

Global Population Aging: Facts, Challenges, Solutions & Perspectives

David E. Bloom, David Canning & Alyssa Lubet

Abstract: The rapid aging of populations around the world presents an unprecedented set of challenges: shifting disease burden, increased expenditure on health and long-term care, labor-force shortages, dissaving, and potential problems with old-age income security. We view longer life spans, particularly longer healthy life spans, as an enormous gain for human welfare. The challenges come from the fact that our current institutional and social arrangements are unsuited for aging populations and shifting demographics; our proposed solution is therefore to change our institutions and social arrangements. The first section of this essay provides a statistical overview of global population aging and its contributing factors. The second section outlines some of the major challenges associated with widespread population aging. Finally, the third section of the essay describes various responses to these challenges, both current and prospective, facing individuals, businesses, institutions, and governments.

DAVID E. BLOOM, a Fellow of the American Academy since 2005, is the Clarence James Gamble Professor of Economics and Demography in the Department of Global Health and Population at the Harvard T.H. Chan School of Public Health.

DAVID CANNING is the Richard Saltonstall Professor of Population Sciences and Professor of Economics and International Health in the Department of Global Health and Population at the Harvard T.H. Chan School of Public Health.

ALYSSA LUBET is a Research Assistant in the Department of Global Health and Population at the Harvard T.H. Chan School of Public Health.

(*See endnotes for complete contributor biographies.)

We are in the midst of an unprecedented transition in global demography. The world's population is aging rapidly, and older adults compose a larger proportion of the world's population than ever before – a share that will only increase over the next century. By 2050, the percentage of the United States' population that is aged sixty years and older will grow from the current figure of about 20 percent to 27 percent. The global number of centenarians worldwide – those aged one hundred years and older – is expected to more than double by 2030, with projections of nearly 3.4 million by 2050.¹ Three major factors are driving this transition: decreasing fertility, increasing longevity, and the aging of large population cohorts.

Falling fertility rates are the main determinant of population aging. Low fertility rates lead to smaller youth cohorts, which create an imbalance in the age structure: older age groups become larger than their younger counterparts. Thanks to accessible and effective birth control, increased child survival, and cultural changes, birth rates have dropped dramati-

ically in the past century. In 1950, the global total fertility rate (TFR), or the average number of children per woman, was about 5; by 2010, that number had dropped by 50 percent. By 2050, the TFR will have dropped even further to about 2.25 children per woman. In many countries, fertility rates are now well below the long-term replacement rate of just over two children per woman.

Changes in fertility rate are accompanied by increased longevity, another driver of population aging. Averaging for sex and location, a child born in 1950 had a life expectancy of only forty-seven years, while an adult who had survived to the age of sixty could expect to live another fourteen years. In contrast, by 2010, life expectancy at birth had increased to seventy years, and continued life expectancy for those aged sixty increased to twenty years. In a number of populations, recent increases in longevity have been attributed to falling rates of tobacco consumption, as well as improvements in medical technologies.² By 2050, life expectancy at birth is expected to have risen to nearly seventy-seven years, while life expectancy at age sixty will increase to twenty-two-and-a-half years.

Meanwhile, large population cohorts, such as the United States' postwar baby boom generation, are moving through middle age and older adulthood. This movement can be seen in Figure 1, which depicts the population of more-developed countries (MDCs) broken down by sex and age group. Males are on the left side of the pyramid and females are on the right. The shifting shape of the population pyramid between the years 2010 and 2050 illustrates the baby boom cohort's movement from middle into older ages.

These global phenomena – decreasing fertility, increasing longevity, and the aging of large birth cohorts – combine to drive up the percentage of older adults as a share of the global population. In 1950, only 8

