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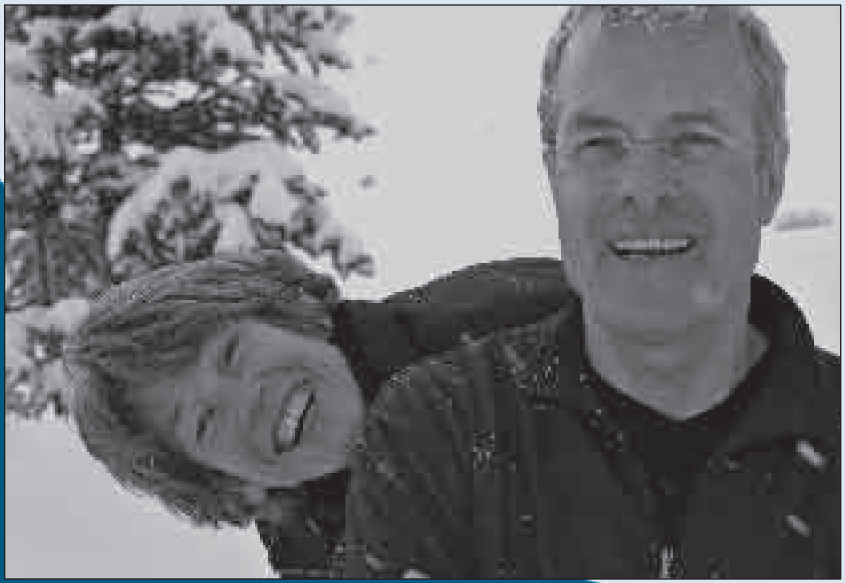
Rethinking Age and Aging

by Warren Sanderson and Sergei Scherbov



- '40 is the new 30' – more than just a catchy phrase.
- With increases in life expectancy, public policy must account for the number of years individuals will live after a given age.
- New measures of population aging introduced.

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Rethinking Age and Aging

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Rethinking Age and Aging

by Warren Sanderson and Sergei Scherbov

According to the United Nations (UN), "Population ageing is unprecedented, without parallel in human history and the twenty-first century will witness even more rapid ageing than did the century just past."[1] In contrast to the growth of interest in and concern about population aging, the concepts used in analyzing it have remained static.

With advances in health and life expectancy, measuring population aging presents a problem to demographers because the meaning of the number of years lived has changed. In western Europe in 1800, for example, less than 25 percent of males would survive to age 60, while today more than 90 percent of them do. A 60-year-old man in western Europe today has around the same remaining life expectancy as a 43-year-old man in 1800. Today, a person who is 60 is considered middle-aged; in 1800, that 60-year-old was elderly. Older people are regularly doing things that were the province of younger people only a few years earlier. Now, 80-year-olds get knee replacements so they can continue hiking. Older people tend to have fewer disabilities than people of the same age in earlier decades, and now there is some evidence that cognitive decline is being postponed as well.[2]

The media have recognized this change. We often read that "40 is the new 30," but this is more than just a pop culture phrase. It is a challenge to demographers to rethink how they measure a population's age and the pace of aging.

This *Population Bulletin* illustrates how to use new measures of population aging that take into account changes in longevity over time and place. First, we discuss the surprising history of life expectancy change within the last 150 years. Because of increases in life expectancies, it is misleading to compare those who are chronologically age 40 today with people who were 40 a century ago. Second, we introduce the concept of "prospective age" as a way to compare people who live in periods and places where life expectancies differ. Finally, we build on the concept of prospective age in developing alternative definitions of median age, the elderly population, and old-age dependency ratios.

Older people live longer and more active lives than ever before, challenging assumptions embedded in conventional measurement of population aging.

