mid-80s, mortality rates were lower for U.S. men than for men in Finland, Denmark, and Belgium but higher than for men in the other Western European countries considered in the study (see Table 9-3). Among women, Denmark was the only Western European country with mortality rates higher than those in the United States (see Table 9-4).

Mortality rates among U.S. blacks were much higher than those among U.S. whites and were higher than those in any of the Western European

TABLE 9-3 Mortality Rates[a] Per 100,000 Person-Years According to Education Level,[b] Distribution of Education, and Population Attributable Fraction (PAF) for Men Aged 30–74 in Selected European Countries and the United States

	Mortality Rates per 100,000 Person-Years				Distribution of Education in the Population			
	Low Ed.	Middle Ed.	High Ed.	Overall Rate	% Low	% Middle	% High	PAF[c]
United States, all	1,840	1,339	885	1,379	20	54	26	39
United States, whites	1,779	1,316	876	1,334	19	54	27	38
United States, blacks	2,264	1,658	1,198	1,903	32	55	14	39
Finland	1,700	1,410	942	1,528	49	30	22	41
Sweden	1,151	953	706	1,026	40	43	16	33
Norway	1,498	1,194	873	1,272	30	48	22	33
Denmark	1,659	1,400	982	1,508	43	38	19	37
England/Wales[d]	1,128	786	652	1,074	83	7	10	39
Belgium	1,590	1,264	999	1,480	61	22	17	32
Switzerland	1,477	1,123	831	1,165	20	56	24	30
France	1,285	955	624	1,132	50	37	13	51

[a]Rates are directly standardized to the U.S. census population of 1995. Most samples were aged 30–74 at baseline and had at least 10 years of follow-up; however, samples in Belgium and Denmark were 30–79 at baseline and had follow-up of 5 years or less. Most data sets begin in the 1990s; for example, the U.S. sample was from the 1989–1993 National Health Interview Survey with mortality follow-up through 2002.

[b]Education categories: low education = comparable to 0–11 years; middle education = comparable to 9–15 years; high education = comparable to 16+ years or a bachelor's degree in the United States.

[c]PAF = population attributable fraction. PAF calculations in this column define the "high education" group as the unexposed category.

[d]Education levels for England and Wales do not correspond to the International Standard Classification of Education levels. The low education category includes some individuals with medium education as well. No further distinction was possible through census data.

SOURCE: Adapted from Avendano et al. (2010, Table 11-2).

TABLE 9-4 Mortality Rates[a] Per 100,000 Person-Years According to Education Level[b] and Population Attributable Fraction (PAF) for Women Aged 30–74 in Selected European Countries and the United States

	Mortality Rates				Distribution of Education in the Population			
	Low Ed.	Middle Ed.	High Ed.	Overall Rate	% Low	% Middle	% High	PAF[c]
United States, all	1,142	839	588	888	20	61	19	36
United States, whites	1,099	818	583	856	18	62	20	34
United States, blacks	1,399	1,091	765	1,197	30	57	13	39
Finland	794	631	528	735	51	29	20	26
Sweden	657	534	402	589	41	40	19	32
Norway	801	616	484	697	36	47	17	31
Denmark	1,037	814	664	960	53	28	19	29
England/Wales[d]	670	472	394	652	87	8	5	40
Belgium	801	628	582	766	67	19	14	22
Switzerland	657	523	472	591	40	53	7	19
France	530	387	334	492	62	28	10	31

[a]Rates are directly standardized to the U.S. census population of 1995. Most samples were aged 30–74 at baseline and had at least 10 years of follow-up; however, samples in Belgium and Denmark were 30–79 at baseline and had follow-up of 5 years or less. Most data sets begin in the 1990s; for example, the U.S. sample was from the 1989–1993 National Health Interview Survey with mortality follow-up through 2002.
[b]Education categories: low education = comparable to 0–11 years; middle education = comparable to 9–15 years; high education = comparable to 16+ years or a bachelor's degree in the United States.
[c]PAF = population attributable fraction. PAF calculations in this column define the "higher education" group as the unexposed category.
[d]Education levels for England and Wales do not correspond to the International Standard Classification of Education levels. The low education category includes some individuals with medium education as well. No further distinction was possible through census data.
SOURCE: Adapted from Avendano et al. (2010, Table 11-3).

countries examined. When the authors looked at how mortality rates varied by educational level, the international rankings differed at high versus low levels. Among those with a low level of education (equivalent to 11 years or less), the mortality among men and women in the United States, both black and white, was higher than that in any of the Western European countries. In contrast, among those with the highest level of education—equivalent to a bachelor's degree or higher in U.S. universities—U.S. men fared better, ranking higher than men in three of the eight Western European countries. However, their U.S. female counterparts fared worse than highly educated women in all but Denmark. Mortality levels among highly educated blacks in the United States were higher than those among the highly educated in any other country. In short, among the most highly educated people, white men in the United States had mortality rates that compared favorably with those of men in some countries in Western Europe, while white women had rates that were higher than those of women in most of the Western European countries, and blacks had mortality rates worse than all of the comparable groups in Western Europe (Avendano et al., 2010).

To provide a summary of the effect of educational inequality on mortality rates, the authors calculated the relative index of inequality (RII) for each country. This number, which is obtained from a regression calculation, can be thought of as the ratio of mortality between those with the least education and those with the most (Mackenbach and Kunst, 1997). Thus an RII of 2 would mean that people at the bottom of the educational distribution have a mortality rate twice as high as that of those at the top (Hayes and Berry, 2002; Pamuk, 1985). The index takes appropriate account not only of differences in mortality among educational groups but also of the relative size of the groups. By comparing the RII among different countries, one can determine in which countries educational inequalities in mortality rates are greatest.

Figure 9-3 shows the RII for men and women in the United States and the Western European countries included in the study by Avendano and colleagues. The RII for U.S. white men was 2.4, similar to the RII for men in Norway and Switzerland and smaller than the RII for men in England or France. The RII for U.S. black men was somewhat smaller than that for white men, but still fell in the middle of that for the Western European countries. The RII for U.S. white women was larger than that for women in all the Western European countries except England and France. The RII for U.S. black women was somewhat lower than that for U.S. white women. The United States, therefore, does not stand out as having unusually large effects of educational inequality on mortality rates in this age range using this measure, although relative inequality appears to be more important for U.S. women than for U.S. men. The relatively large educational differences in mortality rates in the United States are counteracted by having a relatively

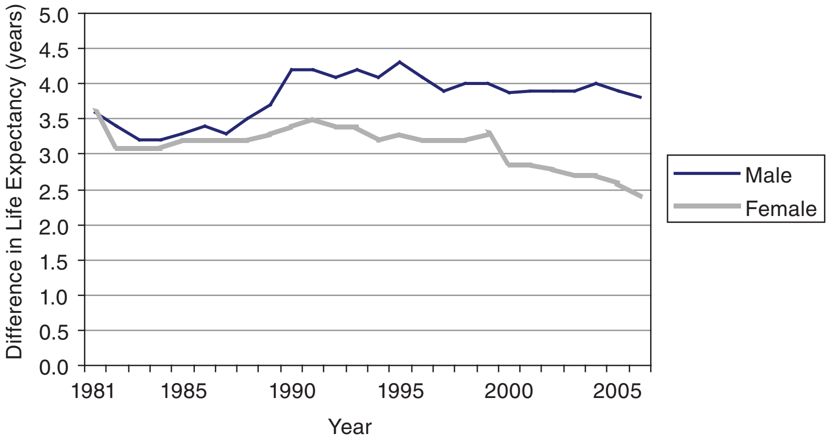

FIGURE 9-3 Relative index of inequality (RII) in mortality by education level for men and women aged 30–74 in the United States and selected European countries
NOTE: The RII is a regression-based measure that accounts for differences in the distribution of education among countries and in mortality by education. This measure regresses mortality on an education ranking, defined as the midpoint of the range of the cumulative distribution of education in each country (Mackenbach and Kunst, 1997). The RII can be interpreted as the ratio of mortality for rank 1 (the lowest point of the education distribution) to that for rank 0 (the top end of the education distribution).
SOURCE: Avendano et al. (2010, Figure 11-1).

large portion of the population at the top of the educational distribution and a relatively small portion at the bottom.

