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Longevity Research: Unraveling the Determinants of Healthy Aging and Longer Life Spans

During the past century, life expectancy in most countries has increased rapidly with advances in public health and living standards, improved diet, and rising levels of education. In 1900, life expectancy in the United States was 47 years. By 2014, U.S. life expectancy had increased to 79 years, and those who reached age 65 could expect to live another 19 years. A growing number of older adults have "exceptional longevity"—typically defined as living to age 95 or 100 or older. Centenarians, or people age 100 or older, make up a small share of U.S. older adults, but their numbers are expected to increase rapidly in the coming decades as the large baby boom population ages (see Box 1, page 2).

The increase in life expectancy in the United States and elsewhere is a public health success story. However, people surviving into their 80s, 90s, and beyond also experience a higher risk of age-related health problems and disability. Scientists hope to slow the process of aging to extend people's lives and increase the number of years that they spend in good health and disability free, a period of life called "health span."

Most people know about the importance of eating a healthy diet, exercising, maintaining a healthy weight, and avoiding smoking to prevent disease and increase longevity. But researchers have identified many other factors—including genetics, social connections, early-life experiences, and even certain personality traits—that may affect life expectancy.

This report highlights recent work by National Institute on Aging (NIA)-supported researchers to answer two main questions: 1) What do we know about the key social, behavioral, and genetic determinants of longevity and

Highlights

- Older adults in their 90s who are resilient—who can adapt positively under adverse circumstances—have a much higher likelihood of living to 100 compared with peers who have lower levels of resilience.
- The oldest old (ages 95 and older) have more positive attitudes towards life and are more extroverted—and less neurotic (experience less general emotional distress)—than the overall U.S. population.
- The link between social connections and health is well-established: Older adults who are socially isolated face a risk of premature death that is on par with the health risks associated with smoking.
- Researchers estimate that between 15 percent and 25 percent of the overall variation in human longevity may be explained by genetic differences in the population.
- Men with the genetic variant known as FOXO3 have almost three times the odds of living to nearly 100 years of age than their peers without the genetic variant.
- On average, long-lived individuals have fewer chronic diseases, better mental health, and better physical and cognitive function than nonsurviving members of their age cohort.
- Among long-lived individuals, men tend to be healthier than women, whites healthier than nonwhites, and highly educated people tend to have better cognitive function than their less-educated peers.
- Among those ages 65 and older, researchers find that the increase in years spent without disability (disability-free life expectancy) outpaced the increase in disabled life over the past 40 years.
- The prevalence of activity limitations is increasing among adults ages 55 to 64, raising concerns that baby boomers will face more health challenges in old age compared with their parents' generation.

This publication summarizes research related to the objectives of the National Institute on Aging (NIA), with emphasis on work conducted at the NIA Centers on the Demography and Economics of Aging. Our objective is to provide decisionmakers in government, business, and nongovernmental organizations with up-to-date scientific evidence relevant to policy debates and program design. These newsletters can be accessed at www.prb.org/About/ProgramsProjects/Aging/TodaysResearchAging.aspx

healthy aging?; and 2) What are the implications of rising life expectancy for the health and well-being of older adults? A box at the end of this report (see Box 3, page 8) provides a link to a list of NIA-funded studies and surveys key to research on longevity.

This research is important not only to identify interventions that may improve individuals' health and function in old age, but also to reduce health disparities among different population subgroups.

Box 1

A Profile of U.S. Centenarians

In the United States, the number of centenarians, or people age 100 or older, has grown from around 32,000 in 1980 to more than 53,000 by 2010 (U.S. Census Bureau 2012). If life expectancy at older ages continues to increase, the Census Bureau projects that the number of U.S. centenarians could rise to more than 600,000 by 2060 (see figure). However, centenarians still represent an extremely small share of the total U.S. population—just a fraction of 1 percent (.017 percent).

Among U.S. centenarians, 92 percent were ages 100 to 104 in 2010. So-called super-centenarians—people ages 110 or older—are part of an elite demographic club. Just 330 super-centenarians were counted in the 2010 Decennial Census, making up 0.6 percent of the population ages 100 and older (U.S. Census Bureau 2012). However, it's likely that the Census Bureau overcounted the number of oldest Americans in previous censuses, raising questions about the accuracy of the data for 2010; the actual number of super-centenarians could be much lower than the number reported by the Census Bureau.

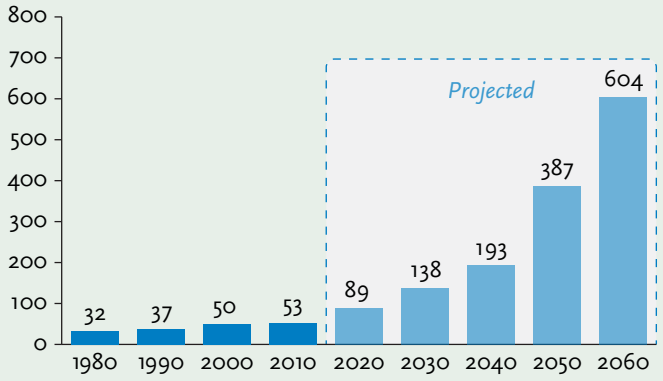
Wide disparities in life expectancy exist across different racial/ethnic groups in the United States, particularly between blacks and non-Hispanic whites. At age 50, white men may expect to live (on average) another 30 years and white women another 33 years. Life expectancy for black men and women at age 50 is considerably shorter, at 27 and 31 years, respectively (Xu et al. 2016). Levine and Crimmins (2014) examine biomarkers (such as blood pressure and blood tests for total cholesterol and C-reactive protein) and find that blacks are "biologically" three years older than whites at any specific chronological age, suggesting an accelerated aging process.