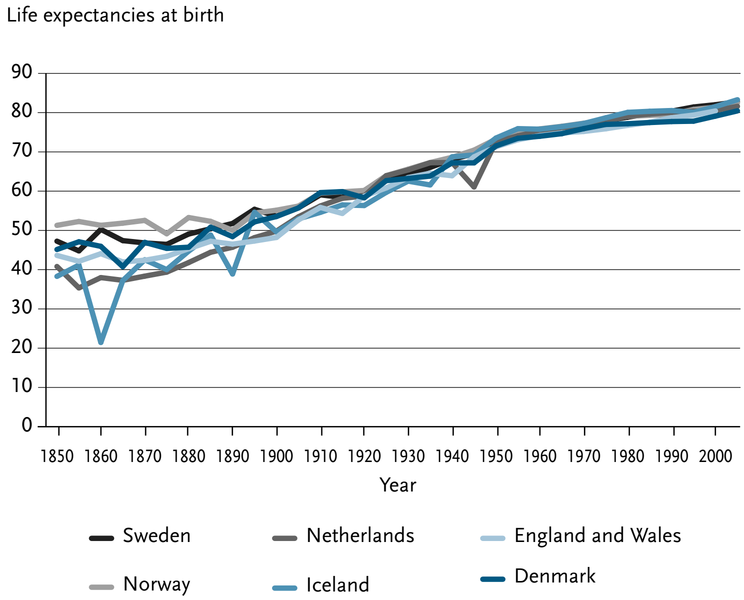
The Concept of Age

The concept of age has become more complicated because life expectancy has increased and people at each age have had progressively more remaining years of life. As people modified their behavior to reflect these changes, 40-year-olds began to act more like 30-year-olds had acted in the past. The key to understanding how 40 could be the new 30 lies in the history of life expectancy change (see Figure 1, page 4).

Increases in life expectancy cannot be separated from improvements in health. The UN estimates and forecasts life expectancy at birth for all countries from 1950 to 2050, but statistics on health are sparse and often quite subjective. Because of the paucity of consistent data on health, we do not take health status into account here. When we discuss life expectancy increases, we are also talking about general improvements in health.

Although life expectancies have changed substantially over time and vary widely across countries, measures of aging based on chronological age do not take these variations into account. Two commonly used indicators of aging—the proportion of the population ages 65 and older and the old-age dependency ratio—assume that people become old at age 65. But generally, 65-year-olds today live longer than 65-year-olds in the past. A third commonly used indicator, median age, suffers from the

Figure 1
Life Expectancies at Birth, Females, 1850–2005



Source: University of California, Berkeley and Max Planck Institute for Demographic Research, *Human Mortality Database* (www.mortality.org and www.humanmortality.de, accessed Feb. 1, 2008).

same drawback. If today's median population age is 40, is this really the same as a median age of 30 in the past?

In a recent article in *Nature*, we provided the scientific underpinning for understanding how 40 can be the new 30.[3] Our work suggests that now is the time to shift to new ways of thinking about both age and aging. To facilitate such new thinking, we have produced a set of data with three new measures of population aging: the counterparts of the proportion of the population ages 65 and older, the old-age dependency ratio, and the median age. All three new measures are adjusted to take into account differences in life expectancy. The new data cover all countries from 1955 to 2045. A subset of these new data for major regions of the world are in Table 2 (page 10). The complete data set for all countries in the world is online at www.prb.org/Publications/PopulationBulletins/2008/globalaging.aspx.

Perhaps the most innovative feature of our approach is that we think about people as simultaneously having two ages. One is chronological age—the number of birthdays a person already has had. The second is prospective age—based on the number of birthdays a person can expect to have. That future number is their remaining life expectancy. With two different age concepts, a person can be both 40 and 30 at the same time.

Demography is a quantitative discipline. Demographers inform us about population histories and possible futures through numbers. The numbers used in their tables and graphs have built-in assumptions. By studying population aging and formulating policies in terms of measures that count 65-year-old people in 1900 as being effectively as old as 65-year-old people in 2000, demographers are making a strong and often unjustified assumption about the nature of population aging. They are asserting that, regardless of improvements in health and longevity, 65-year-olds in 1900 and 2000 should be treated identically. In our measures of aging, 65-year-olds in 1900 and 2000 would have different prospective ages and therefore would not be treated as having the same age. Over the next century, 65 could become the new 50.

Life Expectancy Then and Now

One of the greatest accomplishments of humankind in the last 150 years is the increase in life expectancy at birth. Life expectancy figures go back to 1850 only for a handful of countries, but the story they tell is dramatic.[4] Life expectancy at birth for a Swedish woman in 1850 was 47 years. By 2000, it was 82 years. The increase for Dutch women was even more rapid. In 1850, their life expectancy was 41 years and in 2000 it was 81, almost double. The increase for men was just as spectacular. Even though the increase was large, the continuation of life expectancy increases throughout the 20th century was unanticipated by many demographers.[5]

The pace of increase in life expectancies in more developed countries has not slowed over the last half-century. Although somewhat controversial, there is an emerging consensus among demographers that there is little reason to expect a generalized slowdown in the near future.[6]

For most countries, the history of life expectancy change since 1950 has been one of catching up to the countries with the highest life expectancies. But not all countries are catching up, and some are falling behind. For example, the recent life expectancy decreases in Kenya and South Africa are due to the spread of HIV/AIDS. In Russia, the decline began prior to the spread of that disease and has more to do with the deterioration of general social and economic conditions. In these cases, where life expectancies have declined, 30 may be the new 40.