A second way of describing the effect of socioeconomic status on a country's mortality rates is to calculate the population attributable factor (PAF). This calculation assumes that lower educational levels "cause" increased mortality, and the PAF is, in effect, the proportion of deaths in a population that would theoretically be avoided if everyone achieved the mortality rates of the highest educational level. The PAF for U.S. men was 39 percent, about the same as for English or Danish men (see Table 9-3); it was lower than the PAF for men in Finland and France. The PAF for U.S. women was 36 percent, again higher than that for the women in all of the countries except England and Wales (see Table 9-4).

The authors note that the PAF for U.S. men and women is smaller than might be expected because of a higher distribution of educational attainment in the United States. Only 20 percent of U.S. men and women aged 50 and above had an 11th-grade education or less. Among Europeans, the percentages for men were similar in Switzerland (20 percent) but were much higher in other Northern and Western European countries (e.g., 43 in Denmark and 50 in France), while for women the numbers were even higher in the European countries. Similarly, the percentage of men with a bachelor's degree or higher was greater in the United States than in any of the European countries; among women, the percentages with at least 16 years of education were equally high in the United States, Finland, Sweden, and Denmark. From this analysis one can conclude that while the United States has relatively large differentials in health and morality by education, the effect of this inequality is substantially muted relative to other countries because of a favorable educational distribution. For U.S. women, however, the inequality is more important in determining overall levels of mortality than in most other countries, and this is true for both blacks and whites.

U.S. life expectancy, like that of other countries, would be higher if the mortality of groups with the lowest socioeconomic status were lower. However, the poor ranking of U.S. life expectancy is not merely the result of high mortality among those of low socioeconomic status. U.S. women at both higher and lower levels of socioeconomic status rank poorly in mortality. U.S. rankings in life expectancy for women are affected by both the high levels of mortality across all socioeconomic groups and the relatively high levels of inequality.

WHAT CAN BE LEARNED FROM GEOGRAPHIC INEQUALITY?

The discussion in the previous section provides evidence for evaluating the role of differences in socioeconomic status as a source of the gap in life expectancy between the United States and other countries. Geography is a second dimension along which mortality differences can be investigated. Geographic variability in mortality in the United States has been sizable and is highly related to differences by socioeconomic status and race. Murray and colleagues (2006) divided U.S. counties into eight groups based on race, income, population, density, and homicide rates and found that in 2001, the differences in life expectancy at birth between the best-off and the worst-off groups were 15.4 years for males and 12.8 years for females. They also found that the magnitude of the differences between the best-off and the worst-off groups increased somewhat for men and decreased for women between 1982 and 2001. Singh and Siahpush (2006) report a widening of geographic inequality in mortality over the period 1980–2000. Ezzati and colleagues (2008) examined county-level mortality over a longer period, 1961–1999, and found that in 1999, men in the highest-ranked counties had a life expectancy 18 years longer than that of men in the lowest-ranked counties, while women in the highest-ranked counties had a life expectancy 13 years longer than that of women in the lowest-ranked countries. The county-to-county variability decreased from 1961 to 1983 but then increased from 1983 to 1999. During the period 1983 to 1999, there were several counties in which life expectancy actually decreased, especially among women. These studies suggest rising geographic inequality in mortality in recent decades, again particularly for women, but their results include mortality across the age range, and they do not compare changes in the United States with those in other countries.

In a paper prepared for the panel, Wilmoth and colleagues (2010) describe how life expectancy at age 50 in the United States varied across states and counties over the 50 years from 1950 to 2000. Their analysis is based on data for the United States, Japan, and 19 national or large subnational areas of Western Europe, gathered from the Human Mortality Database. The authors also studied regional mortality within five countries: the United States, Japan, France, Canada, and Germany.

The data show that U.S. life expectancy at age 50 varied significantly from state to state (see Figure 9-4). In 2000, Hawaii (not shown), Utah, and several north central states had the highest life expectancies, while the District of Columbia and several southern states had the lowest. No state other than Hawaii had a life expectancy comparable to those of the countries with the highest life expectancies, such as Japan, Australia, and Switzerland. The states with the highest life expectancies after Hawaii, mainly in the north central and mountain regions of the United States, achieved life expectancies only in the middle of the range for high-income countries; thus the U.S. disadvantage was not limited to poorer-performing states. A large number of states, many of them southern, had life expectancies well below the norm for most high-income countries. Only a few countries—Denmark, Ireland, and Scotland—had life expectancies at age 50 comparable to those of these states. These geographic variations suggest that compositional differences play a role in some of the state-to-state variation found in the United States. Southern states, and particularly the District of Columbia, have lower-than-average educational and income levels and a higher proportion of blacks.

Data from this paper can also be used to examine differential trends across time in the United States and other countries (see Figure 9-5). In contrast to most of the populations studied, geographic disparities in mortality in the United States increased over the past two decades of the 20th century for both men and women (Wilmoth et al., 2010). This is shown by the relative size of the bands encompassing the lines indicating life expectancy at age 50 for each quintile of the distribution in the United States, Canada, France, and Western Europe as a whole (see Figure 9-5). In the United States, the spread is wider in more recent years and wider than in the other countries. Comparing the United States with other countries, however, Wilmoth and colleagues conclude that less than 10 percent of the slow progress in gains in life expectancy at age 50 for women can be attributed to differential trends in regional disparities; the years of life expectancy gained at age 50 from

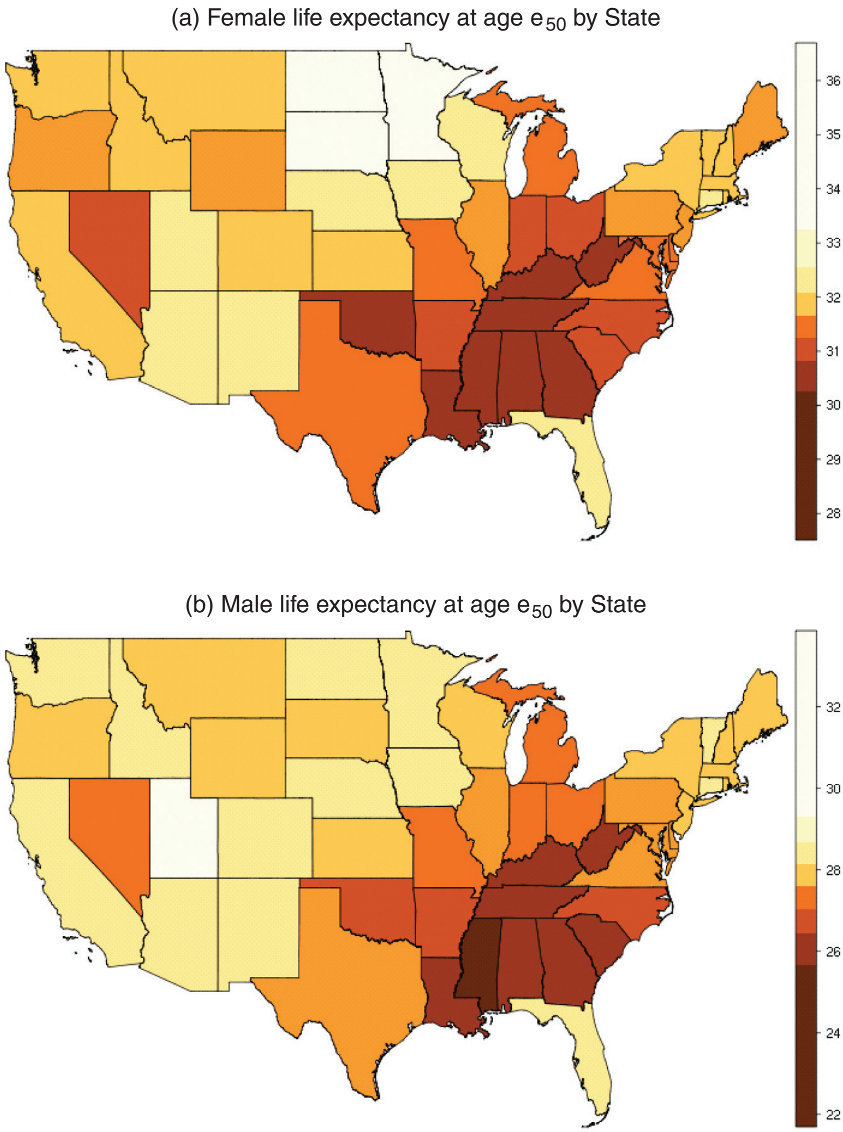

FIGURE 9-4 Geographic variation in life expectancy at age 50 in the contiguous United States, 2000.
SOURCE: Wilmoth et al. (2010, Figures 12-1a–12-1b). Reprinted with permission.

