



**Key Points**

- The United States experienced an unprecedented decline in mortality during the twentieth century, thanks to improvements in public health, medical advances, and behavioral changes.
- But mortality and life expectancy improvements have been uneven across age and socioeconomic status.
- Future changes in mortality will affect the federal budget outlook. However, projections of mortality and life expectancy are highly uncertain. This uncertainty creates additional risk for the nation’s transfer programs to the elderly, which already account for half of government outlays.

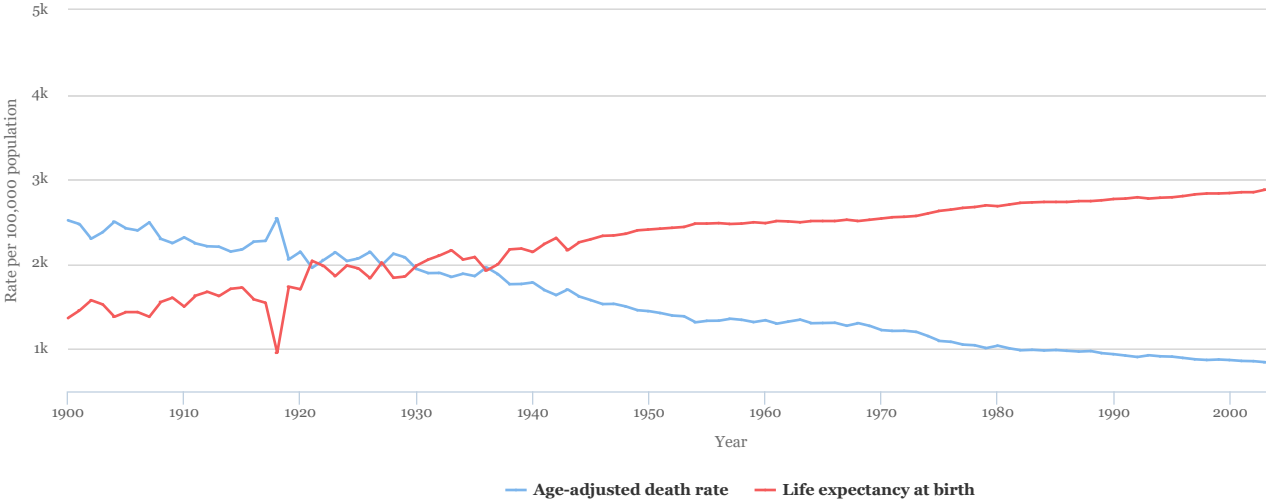
## Mortality in the United States: Past, Present, and Future

### Introduction

The United States has enjoyed more than a century of nearly uninterrupted declines in mortality and rising longevity. In 1900, one in 40 Americans died annually. By 2013, that rate was roughly one in 140, a cumulative improvement of more than two thirds.<sup>1</sup> As shown in Figure 1, life expectancy at birth rose by more than 30 years over this period, from 47 to 79.

While the overall pace of mortality decline has been fairly steady, its causes have varied over time. In the early part of the twentieth century, public health measures and improved nutrition led to rapid reductions in mortality caused by infectious diseases. As a result, cardiovascular disease and cancer accounted for nearly three quarters of all deaths by 1950. Beginning in the 1960s medical advances and changes in people’s behavior turned the tide on these diseases, and mortality improvements since then have been driven primarily by better treatment and disease management.

Figure 1 : U.S. Mortality and Life Expectancy, 1900–2013



Death rate is age-adjusted to the 2000 Census population age distribution.

Source: Centers for Disease Control/National Center for Health Statistics.

Despite the steady decline in overall mortality, differences persist between demographic and socioeconomic groups. Women live longer than men, while whites and Hispanics live longer than blacks. But the largest disparities in life expectancy reflect differences in educational attainment: On average, individuals with a college or advanced degree live more than 10 years longer than those without a high school degree. Moreover, while gaps in life expectancy between men and women and between racial groups have narrowed in recent decades, differences by educational attainment have grown larger.