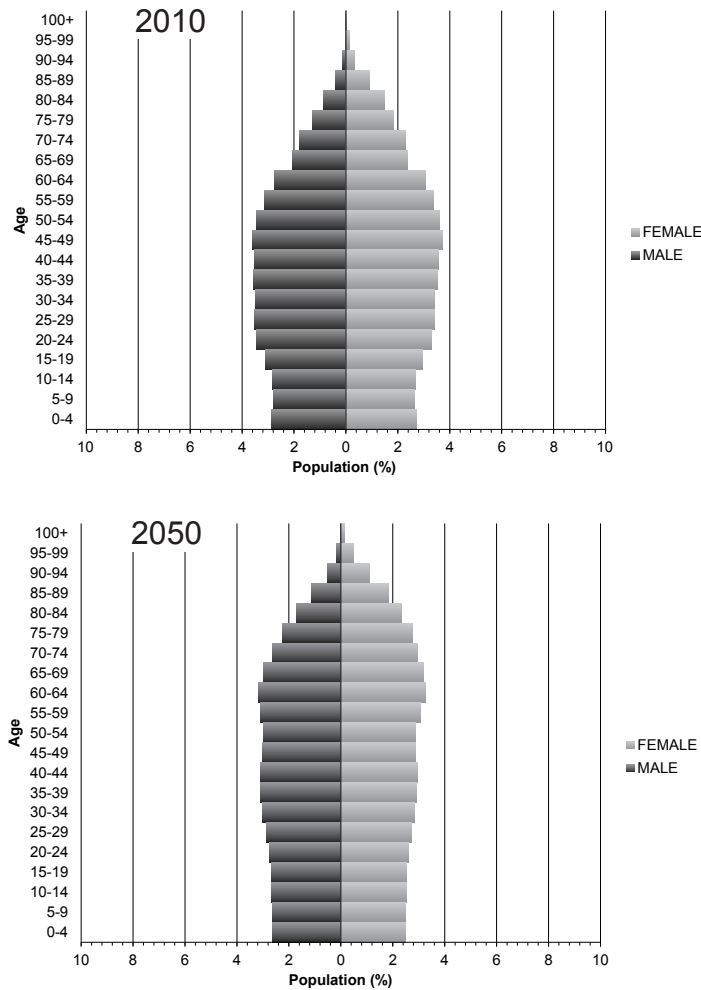
percent of the world's population was sixty years or older; this number increased to 11 percent by 2010. Over the next several decades, this proportion is expected to rise dramatically, reaching a projected 21.2 percent by 2050. The change is even more dramatic for the share of the world's population aged eighty years or older. This proportion climbed from just 0.6 percent in 1950 to 1.6 percent in 2010, and is projected to make up 4.1 percent of the global population by 2050.

While the population of virtually every country is aging rapidly, there remains considerable variation at both regional and country levels, with strong correlations to differing income levels. MDCs trend toward low fertility and high longevity, and less-developed countries (LDCs) trend toward the opposite. At the low end of the fertility range are the MDCs found in Europe and East Asia, with Bosnia, Herzegovina, and Singapore tied for the lowest TFR of 1.28 children per woman. Meanwhile, Sub-Saharan Africa has a regional TFR of just over 5, while also hosting the highest country-level fertility rates: Somalia (6.61), Mali (6.86), and Niger (7.58). As for longevity, Japan is in the lead with a current life expectancy at birth of eighty-three-and-a-half years, in stark contrast to Sierra Leone, where life expectancy at birth is slightly over forty-five years.

Tables 1 and 2 depict the percent of the elderly population in the world's most and least population-aged countries, now (2010) and projected in the future (2050). The 2050 figures are based on a medium fertility projection, which assumes that fertility in all major areas will stabilize at replacement level (at slightly over two children per woman). This comparison reveals stark differences in age profiles between countries. For example, currently 23 percent of Germany's population is aged sixty-five years and older, while the corresponding figure for Qatar (with its large expan-

David E. Bloom,
David Canning
& Alyssa Lubet

Figure 1
Population Pyramids for More-Developed Countries, 2010 and 2050



Source: United Nations Department of Economic and Social Affairs Population Division, Population Estimates and Projections Section, *World Population Prospects: The 2012 Revision* (New York: United Nations Department of Economic and Social Affairs, 2014), <http://esa.un.org/unpd/wpp/index.htm>.

triate worker population) is only 1 percent. These rankings are projected to shift considerably in the next half century, with only Japan holding over in the top five most population-aged nations.

Rapid population aging is accompanied by several distinctive challenges in health,

labor supply, and economic growth. The economic and social consequences of greater numbers and increased shares of the elderly will be seen in rich and poor countries alike.

Nations with swiftly aging populations may find themselves with a growing disease burden on their hands: nearly one-

Table 1

The World's Most and Least Population-Aged Countries, 2010: Actual Population Percentages

David E. Bloom,
David Canning
& Alyssa Lubet

Country	% of population aged 65+	% of population aged 80+
<i>Top 5</i>		
Japan	23	6
Germany	21	5
Italy	20	6
Greece	19	5
Latvia	18	4
<i>Bottom 5</i>		
Kuwait	2	0.2
Eritrea	2	0.2
Bahrain	2	0.3
Qatar	1	0.1
United Arab Emirates	0.3	0.1

Source: United Nations Department of Economic and Social Affairs Population Division, Population Estimates and Projections Section, *World Population Prospects: The 2012 Revision* (New York: United Nations Department of Economic and Social Affairs, 2014), <http://esa.un.org/unpd/wpp/index.htm>.