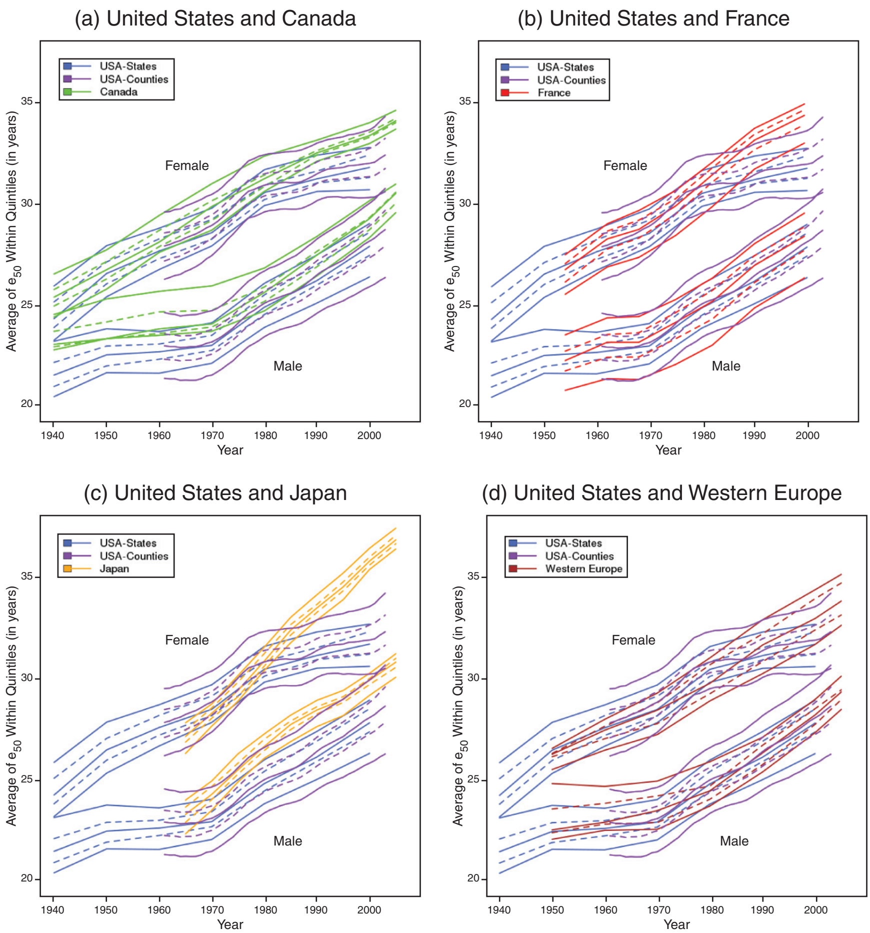

FIGURE 9-5 Trends in the average value of life expectancy at age 50 within quintiles of geographic distribution, United States compared with Canada, France, Japan, and Western Europe, 1940–2005.
NOTE: Each line represents the trend for one quintile; the spread of the lines represents the inequality across quintiles.
SOURCE: Wilmoth et al. (2010, Figures 12-7a–12-7d). Reprinted with permission.

1980 to 2000 were not much different in the upper half of the distribution than in the lower half. The authors report that for men, on the other hand, the slower progress in states with lower versus higher life expectancy was a significant factor in the slow progress of U.S. life expectancy compared with that of other countries. Thus, it appears that diverging trends in life expectancy among women are not simply a result of slowing mortality decline among the least advantaged regions of the United States. Wilmoth and colleagues conclude that "any proposed explanation of the divergence in levels and trends of life expectancy observed among high-income countries in recent decades needs to acknowledge that even the most advantaged areas of the United States (at the state or county level) have been falling behind in international comparisons" (Wilmoth et al., 2010, p. 360).

WHAT EXPLAINS INCREASES IN INEQUALITY IN MORTALITY?

As indicated at the beginning of this chapter, socioeconomic status can be considered a fundamental cause of differentials in health and mortality and one that works through many mechanisms. Explanations for the existence of changes in inequality in mortality often focus on two levels: causes of death and more proximate behavioral mechanisms. For both the United States and Europe, the most important causes of death—cardiovascular diseases and cancer—tend to account for much of the inequality in mortality (Danaei et al., 2010; Mackenbach and Garssen, 2010). Recent trends in mortality differentials also have been affected by differential changes in cardiovascular diseases and cancer (Jemal et al., 2008; Mackenbach and Garssen, 2010; Meara et al., 2008). Among the types of cancer, lung cancer has had an important role in these trends.

Meara and colleagues estimated that 20 percent of the increase they observed in U.S. inequality in morality is related to different patterns of smoking. Ezzati and colleagues (2008) indicate that the increase in geographic inequality in mortality in the United States is explained in part by differential patterns of smoking and overweight.

One can ask whether larger disparities in behavioral risk factors exist in some countries than in others. Using the same educational differences as those examined by Avendano and colleagues (2010), it appears that differences in the proportion smoking in low and high education groups are larger for men in the United States than for those in most European countries or Japan (see Table 9-5). American men with less than a high school education are 2.5 times more likely to currently smoke and 1.5 times as likely to ever have smoked as those who have completed college. The current smoking prevalence among U.S. women with low education is 2.25 times higher than among the high education group. The other countries with large educational differentials among women are England and the Netherlands.

For men the educational differential in obesity is relatively small in the United States (1.3); it is similar to the differentials in Canada and England and lower than those in other countries. The educational differential in obesity for women is moderate in the United States (1.50); it is similar to those in Canada and England. Thus while there are consistent differentials in health behaviors in the United States that raise health risks among

TABLE 9-5 Smoking and Obesity by Education: Proportion Who Currently Smoke, Ever Smoked, or Are Obese by Years of Education and Ratio of Lowest Education Group (≦ years) to Highest (≦16 years)

	Males Aged 50+											
	Currently Smoking				Ever Smoked				Obese			
Education (years)	≦11	12–15	≦16	Ratio	≦11	12–15	≦16	Ratio	≦11	12–15	≦16	Ratio
Netherlands	.31	.26	.23	1.35	.79	.74	.73	1.08	.17	.10	.06	2.83
Spain	.28	.51	.31	.90	.67	.80	.61	1.10	.22	.05	.08	2.75
Italy	.24	.24	.21	1.14	.62	.71	.64	.97	.18	.12	.06	3.00
France	.18	.16	.30	.60	.64	.61	.68	.94	.17	.10	.08	2.12
Denmark	.34	.34	.29	1.17	.74	.73	.68	1.09	.20	.13	.10	2.00
England (aged 52+)	.16	.13	.10	1.60	.74	.68	.64	1.16	.27	.29	.21	1.29
Japan (aged 67+)	.20	.23	.20	1.00	.78	.73	.73	1.08	.02	.01	.01	2.00
Canada	.21	.20	.16	1.31	.75	.72	.65	1.15	.20	.20	.16	1.25
United States	.25	.20	.10	2.50	.79	.72	.54	1.46	.28	.30	.21	1.33

	Females 50+											
	Currently Smoking				Ever Smoked				Obese			
Education (years)	≦11	12–15	≦16	Ratio	≦11	12–15	≦16	Ratio	≦11	12–15	≦16	Ratio
Netherlands	.22	.22	.08	2.75	.46	.51	.55	.84	.19	.13	.08	2.38
Spain*	.07	.27	.00	.22	.11	.46	.55	.20	.27	.13	.13	2.08
Italy	.12	.21	.21	.57	.23	.50	.56	.41	.19	.11	.06	3.17
France	.06	.18	.20	.30	.16	.38	.51	.31	.18	.10	.05	3.60
Denmark	.33	.30	.24	1.38	.59	.57	.57	1.03	.16	.13	.08	2.00
England (aged 52+)	.16	.16	.07	2.29	.74	.53	.54	1.37	.27	.31	.22	1.23
Japan (aged 67+)*	.04	.08	.20	.20	.08	.10	.39	.20	.03	.01	.00	3.00
Canada	.16	.18	.14	1.14	.44	.50	.48	0.92	.22	.16	.15	1.47
United States	.18	.16	.08	2.25	.49	.50	.45	1.09	.33	.29	.22	1.50

*Ratio for current smoking in Spain is ≦11/12–15; ratio for obesity in Japan is ≦11/12–15; ratio for ever smoked in Japan (1999) is ≦11/12–15.