However, African Americans who survive to age 85 may expect to live slightly longer than whites of the same age, resulting in a relatively high proportion of centenarians who are African American. In 2010, the U.S. population ages 100 or older was 82 percent white (including Hispanics), 12 percent black, and 2 percent Asian American, with other groups making up the remaining 4 percent. About 6 percent of U.S. centenarians were Hispanic or Latino in 2010.

Women in the United States continue to live longer than men and made up 83 percent of the centenarian population in 2010. However, in the United States and many other developed countries, the gender gap in life expectancy is narrowing, resulting in an increase in the number of men, relative to women, surviving to old age. Globally, there are about four women age 100 or older for every man in that age group (He, Goodkind, and Kowal 2015).

Centenarians in the United States

Number (in thousands)



Source: U.S. Census Bureau, 2010 Census Special Reports, *Centenarians: 2010*; and U.S. Census Bureau, 2014 National Population Projections.

While the majority of U.S. older adults live at home, the percent who require nursing-home care increases with age. In 2010, about 35 percent of U.S. women ages 100 and older lived in nursing homes, compared with 19 percent of women in their 90s. Men are less likely to live in nursing homes than women; in 2010, about 11 percent of men in their 90s resided in nursing homes, compared with 18 percent of men age 100 or older. White, non-Hispanic centenarians are more likely to live alone than those in other racial/ethnic groups (U.S. Census Bureau 2012).

References

Wan He, Daniel Goodkind, and Paul Kowal, "An Aging World: 2015," *International Population Reports* P95/16-1 (Washington, DC: Government Printing Office, 2016).

Morgan Levine and Eileen Crimmins, "Evidence of Accelerated Aging Among African Americans and Its Implications for Mortality," *Social Science & Medicine* 118, no. 1 (2014): 27-32.

U.S. Census Bureau, "Centenarians: 2010," *2010 Census Special Reports* C2010SR-03 (Washington, DC: Government Printing Office, 2012)

U.S. Census Bureau, "2014 National Population Projections" (March 4, 2015), accessed at www.census.gov/population/projections/data/national/2014.html on Aug. 4, 2016.

Jiaquan Xu et al., "Deaths: Final Data for 2013," *National Vital Statistics Report* 64, no. 2 (2016): 1-119.

Behavioral and Psychological Factors Influencing Longevity

Numerous studies of longevity have focused on the role of genetics in postponing the onset of age-related diseases. But many social, psychological, and behavioral factors also contribute to differences in health and longevity. These factors tend to cumulate over time, resulting in disparities in life expectancy among older adults in different population subgroups.

Behavioral Factors

Certain unhealthy behaviors can cut people's lives short before they reach old age. In fact, up to half of premature deaths in the United States have been linked to behavioral factors and other preventable causes (National Research Council and Institute of Medicine 2015). Recent work by Case and Deaton (2015) highlight the role of substance abuse in rising mortality rates among middle-aged whites. And historical smoking patterns in the United States have contributed to lower life expectancy in the United States compared with Europe (National Research Council 2011), as well as differences in life expectancy across U.S. states (Fenelon and Preston 2012).

Although individual health behaviors, such as physical activity, diet, and substance abuse, are good candidates for policy intervention, they are often linked to broader socioeconomic disparities that are more difficult to address. For example, a recent report by the National Academies of Sciences (2015) shows that there are wide differences in life expectancy for people with different levels of income, and that this gap has increased over time (see Box 2). There are also wide gaps in life expectancy for people with different levels of education reflecting differences in environment, health-related behaviors, and access to health care; life expectancy at age 25 is about a decade shorter among high school dropouts compared with college graduates (National Center for Health Statistics 2012).

Along with genetics, many social, psychological, and behavioral factors contribute to differences in health and longevity.

From a policy standpoint, identifying which behaviors are most important for healthy aging and longevity can be challenging. Researchers have found that certain behaviors can have different effects on mortality in combination than they would have individually. Using data from the Health and Retirement Study (HRS), Shaw and Agahi (2012) find that

Box 2

Exploring Why Costa Rica Outperforms the United States in Life Expectancy

Rosero-Bixby and Dow (2016) find that the poorest Costa Ricans outperform the poorest U.S. residents in life expectancy, based on an analysis of census records and death registries from the 1990s for both countries. Their study shows the potential for substantially lowering mortality in other middle-income countries.