Perhaps even more surprising than the increases in life expectancy at birth is the unabated upward trend in life expectancies at age 65. These increases are shown in Figure 2 for women in Australia, Italy, Japan, and western Germany. From 1970 to 2002 in Australia, Italy, and western Germany, life expectancy at age 65 increased at a rate of around 1.6 years per decade. In Japan, it increased at an amazing 2.3 years per decade. Regular increases in life expectancies at older ages in most countries of the world are now the norm.

Prospective Age

The notion that 40 is the new 30 implies that people have two ages. A person can currently be 40, but in some other mode of accounting may also be 30. Is this notion just confusing what really ought to be a simple matter or is there real substance to the idea? Can demographers really think about age in two dimensions?

In 1984, economist Victor Fuchs suggested that people have two different ages.[7] Borrowing from the common distinction in economics between values measured in current prices (nominal values) and those adjusted for inflation (real values), Fuchs suggested people have "nominal" and "real" ages. Nominal ages were chronological ages and real ages were ages adjusted for life expectancy or changes in mortality rates. In 2005, we independently reinvented Fuchs' proposed "real age" and provided examples of how it could be consistently measured over time and across countries.

Figure 3 illustrates our concept of two ages. Life expectancies in these figures are measured in the traditional way using period life tables. Period life tables reflect mortality risks in a particular year. We usually refer to life expectancy at an age other than at birth as "remaining life expectancy." We use remaining life expectancy here to avoid confusion between life expectancy at birth and life expectancies at other ages.

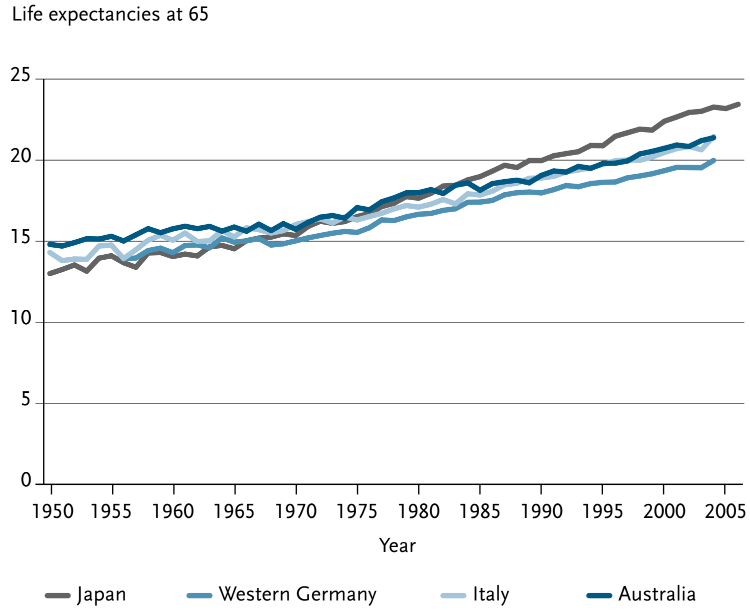
Figure 3 shows information about French women. The top bar in Panel A illustrates the life course of women born in 1922 who survived to age 30. In 1952, these women had a remaining life expectancy of 44.7 years. The bottom bar illustrates the life course of women born in 1975, who survived to age 30 in 2005. In 2005, they had a life expectancy of 54.4 years. If you asked the first group of women how old they were in 1952 and the second how old they were in 2005, women in both groups would answer that they were 30 years old. And indeed, women in both groups would have lived 30 years.

Although women in both groups had lived the same number of years, their remaining life expectancies were quite different. On average, the 30-year-olds in 2005 had a remaining life expectancy of 54.4 years—9.7 more years than the 30-year-olds in 1952. Have women in the two groups aged at the same rate if their remaining life expectancies are so different?