SOURCES: For England, English Longitudinal Study of Ageing (ELSA), 2004–2005; for other European countries, Survey of Health, Ageing and Retirement in Europe (SHARE), 2004; for the United States, Health and Retirement Study (HRS), 2004; for Japan, Nihon University Japanese Longitudinal Study of Aging (NUJLSOA), 2006; for Canada, Canadian Community Health Survey (CCHS), 2003. More information about these data sets is available at the following websites: http://www.share-project.org/ (SHARE); http://hrsonline.isr.umich.edu/ (HRS); http://www.usc.edu/dept/gero/CBPH/nujlsoa/ (NUJLSOA); http://www.ifs.org.uk/elsa/ (ELSA); and http://www.statcan.gc.ca/cgi-bin/imdb/p2SV.pl?Function=getSurvey&SDDS=3226& lang=en&db=imdb&adm=8&dis=2 (CCHS).

those with lower education, a number of other countries have similar differentials.

Studies in both Europe and the United States have noted the significant role of behavioral differences in partially explaining differentials in mortality by socioeconomic status (Cutler et al., 2010; Mackenbach and Garssen, 2010; Meara et al., 2008). However, these same studies have noted that these behavioral factors do not explain most of the differentials by socioeconomic status in health, nor do they explain most of the trend. An exception is Jha and colleagues (2006), who used the Peto/Lopez method described in Chapter 7 to estimate deaths attributable to smoking at ages 35–69 among three social classes in the United States, England and Wales, Canada, and Poland. They found that a majority of the difference in mortality between the lowest and highest classes in each of these countries is attributable to smoking.

DISCUSSION

Much of this chapter has examined differences in mortality by educational level in the United States and other countries, viewing education, as an indicator of socioeconomic status, as a fundamental cause of inequalities in health. With respect to income inequalities, it is widely believed that such inequalities are greater in the United States than in other high-income countries, in part because the United States does less to redistribute wealth among its citizens (Organisation for Economic Co-operation and Development, 2008; Wolf, 1996). Poverty rates also appear to be higher in the United States than in most of the other countries considered here, as evidenced by further data from the OECD study indicating the proportion of the population below half-median income, or by micro-level data on the ratio of income at the 10th percentile relative to median income (Krueger et al., 2009).

Furthermore, a large number of people in the United States, especially at lower levels of socioeconomic status, have no health insurance, while most Western European countries have national health care coverage programs. It is also true that people in the United States are less protected from loss of either income or wealth because of health problems than those in most Western European countries. Health problems are a major reason for bankruptcy in the United States, and this is less likely to be the case in Europe or Japan (Himmelstein et al., 2005). We have also seen that socioeconomic differentials in smoking tend to be larger in the United States than in other countries.

This combination of factors could result in higher mortality rates among people in lower socioeconomic brackets in the United States than in other countries, pulling down U.S. life expectancy levels in general. This possibility is consistent with the conclusion of Avendano and colleagues (2010, p. 322), that "our results partly support the hypothesis that U.S. excess mortality is to some extent attributable to larger excess mortality at lower education levels." In particular, there is a clear pattern among U.S. white males that fits this hypothesis: among those with the least education, mortality is significantly higher in the United States than in European countries, while among those with the most education, the U.S. mortality rate ranks in the middle of values for Northern and Western European countries. On the other hand, the pattern for U.S. women is somewhat different: mortality rates are higher than in most Northern and Western European countries among both those who are highly educated and the least educated. This generalization for women is similar to that noted for geographic differences, with states in the United States faring relatively poorly compared with OECD countries at comparable points in their respective educational distributions. It is also consistent with comparative educational differentials for women in a different index of mortality—life expectancy at age 65 (see Table 9-2). By contrast, among males in the lowest educational group, those in the United States are not disadvantaged on this index.

It is difficult to draw a precise conclusion about the magnitude of the role of inequality in relative levels and trends in U.S. mortality above age 50. Clearly, if blacks were to achieve the mortality conditions of whites, the gap in life expectancy between the United States and other countries would be reduced; however, the gap exists for white Americans as well. Based on educational gradients in mortality in combination with educational distributions, the RII in the United States is not exceptionally high relative to that of other countries. Unusually high educational gradients in mortality are substantially offset by an unusually attractive educational distribution. It should be noted that had this calculation been performed differently, that is, if relative rather than absolute categories of education had been used, the conclusion might have differed.

With respect to trends, the differences are less clear. While there are reports from around the world of increasing inequality in mortality, the relative magnitude of such changes is not well understood. Black/white differences in life expectancy for women narrowed between 1980 and 2006 and remained roughly constant among men. On the other hand, the geographic differential in mortality increased between 1980 and 2000 in the United States and decreased in some comparison countries. We know that increases in economic inequality were greater in the United States during the period 1980–2000 than in several comparison countries (Krueger et al., 2009). These trends are consistent with the view that rising socioeconomic disparities contributed to the deteriorating longevity position of the United States, but data on trends in inequality are too scattered to permit a firm conclusion about their role.

10

Conclusions

Over the past 25 years, life expectancy has been rising in the United States at a slower pace than has been achieved in many other high-income countries. Consequently, the United States has been falling steadily in the world rankings for level of life expectancy, and the gap between the United States and countries with the highest achieved life expectancies has been widening. Life expectancy at birth in the United States for both sexes combined now ranks 28th in the world, just behind the United Kingdom, Korea, and Malta and more than 2 years behind Australia, Canada, France, Iceland, Italy, Japan, and Switzerland (United Nations, 2009). International comparisons of various measures of self-reported health and biological markers of disease reveal similar patterns of U.S. disadvantage. What are the reasons for the relatively poor performance of the United States? Are these factors visibly at work in two other underachieving countries—Denmark and the Netherlands?

PATTERNS OF MORTALITY AT OLDER AGES

It is not surprising that differences in levels of life expectancy exist among various high-income countries. What is perhaps more surprising is that large differences did not exist among many high-income countries around 1950, that the divergence discussed in this report began relatively abruptly around 1980, and that it has taken so long for this divergence to be recognized and analyzed. If one examines trends in life expectancy at various ages across countries, it becomes clear that the divergence has occurred for both men and women and at ages above and below 50. Nevertheless, the largest divergence among countries appears to have been for women aged 50 and over, and this segment of the population has been the primary focus of this report.

Descriptive analysis can be a powerful tool in demography. In this case, the panel undertook a careful examination of cause-of-death statistics to ascertain whether specific causes of death could account for the relatively low level of life expectancy in the United States and were associated with improvements in life expectancy in vanguard countries. Comparative analysis of causes of death is complicated by issues of variation in coding practices across countries and over time. Nevertheless, it does appear that higher mortality rates for lung cancer and respiratory diseases in the United States, Denmark, and the Netherlands are an important part of the story. Such a finding is clearly consistent with the hypothesis that smoking was an important factor accounting for the slowing of mortality decline among women in these three countries.

Other conditions that account for the poor performance of U.S. women include cerebrovascular conditions (primarily stroke), diabetes, and mental disorders. Stroke is another cause of death for which smoking is a risk factor. Obesity is a risk factor for both stroke and diabetes. With respect to mental disorders, the increase in such disorders is difficult to interpret, and the idea that this increase is attributable to differences in coding cannot be rejected. It should be noted, however, that the risk factors for heart disease, diabetes, and stroke overlap with those for Alzheimer's disease, and it is possible that the trend in deaths due to mental disorders is related to some of the same underlying factors. Although mortality from heart disease played little role in the divergent trends in life expectancy—because even 50 years ago the United States already had much higher levels of mortality from heart disease than the other countries examined for this study—it accounts for about half the current gap between the United States and the countries with highest life expectancies; therefore, this condition should be a focus of efforts to bring U.S. life expectancy in line with that of the exemplar countries.

While descriptive analysis of causes of death is certainly informative, this report has begun the process of moving from description to identifying the underlying determinants of the observed differences, a necessary first step toward ultimately developing an integrated model of causal processes. More specifically, the panel examined a number of possible risk factors and considered how differences among countries in exposure to these risk factors might account for observed disparities in improvement in life expectancy. Such an approach is not without its limitations. For some factors, comparable cross-country data exist on the current levels of risk, while for others, surprisingly little direct evidence can be brought to bear. Few countries are conducting systematic surveillance of health risk factors, so that directly comparable data even for the present often are not available for a large number of countries, and for a substantial number of countries, data are available for almost no risk factors for the 50-year period examined for this study. Much is known about current international differences in smoking patterns and levels of obesity, but far less about international differences in stress, physical exercise, or social networks.[1] Very little is known, moreover, about changes over time and across countries in lifetime exposures and behaviors for most risk factors.