They find that the overall mortality rate in the United States is 18 percent higher than in Costa Rica among men ages 40 to 89, and 10 percent higher among women ages 40 to 64, despite the United States being a much wealthier country with greater spending on health and health care.

While the richest quartile of the U.S. population has a higher average life expectancy than the richest quartile in Costa Rica, the poorest socioeconomic quartile of the U.S. population has mortality rates significantly worse than Costa Rica's poorest quartile.

The researchers suggest that Costa Rica's overall mortality advantage can largely be explained by looking at lung cancer and heart disease mortality—both more prevalent in the United States. Their analysis shows that lung cancer mortality in the United States is four times higher among men and six times higher among women compared with Costa Rica. And mortality from heart disease is 54 percent higher for men and 12 percent higher for women in the United States. According to the researchers, these patterns may be partly explained by behavioral and medical risk factors—such as smoking, obesity, lack of health insurance, and uncontrolled dysglycemia (blood sugar) and hypertension—that are more common in the low-income population of the United States than among people in the equivalent socioeconomic position in Costa Rica.

Source: Jasmin M. Huynh, "Binational Study Explores Why Costa Rica Outperforms the United States in Life Expectancy," University of California, Berkeley, School of Public Health, accessed at http://sph.berkeley.edu/binational-study-explores-why-costa-rica-outperforms-united-states-life-expectancy, on July 7, 2016. Abbreviated version reprinted with permission.

References

Luis Rosero-Bixby and William H. Dow, "Exploring Why Costa Rica Outperforms the United States in Life Expectancy: A Tale of Two Inequality Gradients," *Proceedings of the National Academy of Sciences* 113, no. 5 (2016): 1130-7.

the risk of death related to smoking among those ages 51 and older is greatest when it is combined with heavy drinking. Lack of physical activity also increases the risk of death among older adults—but less so among smokers. Understanding these combined risks can help health professionals and others devise more appropriate treatments to improve health and increase longevity.

Daily intake of fruits and vegetables is associated with lower mortality.

Researchers have also investigated the role of diet and calorie restriction on longevity. Although results have been mixed, more than two decades of NIA-funded research on rhesus monkeys shows that reducing calories by 30 percent does not significantly increase longevity, although it does reduce rates of diabetes, arthritis, cancer, and heart disease among older adults (Mattison et al. 2012).

The type of food consumed by older adults also matters. Observational data from the Chinese Longitudinal Healthy Longevity Survey (CLHLS) show that daily intake of fruit and vegetables is associated with lower mortality among Chinese adults ages 80 and older, while frequent consumption of protein-rich foods such as meat, fish, beans, and eggs does not have the same protective effect (Shi et al. 2015).

Ruan and colleagues (2013) use CLHLS data to investigate whether tea consumption—primarily green tea—is linked to longevity among the oldest old in China. They find that higher frequency of tea consumption is associated with reduced mortality risk among the oldest old, after controlling for sociodemographic characteristics, self-reported health status, and health behaviors.

Levine and colleagues (2014) examine high-protein diets and mortality and find diet plays different roles at different ages. Among older adults ages 50 to 65, diets high in animal protein are associated with increased overall mortality and a four-fold cancer risk over the following 18 years. Diets high in plant proteins reduced or eliminated these risks for this age group. But among adults over age 65, they find that diets high in animal proteins are associated with a lower risk of death and cancer.

Diet also can interact with other factors to contribute to longevity. Rosero-Bixby, Dow, and Rehkopf (2013) studied men in Costa Rica's Nicoya region to explain their exceptionally high longevity. At age 60, Nicoya men are seven times more likely than Japanese men to reach 100 and have an average life expectancy that is 2.2 years higher. Their diets—centered on traditional foods such as rice, beans, and animal protein—tend to be low on the glycemic index and high in fiber. The researchers link Nicoya men's exceptional longevity to lower cardiovascular disease risk and find that it is unrelated to socioeconomic background. They also note that Nicoya men use more preventive health services and are taller, leaner, and have fewer physical or mental disabilities than other older Costa Rican males. Nicoya men who left the region did not did not live as long on average as those who stayed, suggesting that the region's environment plays a role.

Personality Traits and Psychological Factors

Personality traits and psychological factors can affect longevity by predisposing people to certain behaviors that are linked to health and survival. For example, conscientious, self-disciplined individuals are more likely to be physically active and eat healthy meals, and less likely to use alcohol, drugs, and cigarettes compared with people who are less disciplined (Hill et al. 2011). Using HRS data, Hill and colleagues find that conscientiousness also predicts better cognitive function in old age, an important aspect of healthy aging and longevity. And data from the CLHLS show that that older adults in their 90s who are resilient—who can adapt positively under adverse circumstances—have a 43 percent higher likelihood of living to age 100 compared with peers who have lower levels of resilience (Zeng and Shen 2010).

While some psychological factors can help protect people from health problems in old age, others—such as anger—are linked to increased risks of mortality, according to a recent study of older adults based on data from the Panel Study of Income Dynamics (Karraker, Schoeni, and Cornman 2015).