Table 2

The World's Most and Least Population-Aged Countries, 2050: Projected Population Percentages (Medium Fertility Model)

Country	% of population aged 65+	% of population aged 80+
<i>Top 5</i>		
Japan	37	16
Republic of Korea	35	14
Spain	35	13
Portugal	34	12
Cuba	34	15
<i>Bottom 5</i>		
Chad	4	0.4
Somalia	3	0.4
Timor-Leste	3	0.7
Mali	3	0.1
Niger	2.5	0.3

Source: United Nations Department of Economic and Social Affairs Population Division, Population Estimates and Projections Section, *World Population Prospects: The 2012 Revision* (New York: United Nations Department of Economic and Social Affairs, 2014), <http://esa.un.org/unpd/wpp/index.htm>.

Downloaded from http://direct.mit.edu/daed/article-pdf/144/2/80/1830565/daed_a_00332.pdf by guest on 30 March 2023

quarter of the world's burden of disease is attributable to illness in adults aged sixty and over. In turn, the majority (nearly 70 percent) of the older-adult disease burden is due to noncommunicable diseases (NCDs) such as heart disease, cancer, chronic respiratory disease, musculoskeletal conditions, and mental disorders such as Alzheimer's and dementia.³ Adding to and significantly complicating the concerns posed by NCDs is the issue of multimorbidity, which affects a majority of older adults with NCDs.⁴ The increasing burden of these health problems reflects the epidemiological transition that has taken place over the last century and that is still occurring in many developing nations, defined by a fundamental shift in the predominant causes of morbidity and mortality away from infectious diseases and malnutrition and toward NCDs.

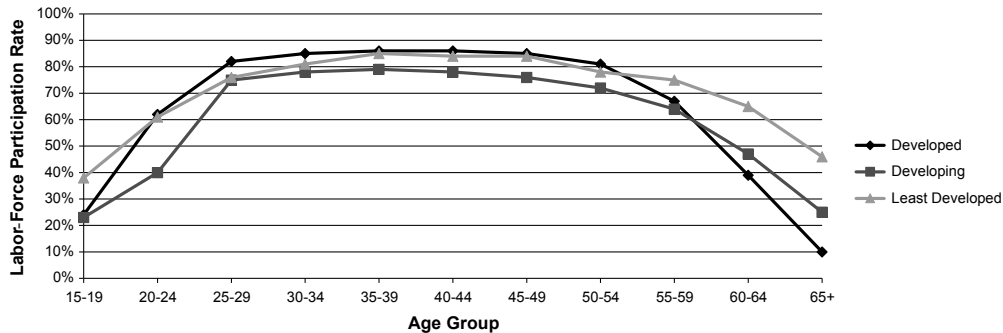
The growing NCD burden could also be a significant path through which population aging slows economic growth. The treatment and care of people suffering from NCDs weighs heavily on government expenditure and household wealth and also results in decreased investment. Indeed, where losses are quantifiable, the projected economic cost of NCDs is staggering, particularly in low- and middle-income countries: recent projections show that India stands to lose US\$4.58 trillion, while China stands to lose US\$23.03 trillion due to NCDs in the period between 2012 and 2030; during this time each country's proportion of adults aged sixty-five and older is expected to double.⁵ On an individual level, NCDs prevent people from working as long, hard, and productively as they otherwise might; this is reflected in decreased labor participation rates at older ages (see Figure 2).

A key factor in determining the effects of population aging is the "compression of morbidity," predicted in the 1980s by professor of medicine James Fries. His theory

postulates that increasing life expectancies will result not only in deaths at later ages, but also in fewer years of life lived in the presence of disease and reduced physical and cognitive functioning, resulting in healthier, as well as extended, old age.⁶ So far, analyses of existing data to test the compression of morbidity hypothesis have not been conclusive. Some studies have shown that certain populations – such as centenarians, adults with active cognitive lifestyles and social connections, and those with healthy lifestyles – do indeed seem to experience fewer years of illness and disability at the end of their lives.⁷ However, other recent analyses found that in the United States, disease prevalence has increased along with average lifespan, and that years of life lived with disease and loss of mobility function have increased along with life expectancies.⁸ Meanwhile, a number of studies using data from low- and middle-income countries show no evidence of compression of morbidity; conversely, an expansion of morbidity is also a possibility, threatening increased burdens on governments, health systems, and households.⁹ It is clear that more research into the compression of morbidity will be necessary and that, in any case, healthy living must be emphasized.¹⁰

Another economic challenge presented by population aging is the falling labor supply. In many countries, labor-force participation falls off drastically at older ages (see Figure 2). As a result, population aging may slow national economic growth, reduce asset values, strain existing pension and health care systems, and weigh down younger generations in the process. In the United States, labor-force participation rates for both sexes peak between the ages of forty and forty-four: in 2010, the rate for this group was 82.3 percent. From there, rates drop gradually along with age, before falling precipitously from 72 percent for adults aged fifty-five to fifty-nine to 55 per-

Figure 2
Labor-Force Participation Rate by Age Group, 2010



David E.
Bloom,
David
Canning
& Alyssa
Lubet

Source: International Labour Organization, *ILOSTAT Database* (Geneva: International Labour Organization, 2014), <http://www.ilo.org/ilostat>.