The fluid nature of the relationship between mortality and some of the major risk factors also complicated the panel's work. For example, the epidemiological literature still reflects considerable differences of opinion with respect to the magnitude of the relationship between obesity and mortality. As the obesity epidemic has spread, the number of people at risk of obesity-related health problems has risen. At the same time, however, management of some of the more serious obesity-related health problems, such as heart disease and type 2 diabetes, has improved. Thus, the net effect of rising obesity on mortality is difficult to estimate.

Acknowledging these limitations, the panel's strategy was to try to establish the strength of the evidence for a number of the most commonly proffered explanations for differences in life expectancy between the United States and other high-income countries—for example, that these differences are the result of a particularly inefficient U.S. health care system or that they are a function of poor health behaviors in the United States, particularly with respect to smoking, overeating, and failing to exercise sufficiently. The panel also considered differences among countries in levels of social integration and in socioeconomic inequality. Ultimately, all of these potential risk factors will need to be examined in an integrated framework across the entire life course, taking account of the effects of differences in socioeconomic status, behavioral risk factors, and social policy, as well as effects across particular cohorts and periods.

Smoking appears to be responsible for a good deal of the divergence in female life expectancy. Other factors, such as obesity, diet, exercise, and economic inequality, also have likely played a role in explaining the current gap between the United States and other countries, but evidence of their importance to the divergence is not as firm. The case against smoking, by contrast, is quite strong. Fifty years ago, smoking was much more widespread in the United States than in Europe or Japan: a greater proportion of Americans smoked and smoked more intensively than was the case in other

[1]Fortunately, thanks to survey programs such as the Health and Retirement Study in the United States, the English Longitudinal Survey of Ageing in the United Kingdom, and the Survey of Health, Ageing, and Retirement in Europe, large-scale internationally comparable surveys containing important measures of current differences in many variables of relevance now exist. Nevertheless, the empirical basis for certain conclusions is significantly stronger in some cases than in others.

countries. The health consequences of this behavior are still playing out in today's mortality rates. Over the period 1950–2003, the gain in life expectancy at age 50 was 2.1 years lower among U.S. women compared with the average of nine other high-income countries (5.7 vs. 7.8 years gained, respectively). The damage caused by smoking was estimated to account for 78 percent of the gap in life expectancy for women and 41 percent of the gap for men between the United States and other high-income countries in 2003 (Chapter 5). Smoking also has caused significant reductions in life expectancy in the Netherlands and Denmark, which as noted are two other countries with relatively poor life expectancy trends. It has had a major negative effect as well on life expectancy in Canada, where life expectancy trends have been much more favorable.

While smoking appears to be an important part of the story, it is by no means the entire story. Other factors, particularly the rising level of obesity in the United States, also appear to have played a significant part, although as noted, there is a good deal of uncertainty in the literature regarding the mortality consequences of obesity and possible trends therein. Several peer-reviewed articles appearing recently suggest effects of quite different orders of magnitude. Preston and Stokes (2010) conclude that, even using relatively low estimates of associated risk, obesity accounts for a fifth to a third of the shortfall in life expectancy in the United States relative to other high-income countries.

Other specific risk factors also are surely important, but their effects are even more difficult to quantify. The panel found some evidence to suggest that adults aged 50 and over in the United States are somewhat more sedentary than those in Europe, but the research base is insufficient even to identify a reasonable range of uncertainty in estimates of the contribution of physical activity to international differences or trends in mortality.

In other cases, the panel determined that certain risk factors are unlikely to have played a major role in the divergence of life expectancy in various countries over the past 25 years. A large body of work shows a causal relationship between social ties and social integration and mortality. Yet there is little basis for concluding that levels or trends in the quality of social networks have played a role in the divergent life expectancies studied. Similarly, little evidence supports the hypothesis that postmenopausal hormone therapy played a part in an emergent longevity shortfall for American women.

Finally, the panel examined whether differences in health care systems across countries might help explain the divergence in life expectancy over the past 25 years. The health care system in the United States differs from those in other high-income countries in a number of ways that conceivably could lead to differences in life expectancy. Certainly, the lack of universal access to health care in the United States has increased mortality and reduced life expectancy. However, this is a smaller factor above age 65 than at younger ages because of Medicare entitlements. For the main causes of death at older ages—cancer and cardiovascular disease—available indicators do not suggest that the U.S. health care system is failing to prevent deaths that would elsewhere be averted. In fact, cancer detection and survival appear better in the United States than in most other high-income countries. Survival rates following heart attack are also favorable in the United States.

Most of the comparative data the panel reviewed relate to the performance of the U.S. health care system relative to those of other high-income countries after a disease has already developed. A separate concern is that the U.S. health care system does a particularly poor job at prevention, an observation that may be especially relevant in the midst of a nationwide obesity epidemic. The panel reviewed scattered evidence on the performance of the United States with respect to preventive medicine relative to European countries and found the evidence to be inconclusive. Certainly the high prevalence of certain health conditions in the United States is consistent with a failure of preventive medicine. But it could also be consistent with a higher prevalence of smoking, obesity, and physical inactivity among Americans, or with a medical system that may be unusually effective at identifying certain diseases.

There is no question that high mortality rates among those of low socioeconomic status are one reason the United States has a lower level of life expectancy than it might otherwise. A useful proxy for socioeconomic status is educational level (Avendano et al., 2010). Death rates at particular levels of educational attainment tend to be higher in the United States than in other countries, and the differences are generally greatest at the lowest levels of education. On the other hand, lifetime socioeconomic status has generally been higher for these cohorts of Americans than for the comparable cohorts of Europeans. Because educational levels in the United States have been relatively high, the low-education group is quite small in the United States, while the high-education group is quite large. As a result, measures of inequality in mortality that combine distributions with rates indicate that the United States is not unusual in the size of its mortality differentials by educational attainment.

Determining the role of socioeconomic inequality in the divergence in life expectancy among high-income countries is more difficult than determining its role in mortality levels, although it appears to have played some role. Data from the period after 1980 do suggest, however, that growing inequality in mortality in the United States is attributable to a slowdown in mortality improvement among white women, particularly those with low levels of education.

Finally, with respect to racial differentials, high mortality rates among blacks clearly help explain why the level of life expectancy in the United

States is lower than it might otherwise be. However, racial differences in mortality are unlikely to contribute significantly to explanations for the divergence in life expectancy between the United States and other high-income countries since 1980. Neither the relative size of the white and black populations nor the mortality differential between the two has changed dramatically enough since that time for that differential to hold much explanatory power.

LOOKING TO THE FUTURE

What will happen to life expectancy in the United States and other countries in the coming decades? Although it is impossible to answer that question with any certainty, the analyses described in this volume do point to some likely patterns for the future. Because there appears to be a lag of several decades between smoking and its peak effects on mortality, there is some opportunity to predict how smoking will affect life expectancy in various countries over the next 20 to 30 years.

Smoking has been shown to affect both levels and trends in life expectancy. High levels of smoking in the United States have produced an increase in smoking-related mortality and a reduction in the pace of improvement in life expectancy at age 50. As a result, the level of life expectancy at age 50 in the United States has fallen below that of countries with lower levels of smoking. However, the imprint of smoking has started to recede in the United States among males, contributing to a more rapid reduction in mortality than would have occurred had its imprint been constant or rising (Wang and Preston, 2009). Thus, life expectancy for U.S. men is likely to improve relatively rapidly in the coming decades in response to changes that have occurred in smoking patterns over the past 20 years (Wang and Preston, 2009). For U.S. women, on the other hand, smoking peaked among cohorts born in the 1940s, and these cohorts are just entering the prime ages for dying. Thus the impact of smoking on the mortality of U.S. women may not have become fully manifest, and relatively slow mortality declines among this population might be anticipated over the next decade or two. Similarly, life expectancy in Japan can be expected to improve less rapidly than it otherwise would because of the rapid increase in the prevalence of smoking in that country.