Findings on the effects of neuroticism (high emotional distress) on longevity have been consistent across several studies. The New England Centenarian Study (NECS) shows that the children of centenarians are less neurotic and more extroverted than the general population (Givens et al. 2009). A study of Ashkenazi Jewish adults ages 95 to 107 finds similar results: The oldest old have more positive attitudes towards life and are more extroverted—and less neurotic—than the general U.S. population (Kato et al. 2012). Data are from the Longevity Genes Project, a study of Jewish centenarians and their children.

A Life Course Perspective on Health and Longevity

While it is clear that people's behaviors and lifestyles affect their health and risk of mortality, these behaviors are shaped by earlier life experiences—especially their connections with family and friends. There is a well-established link between social connections and health. In fact, research has shown that those who are socially isolated face a risk of premature death that is on par with the health risks associated with smoking (Yang et al. 2016).

Explaining *why* social relationships matter for health and longevity has been a challenge, but recent research by Yang and colleagues (2016) provides some clues. Using data from four separate studies, including the HRS, they find that higher levels of social isolation are linked to health problems among adolescents, and that these negative health effects persisted through midlife into old age, increasing the risk of death. In adolescence, social isolation manifests itself primarily in terms of high blood pressure and obesity, but over a lifetime, relationship deficits can "get under the skin," leading to chronic stress, inflammation, disease, and a higher risk of death (Yang et al. 2016).

Gavrilov and Gavrilova (2015a) use data from the decennial census to investigate other aspects of childhood and midlife conditions that could shape individuals' chances of survival later in life. They find that certain aspects of "shared familial environment and lifestyle" are important predictors of mortality risk in old age, independent of genetic influences. For example, children born to younger mothers tend to live longer than their later-born siblings. The researchers use a "within-family analysis" to study the relationship between birth order and longevity to control for effects related to individuals' shared environment and genetic background.

Midlife experiences also affect the risk of mortality later in life, but Gavrilov and Gavrilova (2015b) find that these risk factors can differ by gender, with occupation affecting men's chances of survival as older adults, and characteristics of the home environment affecting women's longevity.

Genetic Factors and Biomarkers

Researchers estimate that between 15 percent and 25 percent of the *overall* variation in human longevity may be explained by genetic differences in the population, with environment and health-related behaviors playing a larger role (Broer et al. 2015). But for exceptional survival—reaching the mid-90s and beyond—genes appear to play a stronger role. Finding the specific genes that contribute to exceptional longevity among older adults, however, has been challenging: Multiple combinations of environmental exposures, behaviors, and biological processes likely influence healthy aging and survival to very old ages.

One way researchers have identified genes associated with longevity is through genome-wide association studies (GWAS), which investigate common genetic variations in a population to see whether certain variants are linked to better health and function and longer life spans. The ultimate goal is to uncover genetic variations in a population that can be used as biomarkers—biological indicators such as blood pressure, total cholesterol and C-reactive protein—of healthy aging and longevity. By uncovering these biological pathways, researchers may be able to point the way toward new or existing drugs to promote healthy aging.

Genetic factors can affect life span positively, by providing a protective effect, or negatively—by predisposing people to certain diseases that increase the risk of death. Thus far, GWAS approaches have linked two genes—Apolipoprotein E, or APOE and Forkhead Box O3, or FOXO3—to longevity in humans in multiple, independent studies (Newman and Murabito 2013; Broer et al. 2015). APOE is a key genetic variant that has been widely studied in aging research because it is associated with a higher risk of Alzheimer's and heart disease.

Multiple combinations of environmental exposures, behaviors, and biological processes likely influence healthy aging and survival to very old ages.

The relationship between APOE and longevity is complex. While the APOE gene increases the risk of several aging-related diseases later in life, it may not increase risk of mortality. Using data from the Long Life Family Study (LLFS) and Framingham Heart Study, Kulminski and colleagues (2014) show that the APOE gene does not increase risk of mortality in men, and among women, the negative effect of the APOE gene is limited to those in the 70-to-95 age group. The effect of the APOE gene on survival is strongly influenced by age and gender, according to a large study in the United Kingdom (Joshi et al. 2016). The APOE e4 variant has been found to both increase the risk of Alzheimer's disease and provide protection against cancer, as well as some other conditions, suggesting a "trade-off-like influence of APOE on different health traits" (Ukraintseva et al. 2016). Such effects are not limited to APOE. The trade-

off-like influence of genes on different health and aging-related traits appears to be a common phenomenon. It may help explain why genetic variants that are associated with increased risks of major diseases are also found in genomes of long-lived people and do not seem to compromise longevity (Ukrainsteva et al. 2016).

FOXO3, the second gene, was originally identified through "candidate gene studies" that focus on specific genes based on their hypothesized roles in disease and aging as well as positive associations found in studies of lower organisms. Researchers compared Japanese American men ages 95 and older with those who died before age 81 and found that men with the FOXO3 genetic variant have almost three times the odds of living into their 90s. These findings were replicated in subsequent studies focused on other population subgroups (Newman and Murabito 2013).