Although rising life expectancy is clearly beneficial to individuals, it has led to higher costs for federal programs such as Social Security and Medicare. Increases in longevity raise both the number of individuals collecting federal retirement benefits and the length of time during which they receive those benefits. Consequently, the outlook for mortality is a key input into federal budget projections. While most forecasters expect mortality to continue declining at roughly the pace observed in recent decades, the Social Security Trustees project a substantial slowdown in the rate of improvement. This more pessimistic outlook for life expectancy results in a significantly more optimistic view of Social Security's finances.

**Epidemiological Drivers of Declining Mortality, 1900-2013**

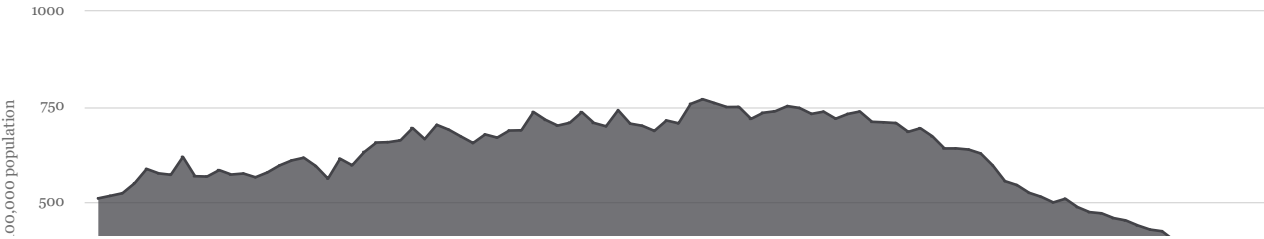
The United States experienced an unprecedented decline in mortality during the twentieth century. Life expectancy at birth rose by more than 30 years between 1900 and 2013 as the overall death rate fell at a relatively constant rate of about 1 percent per year. But the stability of this overall trend masks dramatic changes in the underlying causes of mortality.

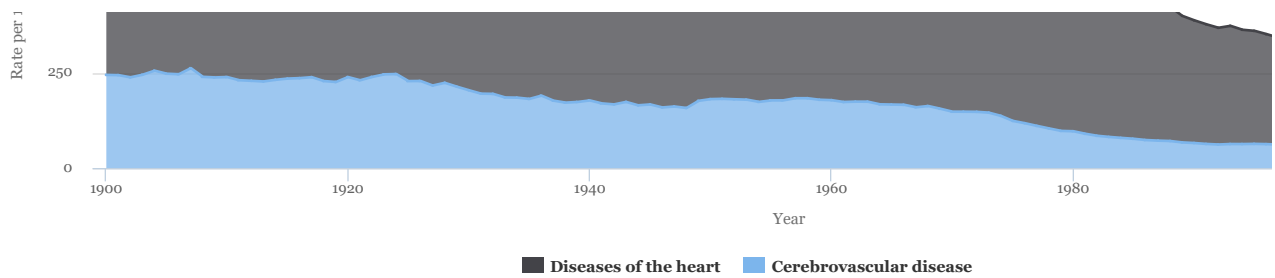
At the start of the twentieth century, infectious diseases were the leading cause of mortality, accounting for nearly a third of all deaths. Rapid urbanization and increasing population density during the preceding decades created ideal conditions for the spread of bacteria, leading to high rates of mortality from tuberculosis, influenza, and waterborne diseases. Over the first few decades of the 1900s, public health measures, improved nutrition, and new medical technologies dramatically reduced the number of deaths from infectious disease. This decline was initially driven by urban sanitation measures such as the introduction of water filtration and chlorination systems in major cities, as well increased resistance to infection from better nutrition. Following the development of antibiotics in the mid-1930s, the rate of improvement accelerated sharply.<sup>2</sup> Altogether, the death rate from infectious disease fell by 90 percent from 1900 to 1950, accounting for nearly two thirds of the overall reduction in mortality during that period.

As deaths from infectious diseases declined in importance, chronic diseases emerged as the leading killers. Driven in part by the steady rise in smoking rates, mortality from cardiovascular disease and cancer rose more than 50 percent from 1900 to 1950, together accounting for more than three quarters of all deaths by the middle of the century.