The mechanics of how obesity is likely to influence life expectancy at age 50 are broadly similar to those described above for smoking. The United States has been in the vanguard of a global obesity epidemic, and obesity also appears to be an important contributor to the shortfall in life expectancy in the United States. In line with Olshansky and colleagues (2005), Stewart and colleagues (2009) conclude that, if the obesity trend in the United States continues, it will more than offset the longevity improvements expected from reductions in smoking. However, recent data on obesity in the United States suggest that its prevalence has leveled off, and some studies indicate that the mortality risk associated with obesity has declined (Flegal et al., 2010; Mehta and Chang, 2010). Yet regardless of whether the prevalence of obesity continues to rise in cross-sectional data, the number of years the average individual will have spent in the obese state is likely to rise because of past increases in prevalence. The interplay between obesity levels and obesity risks bears watching as an important factor in future longevity trends in the United States.

LIMITS TO LIFE EXPECTANCY

Smoking and obesity are only two of many influences on mortality, and the future of longevity in the United States or elsewhere is beyond the scope of this study (see National Research Council, 2000b). However, one exercise that follows directly from this report's consideration of international longevity trends is to compare the current level of life expectancy with the future rate of improvement. If we are approaching a biological limit to the length of life, future gains will become more difficult to achieve, and one might expect to observe an inverse association between the current level of life expectancy and the rate of improvement in the following decade.

Figures 10-1a and 10-1b show the relationship between these two variables for males and females for 22 countries over the past five decades, using life expectancy at age 80 as the basic mortality indicator. For both men and women, little association between the two variables is evident. The correlation coefficient (R^2) for women is 0.03 and for men is 0.01. This simple exercise extends earlier demonstrations by Kannisto and colleagues (1994) and Vaupel (1997), and continues to suggest that if a limit exists, it is probably much higher than 85 years.

For the most part, this report has focused on the potential for improvements in health behaviors to produce longer and more active lives. The report does not address whether dramatic future increases in life expectancy might result from fundamental improvements in our understanding of the basic biology of aging and its genetic and environment modifiers. For example, the concept of Mendelian randomization, a method of using measured variation in genes of known function to estimate the causal effect of a modifiable exposure on disease in nonexperimental studies, provides new opportunities to test causality (Davey Smith and Ebrahim, 2003). It appears plausible that greater understanding of the basic principles governing the progressive deterioration of the body and mind could translate into interventions that would extend life to lengths not yet experienced in existing populations, and that such interventions could be adopted more rapidly in one country than another.

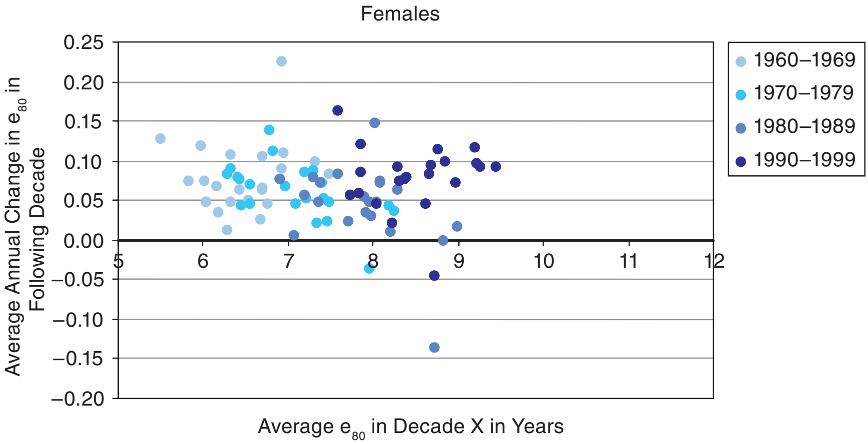

FIGURE 10-1a Female average life expectancy at age 80 (e_{80}) plotted against average annual future change in e_{80} the following decade (R^2 = 0.03) for selected counries.
SOURCE: Data from the Human Mortality Database, see http://www.mortality.org/ [accessed January 12, 2011].

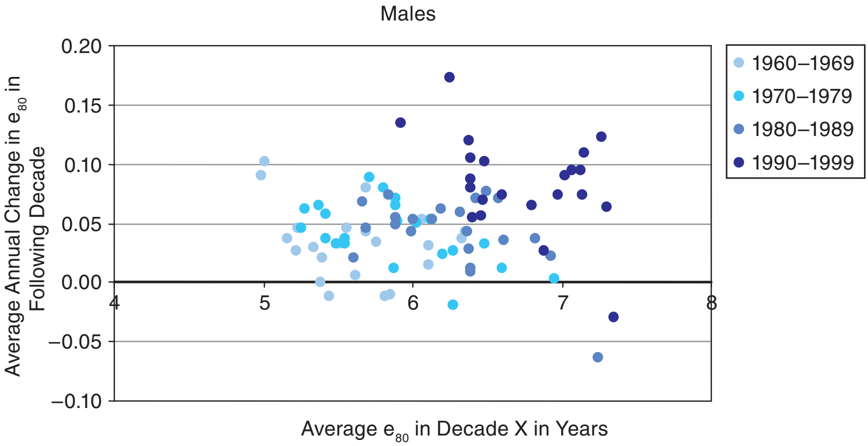

FIGURE 10-1b Male average life expectancy at age 80 (e_{80}) plotted against average annual future change in e_{80} the following decade (R^2 = 0.01) for selected countries.
SOURCE: Data from the Human Mortality Database, see http://www.mortality.org/ [accessed January 12, 2011].

POLICY AND RESEARCH IMPLICATIONS

The question of why U.S. longevity has fallen behind that of many other wealthy countries has proven productive in stimulating research on population health (see the background papers in National Research Council, 2010). Such research is focused on the factors that drive health conditions in large aggregates, providing a valuable complement to studies of health hazards for individuals. The factors that differentiate nations on health measures must not only affect the health of individuals but also vary in their intensity across populations. Moreover, the factors that promote change in population health must themselves be changing. To be convincing, studies attributing variation in population health outcomes to particular health risks must be consistent in the presumed magnitude of risk across levels of aggregation, from individuals to nations.

While the panel believes it made progress in identifying some of the main factors that have been driving differences in life expectancy among wealthy countries, it also identified many research gaps. The main focus of the report has been on a limited set of potential explanations—obesity, physical activity, smoking, social contacts and integration, health care, hormone replacement therapy, and socioeconomic and geographic inequality—the factors that the panel identified initially as most promising. The panel addressed some other hypotheses, such as the role of alcohol, in part in its analysis of specific causes of death, but was unable to examine other possible explanations, such as the role of the nutritional content of the diet.[2]

With respect to the behavioral risk factors that were investigated, a reliable marker of the damage from smoking exists—mortality rates from lung cancer. No such clear-cut and widely available marker has been identified for obesity, physical inactivity, stress, a lack of social relations, or the other risks considered in this report. Evaluation of the importance of these risks is based primarily on observational studies that follow forward people with differing levels of exposure. These studies are subject to many biases, especially those associated with omitted variables, self-selection into categories, and reverse causation. Reverse causation is such a threat in the case of physical activity that it is not clear whether much can be learned about this factor from observational studies. In the case of obesity, observational studies of

[2]Dietary patterns have often been studied in relation to the mortality of older persons. Individual foods and nutrients, as well as particular dietary patterns, have been associated with mortality from all causes, coronary heart disease, cardiovascular diseases, and cancer (see, for example, Haveman-Nies et al., 2003; Huijbregts et al., 1997; Tourlouki et al., 2009; and Trichopoulou et al., 1995). Considerable attention has been focused on the potential role of a Mediterranean diet in longevity (see, for example, Knoops et al., 2004, and Trichopoulou et al., 2005). Three recent systematic reviews found that such a diet had beneficial effects on cardiovascular risk factors, the incidence of acute myocardial infarction, and cardiovascular mortality (Pérez-López et al., 2009; Roman et al., 2008; Tyrovolas and Panagiotakos, 2010).

risk have left a great deal of uncertainty about the magnitude of the risk, which is important in attributing cross-sectional variation to obesity. Yet in view of the rapid increase in the population at risk, knowledge of the hazards of obesity may be especially important for projecting mortality trends in the United States.

A needed improvement in observational studies is the introduction of more information on individual histories, both prospective and retrospective. Studies that relate mortality and health only to levels of exposure at baseline miss the impact of exposures earlier in life, which are typically correlated with current exposure but may carry their own set of risks. Failure to update exposure categories *after* baseline is a form of measurement error and biases the estimated hazard associated with a particular risk factor (Stringhini et al., 2010; Taylor et al., 2002).