cent for those aged sixty to sixty-four (unfortunately, after age sixty-five, labor-force participation rates are generally no longer available in five-year bands as they are for younger age groups).¹¹ Similar drops can also be seen in less-developed, but still aging, countries. In India, the participation rate of the sixty to sixty-four age group is nearly 50 percent, a dramatic drop from the 64 percent participation rate of those aged fifty-five to fifty-nine. In contrast, the more population-aged Japan sees a falloff from 80 percent to 61 percent participation between the fifty-five to fifty-nine and sixty to sixty-four age groups. While this decrease reflects a greater change in percentage points, higher overall proportions also point to longer working lives for a greater number of individuals.

The low labor-force participation of the elderly means that their consumption is financed out of either government pensions, family transfers, or their own savings. A difficulty with transfers such as pay-as-you-go pensions or informal transfers from children to their elderly parents is that they may become unsustainable as the ratio of elderly to working age population

increases. This can be avoided if people save real assets for their own retirement; but rather than accumulating real resources, many government pension systems promise pensions based on future tax receipts. As well as money transfers to the elderly, there are often larger transfers in the form of publicly provided access to health care, which if not financed through savings must be funded through a tax burden on younger workers.

Another challenge posed by population aging is the prospect of slowed economic growth by way of diminished labor and lower savings rates. There are strong life-cycle patterns in work and saving, and older generations do not work and save as much as younger adults do. One dire prediction is that population aging will slow or perhaps even reverse the engines of national economic growth. Reduced labor supply due to population aging may result in economies having to pay “dividend” back in the form of health care, long-term care, and capital deaccumulation as the elderly seek resources to finance their consumption in old age. Economies may also be burdened by increased social protec-

tion expenditures, such as increasing pension costs. Indeed, public pension expenditure as a share of GDP is projected to rise steeply in the coming decades due to population aging and to earlier changes in pension coverage and benefit rates.¹²

The problems outlined above may be offset by accompanying demographic developments, especially if countries are prepared to take advantage of these opportunities. One challenge posed by population aging is an altered age dependency ratio, or the ratio of people of working-age (ages fifteen to sixty-four) to young children and older adults in a population. However, increased elderly dependency will be offset in many economies by a reduced youth dependency ratio. The elderly dependency ratio in the United States, for example, has grown from seventeen adults aged sixty-five and older per one hundred working-aged adults in 1980 to twenty-one elderly per one hundred working-aged in 2013. In the same time period, the ratio of children under age fifteen to working-age adults has decreased from thirty-four per one hundred to twenty-nine per one hundred.¹³ Between 1980 and the present, the United States' overall age dependency ratio has remained relatively constant, contracting from 51 percent to 50 percent.¹⁴ With a lower youth dependency burden, investment can be redirected from social spending on children to investment in physical capital, research and development, and infrastructure – all classic drivers of economic growth.

Individuals may also respond to population aging through behavioral changes, such as increased rates of saving, higher educational attainment in anticipation of longer lives, and increased labor-force participation from women and the elderly. The typical “working lifespan” between the ages of fifteen and fifty-nine is the prime period for saving, and people may

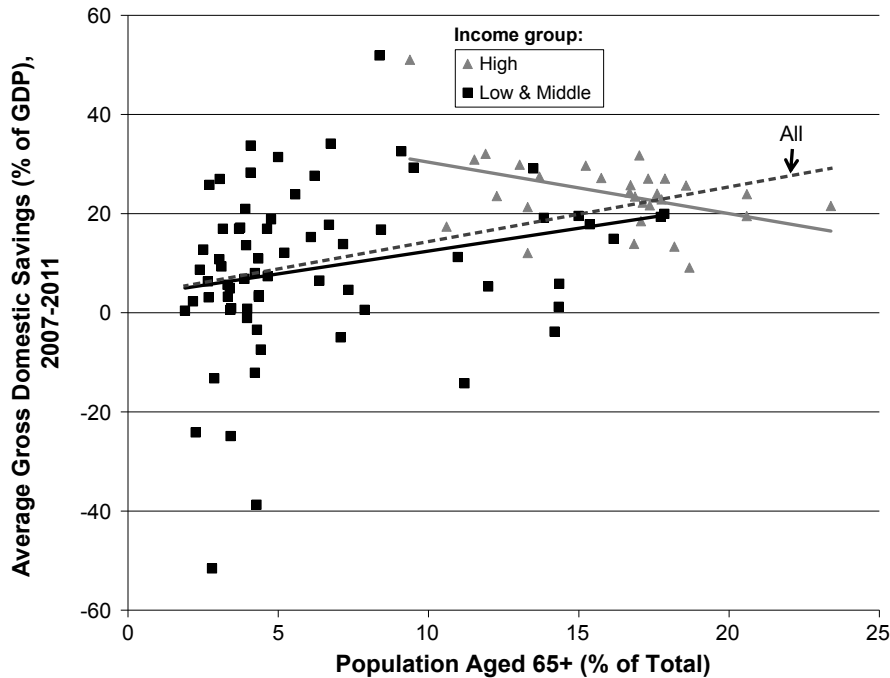
respond to population aging through behavioral changes in this period. Greater longevity leads to longer retirements and increased incentives to save during working years in anticipation of retirement. There is some evidence that people in aging societies have already adjusted to this reality. Figure 3 shows that, for all countries in the aggregate, savings as a percentage of GDP rises along with the share of a country's population aged sixty-five years or older.¹⁵ In economic terms, savings translates into investment, which fuels the accumulation of physical and human capital and technological progress, which are the classic drivers of economic growth.