Cardiovascular mortality peaked in 1950 and began to decline rapidly by the mid-1960s, falling roughly by half from 1960 to 1990 (Figure 2). Medical advances during this period produced more effective treatments for cardiovascular disease and especially for acute heart disease, including specialized coronary care units, new pharmaceuticals, and advanced surgical procedures such as bypass surgery and angioplasty. A more active approach to prevention and disease management, as well behavioral changes such as reduced smoking rates and improved diet, further reduced the likelihood of severe heart disease and the associated mortality risk. Aggregate mortality fell by one-third from 1950 to 1990, with nearly all of that decline attributable to cardiovascular diseases and more than half to heart disease alone.

Figure 2: Mortality from Major Cardiovascular Diseases (Rate per 100,000 Population)





Death rate is age-adjusted to the 2000 Census population age distribution.

Source: Centers for Disease Control/National Center for Health Statistics.

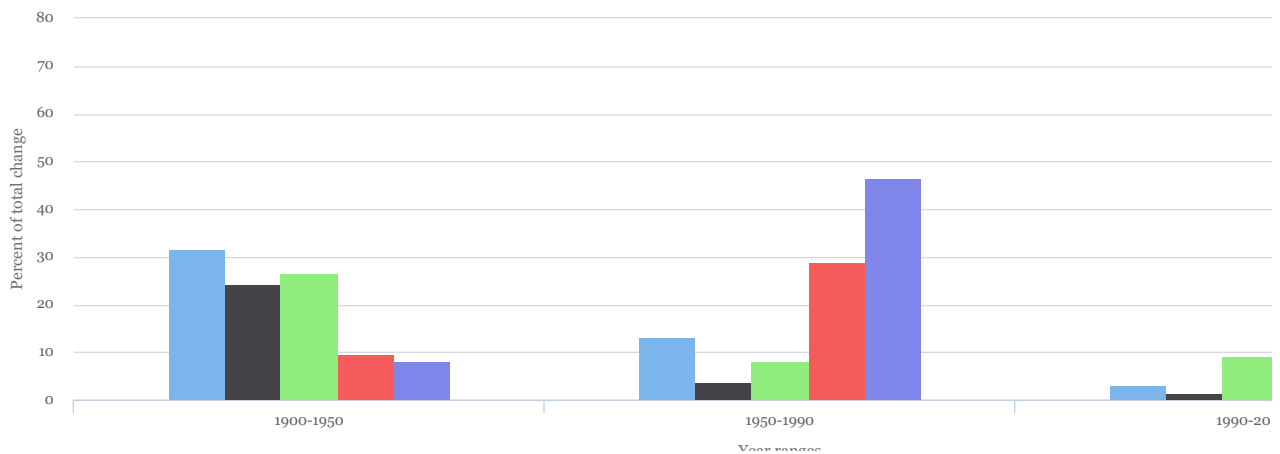
While cancer deaths continued to rise at a gradual pace throughout this period, mortality from cancers peaked in 1990 and then began to fall steadily. Some of this decline is attributable to the reduced prevalence of smoking, and many credit this trend to successful public health campaigns and the imposition of tobacco control.<sup>3</sup> However, medical innovation likely played a greater role, as declines in mortality from specific types of cancer were systematically related to the quality of pharmaceuticals, imaging technology, and surgical procedures used in the treatment of that particular cancer. By one estimate, new drug treatments and medical technologies explain more than three quarters of the decline in cancer deaths since 2000.<sup>4</sup>

### The Distribution of Gains in Mortality

#### Age

As the epidemiological drivers of declining mortality have shifted over time, so too has the age distribution of mortality. During the early part of the 20th century, mortality was concentrated among the young. Infants and children — who are especially vulnerable to infectious diseases because of their developing immune systems — accounted for nearly half of all deaths in 1900, while those over 65 accounted for fewer than one fifth. As infectious disease mortality declined and deaths from cardiovascular disease and cancer rose over the course of the century, the age distribution of mortality shifted dramatically: By 2013, the infant and child share of deaths was around 1 percent, while the elderly share was nearly three quarters.

Figure 3: Age Distribution of the Decline in Mortality (Percent of Total Change)



■ Infants (< 1) ■ Children (1-14) ■ Young adults (15-44) ■ Older adults (45-64) ■ Elderly (65+)

Death rates are age-adjusted to the Census population age distribution in the first year of each period.

Source: Centers for Disease Control/National Center for Health Statistics.