The LonGenity Project at Albert Einstein College of Medicine has noted a variant of another gene (adiponectin) that protects against arterial inflammation (Atzmon et al. 2008). And in another study, these researchers found a mutation in a gene (the cholesteryl ester transfer protein gene) that is more common in centenarians and those in their 90s, counters the role of elevated cholesterol in cardiovascular disease, and is associated with better cognitive function (Sanders et al. 2010).

GWAS studies are also providing other clues to exceptional longevity. For example, in one GWAS study Levine and Crimmins (2016) compare long-lived smokers with other smokers ages 52 to 69 and with nonsmokers; they identify a set of 215 single "nucleotide polymorphisms" (a variation found in the DNA between genes) that make up a functional genetic network that appears to be important to aging, stress resistance, protection from cancer, and longevity.

Other Markers of Aging

GWAS and candidate gene studies have been useful in identifying genetic markers of longevity. But there are many other markers—including biological, behavioral, and cognitive indicators—that have been used to investigate the aging process. The purpose of these studies is generally to identify indicators that are found more—or less—often in individuals with exceptional longevity than in the general population.

The LLFS, a study of long-lived individuals and their families, provides a rich source of data on the genetic and environmental factors that affect healthy aging and longevity. Yashin and colleagues (2010) use data from the LLFS to test whether certain biomarkers in adult children are good predictors of longevity in parents. They find that adult children's characteristics—based on an index consisting of a wide range of physiological, cognitive, and socioeconomic factors—are significantly linked to mother's life spans, but not father's life spans. They conclude that analyses of biomarkers among family members may be useful to pinpoint the biological factors that underlie exceptional longevity.

Five percent of the population ages more rapidly and has shorter life spans than others.

Another large study based on biomarkers suggests that 5 percent of the population ages more rapidly and has shorter life spans than others, even after taking into account known risk factors such as age, gender, smoking, obesity, and disease history (Chen et al. 2016). Based on 13 data sets representing 13,000 individuals, a team of 65 researchers finds that age-related changes to human DNA appear to consistently predict shorter life spans. They calculated the aging of blood and other tissues to determine an individual's biological age (or "epigenetic aging rate") by tracking methylation—a natural process that chemically alters DNA over time. They linked higher biological age—independent of chronological age—to earlier death. In the future, these biomarkers could be used to determine the effectiveness of treatments to slow aging. They note, however, risk factors like smoking, diabetes, and high blood pressure still predict mortality more strongly than biological age.

Most studies of longevity, health, and disability in old age focus on a narrow range of explanatory variables, ignoring the potential role of other factors which, in combination, may have a significant impact on healthy aging and life span. To provide a more comprehensive characterization of aging processes, Kulminski and colleagues (2011) use data from the LLFS to create an Index of Cumulative Deficits (ID) that combined 85 separate indicators of physical and mental health and disability, including feelings of hopelessness, high blood pressure, arthritis, diabetes, and walking ability. They find that health deficits increase exponentially with age, and argue that the ID can be used as an effective proxy measure of longevity, which has typically been studied using only mortality or survival data.

Implications for Healthy Aging

Rising life expectancy in the United States and elsewhere raises questions about the quality of people's lives as they reach the oldest age groups. Health problems and functional limitations tend to increase as people grow older, and understanding these processes will help health professionals and others develop interventions to improve the lives of older adults and their families.

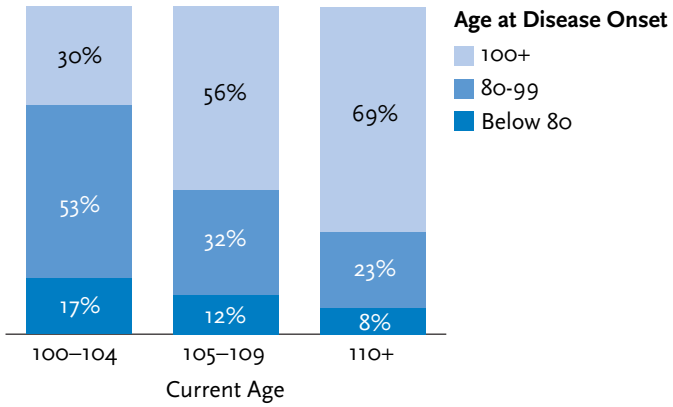
Those with exceptional longevity are a very select group, with different health profiles compared with those who die at younger ages. Among centenarians, onset of physical health problems and cognitive decline tends to occur at much older ages, so that their health spans—or the period of life in which people are generally healthy—approaches their life spans, a phenomenon known as "compression of morbidity." In a recent analysis of centenarians in the NECS, researchers found that onset of diseases—heart disease, dementia, and stroke—and of cognitive and functional decline are delayed among those in the oldest age groups (Andersen et al. 2012). About 83 percent of centenarians ages 100 to 104 were free of major age-related disease until at least age 80. Among supercentenarians ages 110 and older, 92 percent were free of major disease until at least age 80, and 69 percent were disease-free until age 100 or older (see Figure 1).

Health problems and functional limitations tend to increase as people age.