In addition to improvements in observational studies, more studies are needed that randomly assign individuals to exposure categories, although in reality there are limited ethical opportunities to use randomized controlled trials to study the questions at issue here. Yet while it is sometimes difficult, expensive, and ethically challenging to alter individual behavior, there is no perfect substitute for such trials. Where such studies are possible, they largely overcome the problem of omitted variables and reverse causation that plague observational studies. Studies that take advantage of natural experiments, such as increased cigarette taxes, changes in the use of hormone therapy, or the introduction of health care reform, can sometimes serve as valuable supplements to randomized controlled trials.

In addition to studying individual behavioral risks, this study has examined the role of broader, systemic factors, including health care systems, levels of inequality, and the quality of social relations. Such variables and conditions are more difficult to study than individual behavioral risks. If there existed a "score" for each nation on a particular factor, one could study the association between that score and national outcomes. Such an approach would be unlikely to yield important results with a sample of 10 countries, however, a condition the panel imposed for this study, or even with a sample size of 20. Moreover, no single score exists for any of these factors, which are complex concepts that defy simple characterization.

The panel's approach to investigating these factors was eclectic. Indicators of their importance were sought in a variety of places. In the case of medical systems, the panel relied on reasonably complete and reliable international data on cancer screening, identification, and survival. However, there is nothing remotely equivalent to the cancer registries for cardiovascular disease, a more important cause of death. The incidence, prevalence, and case fatality outcomes of heart disease and stroke are not being tracked in national data systems, representing a major gap in those systems. With regard to inequality, the panel investigated how U.S. mortality fared for different socioeconomic and geographic strata. But with so few national observations, it was impossible to investigate how national levels of inequality may have affected the health of all groups, which remains a challenging and important topic.

To make the study tractable, the panel focused on only one part of the life course—age 50 and above. According to the latest life table published by the National Center for Health Statistics, 92.6 percent of males and 95.8 percent of females in the United States survive to at least age 50 (Arias, 2010). Doubtless focusing on a different dependent variable would have resulted in certain underlying factors being emphasized more heavily. For example, smoking and obesity play a relatively small role in explaining the poor ranking of U.S. mortality in the age interval 40–65 (Ho and Preston, 2010; Muennig and Glied, 2010). Life expectancy at birth or age 50 gives weight to the conditions that prevail at a much wider span of ages.

In addition, the panel acknowledges that this report addresses only minimally differentials before age 50 that may have implications for later life, which could range from differentials *in utero* to those in middle age. Observational studies have found associations between early-life nutrition and the risk of adult chronic disease, for example. Likewise, Barker (1998) has assembled evidence showing that intrauterine growth retardation, low birth weight, and premature birth have a causal relationship with the origins of hypertension, coronary heart disease, and noninsulin-dependent diabetes in later life. To the extent that early-life conditions varied across countries 70–80 years ago, then, early-life metabolic adaptations may be associated with differential prevalence of a number of chronic conditions later in life. Thus further study of cohorts exposed to harsh conditions at early-life stages might provide valuable insights as to the early-life factors that affect later-life health and mortality. Indeed, effects on a population's longevity may be transgenerational and even precede fetal development (Bygren et al., 2001; Gluckman et al., 2008; Kaati et al., 2002).

More generally, a key limitation of this study is that its approach is based on exploring individual risk factors, one at a time. Much work remains to be done on disentangling the possible synergies and connections among different risk factors as they play themselves out at the population level. Limited progress toward a fuller understanding of the practical or policy implications of the findings presented in this report can be expected without a clearer understanding of both the theoretical and empirical associations among the various pathways of influence.

The panel concluded that a history of heavy smoking and current levels of obesity are playing a substantial role in the poor longevity performance of the United States. This conclusion poses major issues for the nation. Such behaviors, while carried out individually, are products of a broad social and economic context encompassing, for example, a level of affluence that supports large numbers of automobiles, low taxes on gasoline, and dispersed residences and workplaces that encourage driving; a climate and soil in part of the country that are conducive to growing tobacco; and a productive agricultural sector that produces inexpensive foods. From a cross-national perspective, the United States is often noted for high income inequality and weak social safety nets, labor policies, and child support policies.

Some of the relevant context is political. The panel undertook no analysis of the cost-effectiveness of public interventions designed to change personal health-related behaviors; therefore, recommendations as to what might be undertaken in this regard are not appropriate. It is clear, however, that failures to prevent unhealthy behaviors are costing Americans years of life compared with their counterparts in other wealthy countries.

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Biographical Sketches of Committee Members and Staff

Eileen M. Crimmins (*Cochair*) is AARP chair in gerontology and professor of gerontology and sociology at the University of Southern California. She is also director of the USC/UCLA Center on Biodemography and Population Health. Her research is on health trends, health change with age, healthy life expectancy, and health differences in the population. She also works on how social, psychological, and biological factors affect health. Dr. Crimmins is a coprincipal investigator on the Health and Retirement Survey. She has served on a number of National Institute of Aging Monitoring committees and on the Board of Counselors of the National Center for Health Statistics. She has a Ph.D. in demography from the University of Pennsylvania.

Samuel H. Preston (*Cochair*) is Fredrick J. Warren professor of demography, School of Arts and Sciences, University of Pennsylvania. He has been a member of the sociology department since 1979. His research focuses on the causes and consequences of population change, with special attention to mortality. He is a member of the National Academy of Sciences and Institute of Medicine, as well as the American Philosophical Society. He is a fellow of the American Academy of Arts and Sciences, the American Association for the Advancement of Science, and the American Statistical Association. He holds a Ph.D. in economics from Princeton University.

James Banks is professor of economics at the University of Manchester and deputy research director of the Institute for Fiscal Studies, where he also directs the Centre for Economic Research on Ageing. His research focuses on empirical modeling of individual economic behavior over the life cycle, with particular focus on consumption and spending patterns, saving and asset accumulation, housing dynamics, and retirement and pension choices. Recent work has also begun to look at broader issues in the economics of aging such as health, physical and cognitive functioning and their association with labor market status; the dynamics of work disability; and the nature of expectations of retirement, health, and longevity. He is also coprincipal investigator of the English Longitudinal Study of Ageing and has become actively involved in designing economic measures for survey data. He holds a Ph.D. in economics from University College London.

Lisa F. Berkman is director, Harvard Center for Population and Development Studies and Thomas D. Cabot professor of public policy, epidemiology and population and international health within the Harvard School of Public Health. She is a social epidemiologist whose work is oriented toward understanding social inequalities in health and aging related to socioeconomic status, social networks, support, and social isolation. She has recently started research on labor issues related to job design and flexibility. The majority of her work is devoted to identifying the role of social networks and support in predicting declines in physical and cognitive functioning, onset of disease, and mortality, especially related to cardiovascular or cerebrovascular disease. She has a Ph.D. in epidemiology from the University of California, Berkeley.

Barney Cohen (*Study Director*) is director of the Committee on Population of the National Academies/National Research Council (NRC). His work at the NRC has encompassed a wide variety of domestic and international projects, including studies on fertility, morbidity, mortality, housing, urbanization, migration, aging, and HIV/AIDS. Currently, he is also serving as the liaison of the National Academies to the Academy of Science of South Africa and the Ghanaian Academy of Arts and Sciences as part of a larger project aimed at supporting the development of academies of science in Africa. Dr. Cohen holds an M.A. in economics from the University of Delaware and a Ph.D. in demography from the University of California, Berkeley.

Dana A. Glei is a senior research investigator at Georgetown University. Since 2001, she has worked on the Social Environment and Biomarkers of Aging Study (Taiwan). During 2001–2009, she also served as project coordinator for the Human Mortality Database project (http://www.mortality.org), a joint collaboration between researchers at the University of California, Berkeley, and the Max Planck Institute for Demographic Research. Her current research focuses on the effects of smoking on mortality and sex differences in mortality, the impact of stressors on subsequent health, and the role of bioindicators in mediating the relationship between psychosocial factors and health outcomes. She has an M.A. in sociology from the University of Virginia and a Ph.D. in sociology from Princeton University.

Noreen Goldman is the Hughes-Rogers professor of demography and public affairs at the Woodrow Wilson School, Princeton University. She conducts research in areas of demography and epidemiology, and her current research examines the role of social and economic factors on adult health and the physiological pathways through which these factors operate. She has designed several large-scale health surveys in Latin America and Taiwan. She has been a fellow at the Center for Advanced Study in the Behavioral Sciences, served on the Institute of Medicine's Board on Global Health, the National Research Council's Committee on National Statistics, and the Population Research Subcommittee of the National Institute of Child Health and Human Development. She has a D.Sc. in population studies from Harvard University.