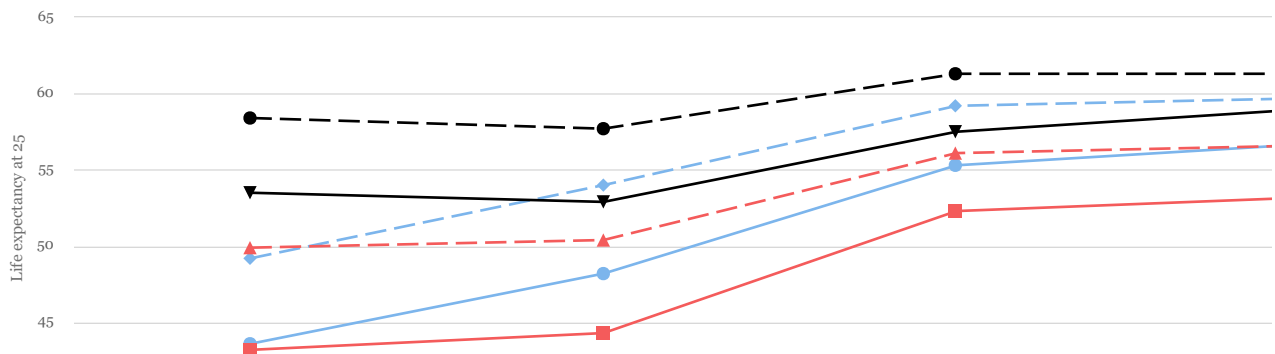
Figure 3 shows the contributions of various age groups to the decline in mortality since 1900. In the first half of the 20th century, the fall in the overall death rate was driven by the young. Infants under a year old, the population most vulnerable to infectious diseases, alone accounted for one third of the decline. By the 1950s, cardiovascular disease was the dominant cause of death and mortality was concentrated among older adults and the elderly. As effective treatments for stroke and heart disease became widespread over the next several decades, declines in adult and elderly mortality accelerated. These groups accounted for three quarters of the total fall in mortality from 1950 to 1990. Since 1990, the concentration of mortality reduction at the upper end of the age distribution has become even more pronounced, as the apparent conquest of cardiovascular disease and the reversal of the rising trend in cancer deaths primarily benefitted the elderly. More than two thirds of the decline in mortality over the last two decades resulted from fewer deaths among those over 65 years of age.

*Socioeconomic Status*

Despite substantial gains in overall mortality and life expectancy, disparities persist between demographic and socioeconomic groups. In 2012, life expectancy at birth for non-Hispanic whites was 78.8 years, compared with 75.5 years for non-Hispanic blacks. Hispanics had the highest life expectancy, at 81.6 years.<sup>5</sup> Within racial groups, women tend to live longer than men: On average, women’s life expectancy exceeds that of men of the same race by about five years, with a somewhat larger difference between black women and black men.

However, the most significant driver of disparities in mortality is education, a principal component of socioeconomic status.<sup>6</sup> As shown in Figure 4, differences in life expectancy by educational attainment dominate differences by race or gender.<sup>7</sup> For instance, the life expectancy gap between the most and least educated black males in 2008 was 10 years, while the largest difference between whites and blacks with the same level of education was four years.<sup>8</sup> Moreover, even as differences in life expectancy by race and gender have narrowed over the past few decades, disparities by education have widened. Among whites, the difference in life expectancy between the most and least educated rose by more than eight years from 1990 to 2008; among blacks, the difference rose by about four years.<sup>9</sup>

Figure 4: Life Expectancy at Age 25 by Sex, Race, and Years of Completed Education, 2008





"White" and "Black" refer to the non-Hispanic population.

Source: S. Jay Olshansky, Toni Antonucci, Lisa Berkman, et al., "Differences In Life Expectancy Due To Race And Educational Differences Are Widening, And Many May Not Catch Up," *Health Affairs*, 31:8, pp. 1803-13.

The relationship between mortality and educational attainment is not well understood. One possible explanation is that better educated (and usually wealthier) individuals have access to better medical care. This account appears particularly plausible for the U.S., where a large share of the population has historically lacked health insurance and many of those with low socioeconomic status have little access to health care of any quality.