Based on analysis of HRS data, Ailshire, Beltrán-Sánchez, and Crimmins (2015; 2011) also find that, on average, long-lived individuals (centenarians or those who reached at least age 97) have fewer chronic diseases, better mental health, and better physical and cognitive function than nonsurviving members of their age cohort. However, they identify differences based on gender, race/ethnicity, and education level: Men are healthier than women, whites healthier than nonwhites, and highly educated people have better cognitive function than their less-educated peers.

Researchers have found a similar compression of health problems among long-lived individuals and their siblings in the LLFS and the Longevity Genes Project (Sebastiani et al. 2013; Ismail et al. 2016). This observed delay in health problems likely means that these individuals are biologically more alike, thus making it easier and more plausible that the factors that facilitate such remarkable healthy aging can be discovered by studying people at these oldest ages. LLFS found that even spouses of long-lived individuals experienced a delay in the onset of health problems, possibly because they also share the same environment and have similar health behaviors as the LLFS subjects.

Figure 1
Age at Onset of at Least One Disease, by Age Group



Note: Diseases include cancer, heart disease, chronic obstructive pulmonary disease, dementia, diabetes, or stroke.

Source: Stacy L. Andersen et al., "Health Span Approximates Life Span Among Many Supercentenarians," *Journals of Gerontology, Series A; Biological Sciences and Medical Sciences 67,* no. 4 (2012) 395-405.

Looking more broadly at the health of U.S. adults ages 20 and older, Crimmins and Beltrán-Sánchez (2011) find that overall, diagnoses of age-related health problems have not declined as life expectancy has increased, despite advances in medical technology. They argue that "diseases are both less lethal and less disabling," but that they have become more chronic than they were in previous years.

When researchers focus on those ages 65 and older over the past 40 years, they find that the increase in years spent without disability (disability-free life expectancy) outpaced the increase in disabled life (Crimmins, Zhang, and Saito 2016). Another recent analysis, based on the National Long Term Care Survey (NLTCS), calculates a nearly 2.3 percent overall annual decline in disability related to both functional limitations (classified as "Activities of Daily Living") and cognitive impairment among U.S. older adults between 1984 and 2004 (Stallard and Yashin 2016).

While active life expectancy has increased among adults ages 65 and older, the long-term trends have differed for men and women. Freedman, Wolf, and Spillman (2016) use data from the NLTCS and National Health and Aging

Trends Study to show that the rise in men's life expectancy over the past 30 years has been accompanied by an increase in years of active life. Among women, who experienced smaller gains in life expectancy over the same period, the gains in active life expectancy have been more modest. A companion study suggests racial gaps in active life expectancy have persisted since the 1980s and that older black women are especially disadvantaged (Freedman and Spillman 2016). However, there is evidence that the prevalence of activity limitations is increasing among adults ages 55 to 64, raising concerns that baby boomers will face more health challenges in old age compared with their parents' generation (Freedman et al. 2013).

While many researchers have documented the decline in disability among older adults, there has been less research on broader quality-of-life issues, such as social and psychological well-being. Ailshire and Crimmins (2011) used HRS data to compare social relationships, loneliness, life satisfaction, and attitudes on aging between the oldest old (those ages 90 and older) and those in their 70s. They find that the oldest old have more contact and receive more positive support from children and other relatives compared with those in their 70s. But the oldest old are also more likely than those in their 70s to have lost a spouse, leading to feelings of loneliness.

Policy Implications

Recent NIA-funded research on longevity has identified a broad range of social, behavioral, genetic, and environmental factors that can affect the risk of mortality among older adults. While genetics play an important role in longevity, people's life experiences—from birth through old age—also shape their chances of living to 100 and beyond. A growing body of interdisciplinary research is being conducted to address this complexity, and to provide a more comprehensive view of the aging process. New data resources are also becoming available to help researchers explore the interaction of social and biological processes affecting longevity (see Box 3).

Box 3

Key NIA-Funded Studies and Surveys for Longevity Research

Over the past several decades, NIA has funded many research and data collection projects to help illuminate the factors associated with human longevity. Descriptions and links to these projects can be found at www.prb.org/pdf16/TIA34-Additional-Research-on-Longevity.pdf

The Census Bureau projects that the number of adults ages 85 and older will more than triple between 2015 and 2050, from 6.3 million to 19.0 million. The rapid growth in the number of older Americans—and those with exceptional longevity in particular—will create challenges for family members and health care professionals who provide assistance to this unique segment of the population. Longer life expectancy in the United States also has implications for entitlement programs. Social Security and Medicare expenditures are expected to increase substantially, but researchers argue that these costs can be offset by policy changes, such as increasing the eligibility ages for those programs (Goldman et al. 2013). Additionally, significant Medicare and Medicaid savings could be achieved by investing research funds in advances that slow the aging process and by increasing population-wide physical fitness, argue Goldman, Gaudette, and Cheng (2016).

As the U.S. population ages, it is also becoming more racially and ethnically diverse. Yet there are persistent gaps in the health and longevity of older adults in different population subgroups, with a significant white-black gap in health and life expectancy. Policymakers can improve the outlook for older adults in the coming decades by reducing current racial/ethnic and socioeconomic gaps between population groups of all ages, and promoting health throughout the life span.