We designed the bars in Panel A so that the lengths of the left-hand segments were the same, in this case 30 years. When we did this, the lengths of the right-hand segments (remaining life expectancies) had to be different. Panel B shows an alternative perspective: The right-hand segments (remaining life expectancies) are the same length and left-hand segments (chronological age) vary.

Figure 2

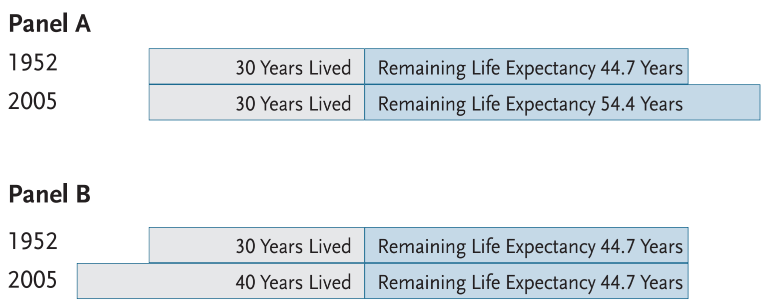
Life Expectancies at Age 65, Females, 1950–2005



Source: University of California, Berkeley and Max Planck Institute for Demographic Research, *Human Mortality Database* (www.mortality.org and www.humanmortality.de, accessed Feb. 1, 2008).

Figure 3

Remaining Life Expectancy Among French Women, 1952 and 2005



Source: University of California, Berkeley and Max Planck Institute for Demographic Research, *Human Mortality Database* (www.mortality.org and www.humanmortality.de, accessed Feb. 1, 2008).

In Panel B, the top bar again refers to French women who were 30 years old in 1952. They had a remaining life expectancy at that time of 44.7 years. The bottom bar again refers to women in 2005. Now, we make the right-hand portion of the bar (remaining life expectancy) just as long as it was for the 30-year-old women in 1952 (44.7 years). But French women in 2005 who had a remaining life expectancy of 44.7 years were 40 years old.

In one sense, 30-year-old women in 1952 had aged as much as 40-year-old women had in 2005 because both groups had the same remaining life expectancy. So, 40 is the new 30, or to be more technically accurate, 40-year-old French women in 2005 had the same remaining life expectancy as 30-year-old French women had in 1952. When we measure age using 1952 as a base, we find that French women who were 40 years old in 2005 would have a *prospective* age of 30 because they had the same remaining life expectancy as 30-year-old French women in 1952. We call our new age measure prospective age because it assigns ages to people on the basis of their remaining life expectancies in a reference year, not on the number of years that they have already lived.

Although this sort of thinking is rarely used in demography, it is used every day in economics, where quantities are measured both before and after adjustment for inflation (see Box 1).

Prospective age is important because it affects how people live their lives and plan for the future. People with high prospective ages are less likely to invest in new skills and less likely to invest their savings based on a long-run rate of return.

In the United States, the increasing remaining life expectancies of older people interact with changes in the design of pension plans and retirement planning (see Box 2). Prospective age is also important for the design of public policies with respect to the elderly. New academic research on what individuals estimate their remaining life expectancy to be holds the promise of connecting those expectations forward to various types of behavior and backward to aggregate levels of remaining life expectancies.

While prospective age is a new way of thinking about age and aging, it is not the only useful perspective. Chronological age also remains important. A 40-year-old French woman in 2005 has the same remaining life expectancy as a 30-year-old French woman had in 1952, but she does not have the same remaining years of fecundity. French women who were 40 in 2005 had much more difficulty conceiving and giving birth to children than 30-year-old French women did in 1952. Increased life expectancy has not

Box 1

Adjusting Median Age for Life Expectancy

If you were told that a pair of shoes would cost $500 50 years from now, would you be able to tell whether those shoes were cheap or expensive? Certainly not. Adjusting for inflation, those shoes might cost $30 in today's prices or perhaps $300. If you were told that a person was 65 years old 50 years from now, would you be able to tell whether that person was old or not? Certainly not. People at age 65, 50 years from now, could have a remaining life expectancy of five years or 35 years.

Economists deal with the issue of inflation all the time. In economics, constant dollars are used to compare values from one period to another by taking inflation into account. Prospective age serves an analogous purpose by comparing ages and taking the increase in life expectancy into account. Any kind of financial data that can be represented in dollar terms can be converted into constant dollars by using an appropriate price index. Demographers can follow a similar procedure and convert chronological age into prospective age using appropriate life tables.