However, differential access to health care does not provide a complete explanation for these gaps in life expectancy. Evidence from the introduction of Medicare in the U.S. suggests that access to health care has only minor effects on the mortality of the elderly and the incidence of many health conditions is higher among the less-educated, suggesting that inequalities exist before the health care system becomes involved.<sup>10</sup> Moreover, international experience is not consistent with the view that health care access is key. For instance, both Canada and the United Kingdom provide universal health insurance and equal access to care, but mortality disparities have risen in the U.K and fallen in Canada.<sup>11</sup>

Alternatively, differences in health related behaviors may explain the gap. Individuals with higher education are substantially less likely to smoke, and that difference has been growing over time. In addition, the rapid rise in obesity in recent decades has been concentrated among the less-educated. Yet while these factors explain some of the gap in life expectancy, differences in mortality persist even after they are taken into account.<sup>12</sup>

Another possibility is greater use of preventative care and better adherence to treatment regimes and therapies among the better-educated.<sup>13</sup> Self-management of disease has likely grown more important over time, as it matters most for the chronic illnesses that cause many deaths today. Better education may also provide general human capital that allows more knowledgeable individuals to improve their overall health. For example, the better-educated are more likely to make use of newer and higher quality medical technologies.<sup>14</sup>

### Projections of Mortality

Nearly half of all federal outlays are for transfer programs to retirees, primarily Social Security and Medicare. Because these programs guarantee benefits until death, declining rates of mortality mean more beneficiaries collecting benefits for longer. Future changes in mortality and life expectancy are therefore an important determinant of these programs' costs and the overall budgetary outlook.

Forecasts of mortality are highly uncertain. As discussed above, recent gains in mortality have largely been driven by medical advances, but the development of new drugs, devices, or treatments cannot easily be predicted. In addition, projections of mortality must contend with a more fundamental uncertainty: Is there a biological limit on the human lifespan, and if so, are we approaching it?

As a result of this uncertainty, most forecasters base their projections of mortality on extrapolation of past trends. While the historical stability of the overall rate mortality reduction supports this approach, past declines were driven by idiosyncratic trends in the underlying causes of death, and those trends have not been stable over time. As a result, trends in mortality within particular age groups have changed considerably since the early twentieth century: While the rate of improvement has slowed for the young, it has accelerated for the elderly. This suggests that the historical stability of the overall rate of decline may be a coincidence rather than an intrinsic trend.

**Table 1. Projections of Mortality Decline and Life Expectancy at Birth<sup>15</sup>**

	Average annual rate of mortality decline	Life expectancy at birth	
		2060	2090
2015 Social Security Trustees Report	0.8	83.7	85.9
2015 Technical Panel on Assumptions and Methods	1.0	-	88.3
2011 Technical Panel on Assumptions and Methods*	1.3	85.8	88.7
Congressional Budget Office (2014)	1.2	85.2	-
Census Bureau (2014)	-	85.6	-
Bongaarts (2006), extended	-	85.8	-
Lee and Carter (1992)	-	85.5	-

Death rates are age-adjusted to the 2010 Census population age distribution.

\*Value for life expectancy in 2090 is for 2086.

- = not available.

Table 1 presents several projections of the rate of mortality decline and life expectancy at birth. Consistent with historical experience, most forecasters expect mortality to fall by 1 percent or more per year and life expectancy at birth to rise to more than 85 years by 2060. The Social Security Trustees are a notable exception, projecting a slower decline in mortality resulting in a life expectancy in 2060 that is one to two years lower than other forecasters. This results in a more positive assessment of the Social Security system’s finances. Adopting a more optimistic view of future gains in life expectancy, the Congressional Budget Office projects a substantially larger shortfall in Social Security’s funding over the next several decades compared to the Trustees.<sup>16</sup>

**Conclusion**

The dramatic decline in mortality over the last century is one of the most striking features of recent U.S. (and world) history. Knowledge, science, and technology have propelled a steady extension of Americans’ lifespans and improvements in the quality of their lives even at older ages. Advances in the understanding of infectious diseases and investments in sanitation, water purification, and other public health improvements eliminated infectious disease as a major cause of death. Scientific innovations of new drugs, treatments, and medical devices together with improved health behaviors related to smoking, nutrition, and obesity further reduced mortality from cancer and cardiac diseases.