Individuals and households may also respond to population aging through increased investment in human capital, such as through education and training. Even while a more aged population can lead to a smaller workforce, investment in education can make this workforce more effective. Lower fertility rates lead to fewer children per family, and these children are typically healthier and better educated. Healthy, well-educated children generally grow up to be more productive adults.¹⁶ A workforce with higher human capital has the potential to lead to increased productivity, wages, and standards of living.¹⁷ Other human-capital investments in health will generally also lead to more productive working adults, offsetting the reduction in the labor force as adults age and fertility rates decline.

While reduced fertility rates have shrunk workforces in some countries, lower fertility has also facilitated greater labor-force participation by women. In that sense, lower fertility is tantamount to an increase in the effective labor force. This will further offset the negative effects of population aging on workforce numbers. Older people may also choose to work beyond the statutory retirement age, further mitigating this challenge. In the United States,

Figure 3
Savings by Age in Developed and Developing Countries

David E.
Bloom,
David
Canning
& Alyssa
Lubet



Source: David E. Bloom, Somnath Chatterji, Paul Kowal, Peter Lloyd-Sherlock, Martin McKee, Bernd Rechel, Larry Rosenberg, and James P. Smith, "Macroeconomic Implications of Population Ageing and Selected Policy Responses," *The Lancet* 385 (9968) (2015): 649 – 657.

labor-force participation rates of older individuals have been increasing for the past two decades, especially among those with higher levels of schooling.¹⁸

In addition to individuals and households, businesses can respond to population aging by adjusting human resource protocols and implementing technological innovations to assist and incentivize older workers. As older people make up greater numbers of the workforce, businesses can shift human resources practices to meet older employees' needs for flexible roles and schedules. Other developments may include reallocating more physically demanding tasks to younger employees, offering opportunities for continuing education of older employees, and instituting

worker wellness programs as a way of investing in employee health to cut down on health care and absenteeism costs.¹⁹ Firms may also take advantage of new business opportunities that will accompany population aging, such as the design and marketing of products and services geared toward older adults.

With respect to public policy, it is natural for people to respond to longer and healthier lifespans by planning on longer working lives. But since most of the world's social security systems create strong incentives for retirement between the ages of sixty and sixty-five, public policy has been extremely sluggish in adapting to new demographic realities. For example, data on public pension systems in twenty-three

Downloaded from http://direct.mit.edu/daed/article-pdf/144/2/80/1830565/daed_a_00332.pdf by guest on 30 March 2023

European countries between 1965 and 2005 show that while male life expectancy in those countries increased by an average of seven years, the mean legal retirement age did not change.²⁰ Fortunately, several countries – including France, Ireland, Greece, Sweden, and the United Kingdom – have recently raised the normal legal retirement age or have increased incentives to delay retirement.

Some countries have also considered adjusting their pension systems. For example, in Norway, new cohorts of older people will receive a pension calculated as the accumulated entitlement divided by a life expectancy indicator. Thus, as life expectancy increases, the annual pension will decrease.²¹ In addition, some countries are moving toward fully funded systems in which contributions are saved in real assets that generate future pension income, rather than simply transferring contributions of the young to finance pension receipts of the old. Countries could also encourage and complement behavioral shifts by investing in schooling that will enlarge the effective labor force or by emphasizing healthy living and disease prevention throughout life.²²

Institutional changes are also needed to address the new demographic realities. Government-initiated policies and educational programs to promote financial literacy among older adults may help them make better choices about the forms, accessibility, and security of their assets. Older people must make these choices while facing uncertainty about individual longevity and the availability of government benefits; furthermore, they must make these choices during a phase of life that is associated with reduced cognitive function.