Adjusting Current Median Age for Life Expectancy

	U.S. GDP, current dollars (billions)	U.S. GDP, 2000 dollars (billions)	U.S. median age, current chronological ages	U.S. median age, prospective ages based on the 2000 life table
1955	414.8	2,212.8	30.2	36.3
2005	12,421.9	10,989.5	36.1	35.5

Sources: U.S. GDP figures from U.S. Bureau of Economic Analysis, "U.S. Economic Accounts" (www.bea.gov, accessed Aug. 7, 2008); and median ages from authors' calculations using University of California, Berkeley and Max Planck Institute for Demographic Research, *Human Mortality Database* (www.mortality.org and www.humanmortality.de, accessed Feb. 1, 2008).

Without taking inflation into account, the gross domestic product of the United States rose from $415 billion in 1955 to $12 trillion in 2005.[1] When the figures are adjusted for inflation and reported as if prices were at the levels found in the year 2000, the increase is much lower. The median age of the U.S. population increased from 30.2 years in 1955 to 36.1 years in 2005, when chronological ages are used. When prospective ages are used, based on the life table of 2000, the median age of the U.S. population actually decreases a bit. This decrease indicates that people at the median age in 2005 had a longer remaining life expectancy than people at the median age in 1955.

When we compare the gross domestic products of different countries, it is useful to measure them using a standard set of prices, for example, the prices in the United States in 2000. When comparing aging measures across countries, it is also useful to use one standard life table, such as that of the United States in 2000.

Reference

1. The gross domestic product of a country is the value of all the goods and services produced within the borders of that country during a particular period of time, usually a year.

Box 2

Life Expectancy and When to Retire

The decision of when to retire is complex and has recently grown more complicated in the United States. In the last decade, as life expectancies have continued to increase, defined benefit pension plans have become less common and defined contribution plans more common. In defined benefit plans, retirees know the pension payment that they will receive in the future. In defined contribution plans, those payments depend on the returns on the assets in which the contributions were invested. In essence, risk has been shifted from pension providers to pension recipients. The greater uncertainty of pension payouts interacts with the longer retirement times associated with increasing remaining life expectancies because the uncertainty in investment returns increases over time. The additional uncertainty of pension income among those people with defined contribution pension plans is likely to be one factor that leads them to retire later.

Reference

Pierre-Carl Michaud and Susan Rohwedder, "Forecasting Labor Force Participation and Economic Resources of Early Baby Boomers," *Michigan Retirement Research Center Working Paper* WP 2008: 175.

Table 1
Computation of Prospective Age of a 54-Year-Old Australian Male (Using 2000 as a Base Year)

Age in 1950	Life expectancy at age 54 in 1950	Age in 2000	Life expectancy at indicated age in 2000
		60	21.27
		61	20.43
54	19.63	62	19.63
		63	18.82
		64	18.03

Source: University of California, Berkeley and Max Planck Institute for Demographic Research, *Human Mortality Database* (www.mortality.org and www.humanmortality.de, accessed Feb. 1, 2008).

transformed all aspects of our lives, and it is best to use the age concept most appropriate to the context.

Computing prospective age is a simple matter. It only requires matching remaining life expectancies in two life tables. This is shown in Table 1. Australian males who were 54 years old in 1950 had a remaining life expectancy of 19.6 years. To find their prospective age, we assume a base year, 2000 in this example, and look up the age of men who had the same life expectancy in 2000. As can be seen from the table, 62-year-old men in 2000 had exactly the same life expectancy as 54-year-old men did in 1950. In other words, using 2000 as our reference year, the prospective age of a 54-year-old Australian man in 1950 was 62. For Australian men in 2000, 62 was the new 54.

Defining Old Age

Once analysts can think about age from two perspectives, a backward-looking one and a forward-looking one, new ways to assess aging become possible. When analysts compute the likely number of elderly people who will live in a country, should they count this group on the basis of chronological age or prospective age? With two measures of age, just how old do you have to be to be considered old?

It is commonly said that you are only as old as you feel. But if demographers took that view seriously they would have to give up much of their work. Feelings, besides being difficult to quantify, are individual-based measures. Life expectancy is a population-based measure. A person could be in an age group where remaining life expectancy is 30 years and die tomorrow. Life expectancies do not tell us anything about individuals, only about populations. Using prospective age instead of chronological age is a way to implement a population-based concept of old age that takes into account improvements in health and life expectancy.