Nevertheless, not all Americans have shared equally in the benefits of health-enhancing knowledge and innovation. While differences in life expectancy by gender and race are narrowing, those with less education have fallen further behind. Differences in income and corresponding inequalities in access to health care may play some role in this divergence, but the evidence suggests that other factors are also important. Education exerts a direct effect on reducing mortality and morbidity through the adoption of healthier lifestyles, more effective management of chronic diseases, and more frequent and appropriate use of advanced treatment opportunities.

Looking forward, there is little reason to expect the development of life saving ideas and technologies to slow. While this is welcoming news for humanity, it also means higher costs for the federal government from two sources. Seniors will receive more expensive health

care benefits and they will collect all federal retiree benefits for longer periods. This uncertainty implies greater risk of substantial increases in federal elder-support expenditures and budget deficits.

1. Unless otherwise noted, mortality figures cited in this brief are age-adjusted to the 2000 Census population age distribution, meaning they reflect age-specific death rates weighted by each age group's population share in 2000. Age-adjustment is necessary to isolate changes in overall mortality that are attributable to changing death rates rather than changes in the age distribution of the population. Because older individuals are more likely to die, an aging population may experience an increase in overall mortality even if mortality rates are falling at every age. ↩
2. See: David M. Cutler and Grant Miller, "The Role of Public Health Improvements in Health Advances: The Twentieth-Century United States," *Demography* 42, no. 1 (February 2005): 1–22, available at: <http://www.jstor.org/stable/1515174>; Seema Jayachandran, Adriana Lleras-Muney, and Kimberly V. Smith, "Modern Medicine and the Twentieth Century Decline in Mortality: Evidence on the Impact of Sulfa Drugs," *American Economic Journal: Applied Economics* 2, no. 2 (April 2010): 118–146, available at: <http://www.jstor.org/stable/25760208>; and David M. Cutler and Ellen R. Meara, "Changes in the Age Distribution of Mortality over the 20th Century," NBER Working Paper No. 8556 (October 2001), available at: <http://www.nber.org/papers/w8556>. ↩
3. See Ahmedin Jemal et al., "Annual Report to the Nation on the Status of Cancer, 1975–2005, Featuring Trends in Lung Cancer, Tobacco Use, and Tobacco Control," *Journal of the National Cancer Institute* 100, no. 23 (December 2008): 1672–1694, available at: <http://doi.org/10.1093/jnci/djn389>; and Rebecca L. Siegel, Kimberly D. Miller, and Ahmedin Jemal, "Cancer statistics, 2015," *CA: A Cancer Journal for Clinicians* 65, no. 1 (January 2015): 5–29, available at: <http://dx.doi.org/10.3322/caac.21254>. ↩
4. See Frank R. Lichtenberg, "Has Medical Innovation Reduced Cancer Mortality?" NBER Working Paper No. 15880 (April 2010), available at: <http://www.nber.org/papers/w15880>. ↩
5. Caution is required when comparing Hispanic mortality rates to those of other racial groups because of well-known biases related to international migration. Healthier individuals may be more likely to migrate to the United States, and some immigrants return to their country of origin in old age or when their health deteriorates. Because of this "health selection," the life expectancy of U.S. Hispanics is likely biased upwards. Mortality among U.S.-born Hispanics is significantly higher than among Hispanic immigrants and the U.S.-born share of Hispanics is rising rapidly, suggesting the Hispanic advantage in life expectancy may dissipate over time. Values for some racial groups (Asians, Pacific Islanders, and Native Americans) are not discussed due to small sample sizes. ↩
6. See Adriana Lleras-Muney, "The Relationship Between Education and Adult Mortality in the U.S.," *Review of Economic Studies* 72, no. 1 (January 2005): 189–221, available at: <http://dx.doi.org/10.1111/0034-6527.00329>; David M. Cutler, Angus Deaton, and Adriana Lleras-Muney, "The Determinants of Mortality," *Journal of Economic Perspectives* 20, no. 3 (2006): 97–120, available at: <http://dx.doi.org/10.1257/jep.20.3.97>; and S. Jay Olshansky et al., "Differences In Life Expectancy Due To Race And Educational Differences Are Widening, And Many May Not Catch Up," *Health Affairs* 31, no. 8 (August 2010): 1803–1813, available at: <http://content.healthaffairs.org/content/31/8/1803.full.html>. ↩
7. The figure shows life expectancy at age 25, which is the expected number of years of remaining life conditional on having survived to age 25. Age 25 is selected because most individuals have completed their education by that age. ↩
8. Hispanics with 11 years of education or fewer are an exception to this pattern. Their life expectancy is roughly 10 years longer than similarly educated white and blacks, more than twice the size of the difference in life expectancy between the most and least educated Hispanics. See footnote 5 for an explanation of why the pattern differs among Hispanics. ↩
9. Again, Hispanics are an exception to this pattern, as the least educated saw the largest rise in life expectancy from 1990 to 2008. See footnote 5 for an explanation of this difference. ↩
10. Amy Finkelstein and Robin McKnight, "What Did Medicare Do (And Was It Worth It)?" NBER Working Paper No. 11609, September 2005, available at: <http://www.nber.org/papers/w11609>. ↩
11. Congressional Budget Office, "Growing Disparities in Life Expectancy," CBO Economic and Budget Issue Brief (April 2008): 4, available at: [http://www.cbo.gov/sites/default/files/cbofiles/ftpdocs/91xx/doc9104/04-17-lifeexpectancy\\_brief.pdf](http://www.cbo.gov/sites/default/files/cbofiles/ftpdocs/91xx/doc9104/04-17-lifeexpectancy_brief.pdf) ↩
12. Ellen R. Meara, Seth Richards, and David M. Cutler, "The Gap Gets Bigger: Changes in Mortality and Life Expectancy, by Education, 1981–2000," *Health Affairs* 27, no. 2 (March 2008): 350–360, available at:

<http://content.healthaffairs.org/content/27/2/350.full>. ↩

13. Dana P. Goldman and James P. Smith, "Can Patient Self-Management Help Explain the SES Health Gradient?" *Proceedings of the National Academy of Sciences* 99, no. 16 (August 2002): 10929–10934, available at: ["http://www.pnas.org/content/99/16/10929.full](http://www.pnas.org/content/99/16/10929.full). ↩
14. See Adriana Lleras-Muney and Frank R. Lichtenberg, "The Effect of Education on Medical Technology Adoption: Are the More Educated More Likely to Use New Drugs?" NBER Working Paper No. 9185 (September 2002), available at: <http://www.nber.org/papers/w9185>; and Sherry Glied and Adriana Lleras-Muney, "Technological Innovation and Inequality in Health," *Demography* 45, no. 3 (August 2008): 741–761, available at: <http://www.jstor.org/stable/25475999>. ↩
15. Source: Social Security Administration, "The 2015 Annual Report of the Board of Trustees of the Federal Old-Age and Survivors Insurance and Federal Disability Insurance Trust Funds," (July 2015): 82-84; Social Security Administration, 2015 Technical Panel on Assumptions and Methods, *Report to the Social Security Advisory Board*, (September 2015): 13-20; Social Security Administration, 2011 Technical Panel on Assumptions and Methods, *Report to the Social Security Advisory Board*, (September 2011): 55–64; Census Bureau, "Methodology and Assumptions for the 2014 National Projections," 2014; Congressional Budget Office, The 2014 Long-Term Budget Outlook, July 2014, Chapter 3; John Bongaarts, "How Long Will We Live?" *Population and Development Review* 32, no. 4 (December 2006): 605–628 (extended projection from: Congressional Budget Office, "Why CBO Changed Its Approach to Projecting Mortality," CBO Blog, September 24, 2013); and see Ronald D. Lee and Lawrence R. Carter, "Modeling and Forecasting U.S. Mortality," *Journal of the American Statistical Association* 87, no. 419 (September 1992): 659–671. ↩
16. See Congressional Budget Office, "The 2014 Long-Term Budget Outlook," June 2014, Chapter 3, available at: <https://www.cbo.gov/publication/45471>. ↩

**Media (only):** For the fastest response, email us at [inquiries-pwbm@wharton.upenn.edu](mailto:inquiries-pwbm@wharton.upenn.edu).

**All other responses:** Please use our Contact Us.

**Sign up for PWBM Breaking News, Alerts and Newsletter.** Unsubscribe anytime.