Health system reform also has great potential to mitigate the negative effects of population aging; in 2002, the United Nations' *Madrid International Plan of Action on Ageing* called on governments to recognize

“the growing needs of an ageing population” by way of new policies geared toward the health of older adults.²³ In developing countries, especially those in which family and social structures are undergoing rapid transformations, there is a great need for developing basic packages of cost-effective health services suited to the needs of older people, including a realignment of primary health care programs to match changing demographic and epidemiological patterns.²⁴ There is also opportunity to reform health care financing mechanisms to ensure greater fairness and sustainability while also promoting risk pooling and increasing efficiency. This has the potential to reduce the fiscal pressures associated with an older population, and will improve the lives of older individuals by providing access to more and better services. In more-developed countries, a greater concern is securing coverage for the costs and services associated with long-term care. Governments could consider reducing reliance on costly institutional care by promoting self-care, in-home caretaker training, and other services that would enable older people to remain in their own homes.

Reforming health education and research is an important health systems-related solution. Currently, most medical curricula focus on disease cures and specialization. A potential source of cost savings and increased quality of life is to reorient medical education toward a holistic emphasis on prevention and early detection, especially given the increased burden of NCDs and the prevalence of multimorbidity. An additional focus on healthy living and a general understanding of comorbidities, treatment interactions, and palliative and end-of-life care, as well as research on the physical and cognitive transitions associated with aging, would meet the needs of the growing elderly population.

On a larger scale, international migration policies have the potential to ameliorate the economic effects of population aging, insofar as youthful developing-country populations can fill job vacancies in aging developed countries. The bottom-heavy population pyramids of Africa and the top-heavy pyramids of Europe fit together hand in glove. However, integrating the two over the next twenty-five years would require immigrant flows from Africa to Europe that are more than ten times higher than current levels.²⁵ Unfortunately, most countries have gone in the opposite direction and have instituted barriers to immigration, usually in an effort to protect their economies from low-wage workers, to preserve traditions, to maintain cultural and ethnic homogeneity, or to respond to anti-immigrant sentiments. Meanwhile, Japan, another of the world's most rapidly aging countries, has also had difficulty attracting even highly skilled migrant labor, in part due to language and cultural factors and corporate promotion and pension systems designed around lifetime, rather than medium-to-long term, employment.²⁶ It will be necessary to re-evaluate these priorities in order to produce migration policies that can meet both the employment demand of young workers from developing countries and the care needs of older people in developed countries.

Encouraging research on population aging will lead to long-term solutions; there are still many unanswered questions in this field. A great source of data for current and future research lies in the family of Health and Retirement Studies (HRS). Beginning with the first HRS in the United States, these longitudinal studies aim to collect rich and detailed data sets on older adults and their families, covering everything from physical and mental health to economic status and life histories. Countries with the most rapidly aging popula-

tions – including Japan, Korea, and those in the European Union – run their own ongoing sister studies, allowing for international harmonization and comparisons. More recently, low-income and middle-income countries such as South Africa, China, and India have also begun their own HRS surveys, which will provide a valuable look at population aging in emerging economies, for which data of this type are sorely lacking.

Counteracting the potential negative consequences of population aging will involve some combination of behavioral and policy changes. These may include increased rates of savings during the working years; increased labor supply from women, older people, and immigrants; thoughtful policy programs; increased retirement ages; and other adjustments. The combination of interventions chosen will determine how costs are divided among current and future generations of older people. Countries can ensure a smoother transition to an older population by initiating policy and institutional reforms sooner.

The solutions explored above may not only ameliorate the potential economic burden of population aging, but may also enhance the well-being of older people, which is an independently valuable result. Increased longevity can also be of great benefit to society. Older people are repositories of work experience, knowledge, and culture. Regarding them as a resource is critical to cultivating a more effective workforce and offsetting labor shortages. In a globalized world where knowledge and human capital provide an advantage, the experience of older workers is valuable.

Positive perceptions of aging individuals, their overall integration with society, and mitigation of ageist beliefs will also benefit their quality of life. Indeed, subjective well-being – life satisfaction, feel-

*David E. Bloom,
David Canning
& Alyssa Lubet*

ings of happiness, and sense of purpose and meaning in life – has been shown to be closely related to physical health, a link that is particularly important at older ages and is associated with longer survival.²⁷ Shifting the perspective away from an ageist view of burden and diminished value and toward a positive view of older people who offer experience, wisdom, and leadership will enhance their lives and lead to behaviors and policies with the power to resolve or offset the challenges presented by aging.

Adopting policies that allow for healthy living throughout life and into old age will encourage this more positive perspective to take hold. Population aging has vastly different potential for benefit or harm to societies depending on whether aging populations are independent and healthy or are disabled and in need of costly long-term care. As discussed above, it remains to be seen whether increased longevity will introduce improved quality of life and a higher proportion of healthy years. While disability traditionally does increase along with age, research in the United States has

shown that in recent decades the incidence of disability at older ages is declining.²⁸ Policy interventions can reinforce this growing trend: higher socioeconomic status and higher levels of education among older men and women across multiple countries correlates with reduced disability and chronic disease incidence.²⁹ Higher education levels and improved health at older ages has led to such sayings as “seventy is the new sixty,” a sentiment reinforced by findings that the average self-reported health of a sixty-nine-year-old man in the United States in the 2000s was the same as that of a sixty-year-old man in the 1970s.