Policymakers can improve the outlook for older adults by reducing current racial/ethnic and socioeconomic gaps among population groups of all ages, and promoting health throughout the life span.

References

Jennifer A. Ailshire and Eileen M. Crimmins, "Psychosocial Factors Associated With Longevity in the United States: Age Differences Between the Old and Oldest-Old in the Health and Retirement Study," *Journal of Aging Research* 2011, no. 530534 (2011): 1-10.

Jennifer A. Ailshire, Hiram Beltrán-Sánchez, and Eileen M. Crimmins, "Becoming Centenarians: Health and Functioning Trajectories of Older U.S. Adults as They Survive to 100," *Journals of Gerontology Series A: Biological Sciences and Medical Sciences* 70, no. 2 (2015): 193-201.

Jennifer A. Ailshire, Hiram Beltrán-Sánchez, and Eileen M. Crimmins, "Social Characteristics and Health Status of Exceptionally Long-Lived Americans in the Health and Retirement Study," *Journal of the American Geriatrics Society* 59, no. 12 (2011): 2241-8.

Gil Atzmon et al., "Adiponectin Levels and Genotype: A Potential Regulator of Life Span in Humans," *Journals of Gerontology Series A: Biological Sciences and Medical Sciences* 63, no. 5 (2008): 447-53.

Stacy L. Andersen et al., "Health Span Approximates Life Span Among Many Supercentenarians: Compression of Morbidity at the Approximate Limit of Life Span," *Journals of Gerontology Series A: Biological Sciences and Medical Sciences* 67, no. 4 (2012): 395-405.

Linda Broer et al., "GWAS of Longevity in CHARGE Consortium Confirms *APOE* and *FOXO3* Candidacy," *Journals of Gerontology Series A: Biological Sciences and Medical Sciences* 70, no. 1 (2015): 110-18.

Anne Case and Angus Deaton, "Rising Morbidity and Mortality in Midlife Among White Non-Hispanic Americans in the 21st Century," *Proceedings of the National Academy of Sciences* 112, no. 49 (2015): 15078-83.

Brian H. Chen et al., "DNA Methylation-Based Measures of Biological Age: Meta-Analysis Predicting Time to Death," *Aging* 8, no. 9 (2016): 1844-65.

Eileen M. Crimmins and Hiram Beltrán-Sánchez, "Mortality and Morbidity Trends: Is There Compression of Morbidity?" *Journals of Gerontology Series B: Psychological Sciences and Social Sciences* 66, no. 1 (2011): 75-86.

Eileen M. Crimmins, Yuan Zhang, and Yasuhiko Saito, "Trends Over Four Decades in Disability-Free Life Expectancy in the United States," *American Journal of Public Health* 106, no. 7 (2016): 1287-93.

Andrew Fenelon and Samuel H. Preston, "Estimating Smoking-Attributable Mortality in the United States," *Demography* 49, no. 3 (2012): 797-818.

Vicki A. Freedman, Douglas A. Wolf, and Brenda C. Spillman, "Disability-Free Life Expectancy Over 30 Years: A Growing Female Disadvantage in the U.S. Population," *American Journal of Public Health* 106, no. 6 (2016): 1079-85.

Vicki A. Freedman and Brenda C. Spillman, "Active Life Expectancy in the Older U.S. Population, 1982-2011: Differences Between Blacks and Whites Persisted," *Health Affairs* 35, no. 8 (2016): 1351-58.

Vicki A. Freedman et al., "Trends in Late-Life Activity Limitations in the United States: An Update From Five National Surveys," *Demography* 50, no. 2 (2013): 661-71.

Leonid A. Gavrilov and Natalia S. Gavrilova, "Predictors of Exceptional Longevity: Effects of Early-Life and Midlife Conditions, and Familial Longevity," *North American Actuarial Journal* 19, no. 3 (2015a): 174-86.

Leonid A. Gavrilov and Natalia S. Gavrilova, "New Developments in Biodemography of Aging and Longevity," *Gerontology* 61, no. 4 (2015b): 364-71.

Jane L. Givens et al., "Personality Traits of Centenarians' Offspring," *Journal of the American Geriatrics Society* 57, no. 4 (2009): 683-5.

Dana Goldman, Etienne Gaudette, and Wei-Han Cheng, "Competing Risks: Investing in Sickness Rather Than Health," *American Journal of Preventive Medicine* 50, no. 5 (2016): S45-50.

Dana Goldman et al., "Substantial Health and Economic Returns From Delayed Aging May Warrant a New Focus for Medical Research," *Health Affairs* 32, no. 10 (2013): 1698-705.

Patrick L. Hill et al., "Conscientiousness and Longevity: An Examination of Possible Mediators," *Health Psychology* 30, no. 5 (2011): 536-41.

Peter K. Joshi et al., "Variants Near CHRNA3/5 and APOE Have Age- and Sex-Related Effects on Human Lifespan," *Nature Communications* 7, no. 11174 (2016): 1-7.