With the enormous variability in life expectancies at older ages across countries and over time, a fixed age threshold for classifying people as old has not reflected reality. These fixed ages were established initially as rough approximations and have produced measures of population aging comparable across countries and time. Fixed ages, while they are useful, are not the only way to provide approximations. Aging measures based on fixed prospective ages are just as easy to compute and in many cases are more relevant. Measures that do not take variations in remaining life expectancies into account can miss an essential element. Aging is not only about the fact that people in a population are, on average, older. It also means that these older people are healthier and have longer remaining life expectancies than their earlier counterparts.

An alternative to having a fixed age at which people are categorized as old is to define old age as beginning at some threshold level of remaining life expectancy. This theory was first offered by Norman Ryder in 1975; he recommended that old age be considered to begin when remaining life expectancy fell below 10 years. Fuchs followed with a more complete analysis in 1984. In 1993, Jacob Siegel suggested the possibility of using a remaining life expectancy of either 10 or 15 years to demarcate the boundary of old age. He showed what those boundaries would be in the United States for the years 1940 to 1985 and what they were likely to be from 1990 to 2030. To our knowledge, in 2008, Wolfgang Lutz and we did the first computation of the proportions of the elderly in the world and in the populations of major regions, basing the onset of old age on remaining years of life expectancy.[8]

Choosing to define old age as beginning at some remaining life expectancy threshold is equivalent to defining it as occurring at a fixed prospective age. Thus, there are two ways of defining old age: an old-age threshold based on chronological age and one based on prospective age. Here we define old age as beginning when people are at ages where remaining life expectancy is 15 or fewer years.[9]

Each country has its own history of when people could be considered to be old, a history that could be different for men and women, and a history that depends on social and economic changes, public health improvements, and personal consumption choices (such as cigarette smoking). Simply considering men and women old when they reach age 65 ignores this history.

Counting people as old when their remaining life expectancy is 15 or fewer years may not be the best way to determine which individuals are old. We could count people as being old depending on a host of physical, mental, social, economic, and emotional factors, but we have little information about how to do this. We could also set different numbers of remaining years of life in different countries. To take an arbitrary example, we could say that people fall into the category of being old when they are at ages with a remaining life expectancy of 10 years or less in Switzerland and 17 or less in Swaziland. But we would have no basis on which to make such distinctions.

Counting people as old depending on the number of years people in their age group have yet to live is a simple population-based measure, and it has the advantage of being possible to calculate for all the countries for which the UN produces data. We have computed the new old-age thresholds using UN estimates going back to 1955 and UN forecasts through 2045. This allows us to retell the histories of aging in each country in a richer way and to look at the future of aging from a new perspective. (The complete set of data with these thresholds and other measures presented below are available at www.prb.org/Publications/PopulationBulletins/2008/globalaging.aspx.)

There is already a demand for new measures of aging based on prospective age. Prospective median age has already been chosen as one of the basic demographic indicators to monitor as part of the implementation strategy of the Madrid International Plan of Action on Aging.[10] Using prospective age to define target populations for social programs has the potential to make better use of both public and private resources.

With a fixed age for being considered old, public and private assistance may be directed at individuals who are much better off than the elderly were when a fixed age for eligibility was established. For example, eligibility for U.S. Medicare programs was set at age 65 in 1965. If that age were adjusted for life expectancy change beginning in 2004, the eligibility age in 2050 would be 68 for men and 67 for women.[11] As life expectancy increases, the age at which physical care is needed gets pushed back. With a definition of old that uses variable age based on life expectancy, public and private resources for the elderly may be better targeted at a larger or smaller proportion of the population.

Demographers study aging using a number of indicators. Three of the most widely used are the proportion of the population ages 65 and older, the old-age dependency ratio, and the median age of the population.[12] In the next section, we look at the history and the likely future of population aging using these three conventional measures and three analogous ones based on prospective ages that take life expectancy change into account.

Population Aging Measures

The Proportion of Elderly

One common indicator of population aging is the proportion of elderly in the population. Frequently, this is computed using the ratio of people who are 65 and older (or 60 and older) to the total population, and is often supplemented with the ratio of the “oldest-old” (80 and above) to the total population. For simplicity, we take as our conventional measure the ratio of people 65 and older to the total population. We compare it to a new measure of the proportion of the population who are old: the ratio of those in age groups where remaining life expectancy is 15 years or less to the total population. The conventional measure looks at aging from the perspective of the number of years lived. The new measure looks at aging from the perspective of the number of years left to live.