Although demographic change is daunting and has historically introduced significant obstacles to societal cohesion and economic growth, the bottom line is that demography is not destiny. Individuals, businesses, and governments have the option to adapt in the face of change, and many solutions are within reach. The sooner policy changes are considered and implemented, the sooner population aging can transform from a challenge into an opportunity.

ENDNOTES

* Contributor Biographies: DAVID E. BLOOM, a Fellow of the American Academy since 2005, is the Clarence James Gamble Professor of Economics and Demography in the Department of Global Health and Population at the Harvard T.H. Chan School of Public Health. His many publications include recent articles in such journals as *JAMA: The Journal of the American Medical Association*, *Finance & Development*, and *Science*.

DAVID CANNING is the Richard Saltonstall Professor of Population Sciences and Professor of Economics and International Health in the Department of Global Health and Population at the Harvard T.H. Chan School of Public Health. His many publications include recent articles in such journals as *Journal of Political Economy*, *Journal of Applied Statistics*, and *Journal of International Development*.

ALYSSA LUBET is a Research Assistant in the Department of Global Health and Population at the Harvard T.H. Chan School of Public Health. Her research interests include economics, women’s health and reproductive health, and population studies.

Authors’ Note: Preparation of this manuscript was supported by Harvard University’s Program on the Global Demography of Aging, which receives funding from the National Institute on Aging, Grant No. 1 P30 AG024409-09.

- 1 Unless otherwise stated, population figures are drawn from United Nations Department of Economic and Social Affairs Population Division, Population Estimates and Projections Section, *World Population Prospects: The 2012 Revision* (New York: United Nations Department of Economic and Social Affairs, 2014), <http://esa.un.org/unpd/wpp/index.htm>. David E. Bloom,
David Canning
& Alyssa Lubet
- 2 Colin D. Mathers, Gretchen A. Stevens, Ties Boerma, Richard A. White, and Martin I. Tobias, "Causes of International Increases in Older Age Life Expectancy," *The Lancet* 6736 (14) (2014).
- 3 Martin J. Prince, Fan Wu, Yanfei Guo, Luis M. Gutierrez Robledo, Martin O'Donnell, Richard Sullivan, and Salim Yusuf, "The Burden of Disease in Older People and Implications for Health Policy and Practice," *The Lancet* 6736 (14) (2014): 100–111.
- 4 Sube Banerjee, "Multimorbidity – Older Adults Need Health Care that Can Count Past One," *The Lancet* 6736 (14) (2014).
- 5 David E. Bloom, Elizabeth T. Cafiero-Fonseca, Mark E. McGovern, Klaus Prettnner, Anderson Stanciole, Jonathan Weiss, Samuel Bakkila, and Larry Rosenberg, "The Macroeconomic Impact of Non-Communicable Diseases in China and India: Estimates, Projections, and Comparisons," *The Journal of the Economics of Ageing* 4 (2014): 100–111.
- 6 James F. Fries, "The Compression of Morbidity," *The Milbank Memorial Fund Quarterly* 61 (3) (1983): 397–419, reprinted under the same title in *The Milbank Quarterly* (83) (4) (2005): 801–823.
- 7 Stacy L. Andersen, Paola Sebastiani, Daniel A. Dworkis, Lori Feldman, and Thomas T. Perls, "Health Span Approximates Life Span Among Many Supercentenarians: Compression of Morbidity at the Approximate Limit of Life Span," *The Journals of Gerontology: Biological Sciences & Medical Sciences* 67 (4) (2012): 395–405; James F. Fries, Bonnie Bruce, and Eliza Chakravarty, "Compression of Morbidity 1980–2011: A Focused Review of Paradigms and Progress," *Journal of Aging Research* 2011 (2011); and Riccardo E. Marioni, Michael J. Valenzuela, Ardo van den Hout, Carol Brayne, Fiona E. Matthews, and the MRC Cognitive Function and Ageing Study, "Active Cognitive Lifestyle is Associated with Positive Cognitive Health Transitions and Compression of Morbidity from Age Sixty-Five," *PLOS One* 7 (12) (2012): e50940.
- 8 Eileen M. Crimmins and Hiram Beltrán-Sánchez, "Mortality and Morbidity Trends: Is There Compression of Morbidity?" *The Journals of Gerontology: Psychological Sciences & Social Sciences* 66 (1) (2010): 75–86.
- 9 Somnath Chatterji, Julie Byles, David Cutler, Teresa Seeman, and Emese Verdes, "Health, Functioning, and Disability in Older Adults – Present Status and Future Implications," *The Lancet* 6736 (14) (2014).
- 10 David E. Bloom, Axel Boersch-Supan, Patrick McGee, and Atsushi Seike, *Population Aging: Facts, Challenges and Responses*, Program on the Global Demography of Aging Working Paper No. 71 (Cambridge, Mass.: Harvard School of Public Health, 2012), <http://www.hsph.harvard.edu/pgda/working.htm>.
- 11 International Labour Organization, *ILOSTAT Database* (Geneva: International Labour Organization, 2014), <http://www.ilo.org/ilostat>.
- 12 Benedict J. Clements, David Coady, Frank Eich, Sanjeev Gupta, Alvar Kangur, Baoping Shang, and Mauricio Soto, *The Challenge of Public Pension Reform in Advanced and Emerging Market Economies*, International Monetary Fund Occasional Paper 275 (Washington, D.C.: International Monetary Fund, 2012).
- 13 David E. Bloom, David Canning, and Günther Fink, "Implications of Population Ageing for Economic Growth" *Oxford Review of Economic Policy* 26 (4) (2010): 583–612.
- 14 The World Bank, "World Bank Open Data," <http://data.worldbank.org> (accessed January 26, 2015).
- 15 David E. Bloom, Somnath Chatterji, Paul Kowal, Peter Lloyd-Sherlock, Martin McKee, Bernd Rechel, Larry Rosenberg, and James P. Smith, "Macroeconomic Implications of Population Ageing and Selected Policy Responses," *The Lancet* 6736 (14) (2014): 1–9.