Amelia Karraker, Robert F. Schoeni, and Jennifer C. Cornman, "Psychological and Cognitive Determinants of Mortality: Evidence From a Nationally Representative Sample Followed Over Thirty-Five Years," *Social Science & Medicine* 144 (2015): 69-78.

Kaori Kato et al., "Positive Attitude Towards Life and Emotional Expression as Personality Phenotypes for Centenarians," *Aging* 4, no. 5 (2012): 359-67.

Alexander Kulminski et al., "Age, Gender, and Cancer but not Neurodegenerative and Cardiovascular Diseases Strongly Modulate Systemic Effect of the Apolipoprotein E4 Allele on Lifespan," *PLOS Genetics* 10, no. 1 (2014): e1004141.

Alexander M. Kulminski et al., "Do Gender, Disability, and Morbidity Affect Aging Rate in the LLFS? Application of Indices of Cumulative Deficits," *Mechanisms of Ageing and Development* 132, no. 4 (2011): 195-201.

Morgan Levine and Eileen Crimmins, "A Genetic Network Associated With Stress Resistance, Longevity, and Cancer in Humans," *Journals of Gerontology Series A: Biological Sciences and Medical Sciences* 71, no. 6 (2016): 703-12.

Morgan Levine et al., "Low Protein Intake Is Associated With a Major Reduction in IGF-I, Cancer, and Overall Mortality in Middle-Aged but not Elderly Subjects," *Cell Metabolism* 19, no. 3 (2014): 407-17.

Julie A. Mattison et al., "Impact of Caloric Restriction on Health and Survival in Rhesus Monkeys From the NIA Study," *Nature* 489 (2012): 318-21.

National Academies of Sciences, Engineering, and Medicine, *The Growing Gap in Life Expectancy by Income: Implications for Federal Programs and Policy Responses* (Washington, DC: The National Academies Press, 2015).

National Center for Health Statistics, *Health, United States, 2011: With Special Feature on Socioeconomic Status and Health* (Washington, DC: Government Printing Office, 2012): Figure 32.

National Research Council, *Explaining Divergent Levels of Longevity in High-Income Countries* (Washington, DC: The National Academies Press, 2011).

National Research Council and Institute of Medicine, *Measuring the Risks and Causes of Premature Death: Summary of a Workshop* (Washington, DC: The National Academies Press, 2015).

Anne B. Newman and Joanne M. Murabito, "The Epidemiology of Longevity and Exceptional Survival," *Epidemiologic Reviews* 35, no. 1 (2013): 181-97.

Khadija Ismail et al., "Compression of Morbidity Is Observed Across Cohorts With Exceptional Longevity," *Journal of the American Geriatrics Society* 64, no. 8 (2016): 1583-91.

Luis Rosero-Bixby, William H. Dow, and David H. Rehkopf, "The Nicoya Region of Costa Rica: A High Longevity Island for Elderly Males," *Vienna Yearbook of Population Research* 11, no. 1 (2013): 109-36.

Rongping Ruan et al., "Tea Consumption and Mortality Among Oldest-Old Chinese," *Journal of the American Geriatrics Society* 61, no. 11 (2013): 1937-42.

Amy E. Sanders et al., "Association of a Functional Polymorphism in the Cholesteryl Ester Transfer Protein (CETP) Gene With Memory Decline and Incidence of Dementia," *Journal of the American Medical Association* 303, no. 2 (2010): 150-8.

Paola Sebastiani et al., "Families Enriched for Exceptional Longevity Also Have Increased Health-Span: Findings From the Long Life Family Study," *Frontiers in Public Health* 1, no. 38 (2013): 1-9.

Benjamin A. Shaw and Neda Agahi, "A Prospective Cohort Study of Health Behavior Profiles After Age 50 and Mortality Risk," *BMC Public Health* 12, no. 803 (2012): 1-10.

Zumin Shi et al., "Food Habits, Lifestyle Factors, and Mortality Among Oldest Old Chinese: The Chinese Longitudinal Healthy Longevity Survey (CLHLS)," *Nutrients* 7, no. 9 (2015): 7562-79.

P. J. Eric Stallard and Anatoliy I. Yashin, *Long Term Morbidity Improvement Study: Estimates for the Non-Insured U.S. Elderly Population Based on the National Long Term Care Survey 1984-2004* (Schaumburg, IL: Society of Actuaries, 2016).

Svetlana Ukraintseva et al., "Puzzling Role of Genetic Risk Factors in Human Longevity: 'Risk Alleles' as Pro-Longevity Variants," *Biogerontology* 17, no. 1 (2016): 109-27.

Yang Claire Yang et al., "Social Relationships and Physiological Determinants of Longevity Across the Human Life Span," *Proceedings of the National Academy of Sciences* 113, no. 3 (2016): 578–83.

Yi Zeng and Ke Shen, "Resilience Significantly Contributes to Exceptional Longevity," *Current Gerontology and Geriatrics Research* 2010, no. 525693 (2010): 1-9.

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