Alan D. Lopez is professor of global health and head of the School of Population Health at the University of Queensland, Australia. He is also an affiliate professor of global health at the University of Washington, Institute for Health Metrics and Evaluation. Prior to joining the University of Queensland he worked for 22 years at the World Health Organization in Geneva, where he held a series of technical and senior managerial posts, including director of the Epidemiology and Burden of Disease Unit (1999–2001), and senior science adviser to the Director General (2002). His principal research interests are analysis of mortality data; burden of disease methods and applications; and quantification of the health effects of tobacco. He has published widely on mortality analysis and causes of death, including the impact of the global tobacco epidemic, and on the global descriptive epidemiology of major diseases, injuries, and risk factors. He is the coauthor of the seminal Global Burden of Disease Study (1996), which has greatly influenced debates about priority setting and resource allocation in health. He is an honorary fellow of the Australian Faculty of Public Health Medicine and a foreign associate member (one of only four Australians) of the Institute of Medicine. He has an M.S. from Purdue University and a Ph.D. in epidemiology from the Australian National University, Canberra.

Johan P. Mackenbach is chair of the Department of Public Health and professor of public health at Erasmus University in Rotterdam, the Netherlands. He is also a registered epidemiologist and public health physician. His research interests include social epidemiology, medical demography, and health services research. He has coauthored around 350 papers in international, peer-reviewed scientific journals, as well as a number of books, and many book chapters and papers in Dutch-language journals. He is the editor-in-chief of the *European Journal of Public Health* and has co-ordinated a number of international-comparative studies funded by the European Commission. His current research focuses on socioeconomic inequalities in health, on issues related to aging and compression of morbidity, and on the effectiveness and quality of health services. He is actively engaged in exchanges between research and policy, among others as a member of several government advisory councils in the Netherlands (the Health Council, and the Council for Public Health and Health Care). He is a member of the Dutch Royal Academy of Sciences. He has an M.D. and Ph.D. in public health from Erasmus University.

Michael G. Marmot is director of the International Institute for Society and Health, and MRC research professor of epidemiology and public health, University College London. He has led a research group on health inequalities for the past 30 years. He is principal investigator of the Whitehall Studies of British civil servants, investigating explanations for the striking inverse social gradient in morbidity and mortality. He leads the English Longitudinal Study of Ageing and is engaged in several international research efforts on the social determinants of health. He chairs the Department of Health Scientific Reference Group on tackling health inequalities. He was a member of the Royal Commission on Environmental Pollution for 6 years. He is a fellow of the Academy of Medical Sciences and an honorary fellow of the British Academy. In 2000, he was knighted by Her Majesty The Queen for services to epidemiology and understanding health inequalities. Internationally acclaimed, Professor Marmot was a vice president of the Academia Europaea and is a foreign associate member of the Institute of Medicine. He was chair of the Commission on Social Determinants of Health set up by the World Health Organization (WHO) in 2005: Closing the Gap in a Generation. Professor Marmot won the Balzan Prize for epidemiology in 2004, gave the Harveian Oration in 2006, and won the William B. Graham Prize for Health Services Research in 2008. At the request of the British Government, he conducted a review of health inequalities, which published its report *Fair Society, Healthy Lives* in February 2010. He has now been invited by the regional director of WHO Euro to conduct a European review of health inequalities. Professor Marmot will be president of the British Medical Association 2010–2011. He graduated in medicine from the University of Sydney. He has an M.P.H. and Ph.D. in epidemiology from the University of California, Berkeley.

David Mechanic is René Dubos university professor of behavioral sciences and director of the Institute for Health, Health Care Policy, and Aging Research at Rutgers University. He was formerly dean of the Faculty of

Arts and Sciences, and established the Rutgers Institute for Health, Health Care Policy, and Aging Research. He also serves as the director of The Robert Wood Johnson Foundation Investigator Awards Program in Health Policy Research. A member of the National Academy of Sciences (NAS), the American Academy of Arts and Sciences, and the Institute of Medicine, he has served on numerous panels of the NAS, federal agencies, and non-profit organizations. He has received many awards, including the Bernard and Rhoda Sarnat International Prize in Mental Health and the Adam Yarmolinsky Medal from the Institute of Medicine, the Distinguished Investigator Award from AcademyHealth, and the First Carl Taube Award for Distinguished Contributions to Mental Health Services Research and the Rema LaPouse Award from the American Public Health Association. He has written or edited 24 books and approximately 400 research articles, chapters, and other publications. His research and writing deal with social aspects of health and health care. He received his Ph.D. in sociology from Stanford University.

Christopher J.L. Murray, is the director of the Institute for Health Metrics and Evaluation (IHME) and professor of global health at the University of Washington. A physician and health economist, his work has led to the development of a range of new methods and empirical studies to strengthen the basis for population health measurement, measure the performance of public health and medical care systems, and assess the cost-effectiveness of health technologies. IHME is focused on the challenges of measurement and evaluation in the areas of health outcomes, health services, financial and human resources, evaluations of policies, programs, and systems, and decision analytics. Dr. Murray's early work focused on tuberculosis control and the development with Dr. Alan Lopez of the Global Burden of Disease methods and applications. Dr. Murray has authored or edited 14 books, many book chapters, and more than 130 journal articles in internationally peer-reviewed publications. He holds B.A and B.S. degrees from Harvard University, a D.Phil. from Oxford University, and a medical degree from Harvard Medical School.

James P. Smith holds the RAND chair in labor markets and demographic studies and was the director of RAND's Labor and Population Studies Program from 1977–1994. He has led numerous projects, including studies of immigration, the economics of aging, black-white wages and employment, wealth accumulation and savings behavior, the relation of health and economic status, the impact of the Asian economic crisis, and the causes and consequences of economic growth. Dr. Smith has worked extensively in Europe and Asia for 30 years. He currently serves as chair on the National Institute of Aging Data Monitoring Committee for the Health and Retirement Survey and was chair of the National Science Foundation Advisory Committee for the Panel Study of Income Dynamics. He has served as an international advisor on implementing health and retirement surveys in England, continental Europe, China, Korea, and Thailand. Dr. Smith was the public representative appointed by the Governor on the California OSHA Board. He has twice received the National Institutes of Health (NIH) MERIT Award, the most distinguished honor NIH grants to a researcher and is listed in Who's Who in America and Who's Who in Economics. He has a Ph.D. in economics from University of Chicago.

Jacques Vallin is emeritus research director at the Institut National d'Études Démographiques. His research interests include health transition, inequalities in death, causes of death, life expectancy and life span, population and development, consequences of global population growth, and population of the Maghreb. He is a coeditor of *Demography Analysis and Synthesis*, a four-volume treatise of demography recently published by Academic Press. He taught postgraduate courses at the Institut d'Études Politiques de Paris. He is honorary president of the International Union for the Scientific Study of Population, and he is also member of the Population Association of America, the European Association for Population Studies, and the Union for African Population Studies. He has a Ph.D. in demography from the University of Paris.

James W. Vaupel is the founding director of the Max Planck Institute for Demographic Research in Rostock, Germany, as well as being director of Duke University's Population Research Institute. He oversees research projects in Germany, Denmark, the United States, Italy, Russia, Mexico, Japan, and China. He is best known for his research on mortality, morbidity, population aging, and biodemography (for which he received the Irene Taeuber Award from the Population Association of America), as well as for research on population heterogeneity, population surfaces, and other aspects of mathematical and statistical demography (for which he received the Mindel Sheps Award from the Population Association of America). He is a member of the National Academy of Sciences and the Max Planck Society for the Advancement of Science as well as being a fellow of the American Academy of Arts and Sciences. He has a B.A. in mathematical statistics (with highest honors) and a M.P.P. and Ph.D. in public policy analysis from Harvard University.

John R. Wilmoth is associate professor, department of demography, and researcher, Center on the Economics and Demography of Aging, University of California, Berkeley. In 2009–2010, he was a consultant to the World Health Organization to develop the United Nations' maternal mortality estimates.

Prior to this he worked for the Population Division of the United Nations in New York City (2005–2007). His research interests include: causes of the historical mortality decline, future trends in human mortality and life expectancy at birth, exceptional longevity and possible limits to the human life span, and mortality differentials among social groups within populations. He is a member of the American Association for the Advancement of Science, the Population Association of America, and the Gerontological Society of America. He serves on the editorial boards of several journals including *Demographic Research* and *European Journal of Population*. He has a Ph.D. in statistics and demography from Princeton University.