- 16 Gary S. Becker and Nigel Tomes, "Child Endowments and the Quantity and Quality of Children," *Journal of Political Economy* 84 (4, pt. 2) (1976): S143 – S162.
- 17 Klaus Prettner, David E. Bloom, and Holger Strulik, "Declining Fertility and Economic Well-Being: Do Education and Health Ride to the Rescue?" *Labour Economics* 22 (C) (2013): 70 – 79.
- 18 Henry Aaron and Gary Burtless, eds., *Closing the Deficit: How Much Can Later Retirement Help?* (Washington, D.C.: The Brookings Institution, 2013).
- 19 David Bloom and David Canning, "How Companies Must Adapt for an Aging Workforce," *Harvard Business Review*, December 3, 2012, <https://hbr.org/2012/12/how-companies-must-adapt-for-a/>.
- 20 The World Bank, "World Bank Open Data."
- 21 Organisation for Economic Co-operation and Development, "Linking Pensions to Life Expectancy," in *Pensions at a Glance 2011: Retirement-Income Systems in OECD and G20 Countries* (Paris: OECD Publishing, 2011), <http://www.oecd-ilibrary.org/docserver/download/8111011e.pdf?expires=1422285516&id=id&accname=guest&checksum=CB440CD4A7F88CoE9274E171B76C99BD>.
- 22 Clements et al., *The Challenge of Public Pension Reform in Advanced and Emerging Market Economies*; and Ronald Lee and Andrew Mason, "Fertility, Human Capital, and Economic Growth over the Demographic Transition," *European Journal of Population* 26 (2) (2010): 159 – 182.
- 23 The United Nations, *Political Declaration and Madrid International Plan of Action on Ageing*, Second World Assembly on Ageing, Madrid, Spain, April 8 – 12, 2002.
- 24 David E. Bloom and Karen N. Eggleston, "The Economic Implications of Population Ageing in China and India: Introduction to the Special Issue," *The Journal of the Economics of Ageing* 4 (2014): 1 – 7.
- 25 David Bloom, David Canning, and Jaypee Sevilla, *The Demographic Dividend: A New Perspective on the Economic Consequences of Population Change* (Santa Monica, Calif.: RAND Corporation, 2002), http://www.rand.org/pubs/monograph_reports/MR1274.html.
- 26 Nana Oishi, "The Limits of Immigration Policies: The Challenges of Highly Skilled Migration in Japan," *American Behavioral Scientist* 56 (8) (2012): 1080 – 1100.
- 27 Andrew Steptoe, Angus Deaton, and Arthur A. Stone, "Subjective Wellbeing, Health, and Ageing," *The Lancet* 6736 (13) (2014).
- 28 National Research Council of the National Academies, Committee on the Long-Run Macroeconomic Effects of the Aging U.S. Population, *Aging and the Macroeconomy: Long-Term Implications of an Older Population* (Washington, D.C.: The National Academies Press, 2012).
- 29 Ahmad Reza Hosseinpoor, Jennifer Stewart Williams, Ben Jann, Paul Kowal, Alana Officer, Aleksandra Posarac, and Somnath Chatterji, "Social Determinants of Sex Differences in Disability Among Older Adults: A Multi-Country Decomposition Analysis Using the World Health Survey," *International Journal for Equity in Health* 11 (52) (2012).