Both the conventional measure and our new measure are influenced by life expectancy because both depend on the age structure of the population. If, for example, mortality rates at older ages fall, then, other things constant, the proportion of older people in the population will increase. The conventional measure looks at aging from the perspective of the number of years already lived and therefore uses a fixed chronological age cutoff, such as 65, to determine who is old. Changes in life expectancy influence the proportion age 65 or older. When mortality rates fall, there are additional older people, and these older people have longer remaining life expectancies. People at age 65 might have a remaining life expectancy of 13 years before the decline in mortality rates and 17 years after the decline. Because of this, the new measure would count the 65-year-olds as being elderly in the original higher-mortality environment, but not in the later lower-mortality one.

Figure 4 shows the proportion of the world’s population who are 65 and older (Prop. 65+) and the proportion at ages with remaining life expectancies of 15 or fewer years (Prop. RLE 15-). The conventional measure, Prop. 65+, begins with 5.3 percent of the world’s population in 1955 and rises slowly to 7.4 percent in 2005. During the next two decades, the predicted share rises by 2 percentage points to 9.4 percent but then rises much more rapidly to 15.2 percent in 2045. Prop. 65+ is almost three times as high in 2045 as it was in 1955.

In contrast, Prop. RLE 15- shows the share of the elderly at 8.0 percent in 1955 and falling to 6.4 percent in 1990. For a decade and a half, the share roughly stabilizes, then begins to increase slowly to 2025 when it returns to the 8.0 percent level, the same as in 1995. After 2025, the share rises more rapidly, reaching 10.9 percent in 2045.

Both measures show acceleration in the pace of aging starting around 2015, but otherwise the patterns are quite different. Using the conventional measure, the world's population was aging immediately after 1955. When the life expectancy adjusted measure (Prop. RLE 15-) is used, it appears that the world's population was actually getting younger. Using RLE 15-, the proportion of elderly in the population is predicted to be the same in 2025 as it was in 1955. Prop. 65+ indicates that the share of elderly is 4.1 percentage points higher than in 1955. Overall, the conventional measures predict that the share of elderly in the world population will rise by 9.9 percentage points from 1955 to 2045, and Prop. RLE 15- , the measure adjusted for life expectancy, predicts an increase of 2.9 percentage points.

The two indicators of aging for more developed regions are similar for the period from 1955 to 1975 and then begin to diverge. In 2005, Prop. 65+ indicates that 15.3 percent of the population is old, while Prop. RLE 15- shows only 11.7 percent (see Table 2, page 10). There is some acceleration in the pace of aging predicted in those regions starting around 2010 followed by some deceleration beginning around 2030. Both measures predict significant aging for the period from 2005 to 2045. Prop 65+ signals a larger increase, 10 percentage points, than the 4.7 percent points estimated with Prop. RLE 15-. The histories and predicted futures of aging in the more developed regions are roughly similar for both measures, but because Prop. RLE 15- takes life expectancy increase into account, it shows a slower pace of aging.

In less developed countries, the history of aging is different depending on the measure used. Based on Prop. 65+, the share of elderly increases from 3.9 percent in 1955 to 5.5 percent in 2005, indicating a slow process of population aging. Prop. RLE 15-, on the other hand, shows the share decreasing from 7.9 percent in 1955 to 5.6 percent in 2005. Although the two indicators differ in their direction of change in the historical period, they tell the same story about the future. Both show considerable increases in the share of the older population from 2005 to 2045. In the developing regions, aging is certainly speeding up, even after accounting for life expectancy change.

The two indicators differ in their direction of change in the least developed countries during the historical period, while both show increases in aging going forward to 2045. Prop. RLE 15- is considerably higher in 1955 than Prop. 65, because remaining life expectancies at age 65 in those countries in 1955 were well below 15 years and so the threshold age for being considered old was younger than 65. The rapid decline in Prop. RLE 15- after 1955 is due to the rapid increase in life expectancies at older ages in those countries. While we think of life expectancy increase in the least developed countries after 1955 as resulting mainly from decreases in infant mortality, these numbers show consequential increases in the longevity of older people as well.

The Old-Age Dependency Ratio

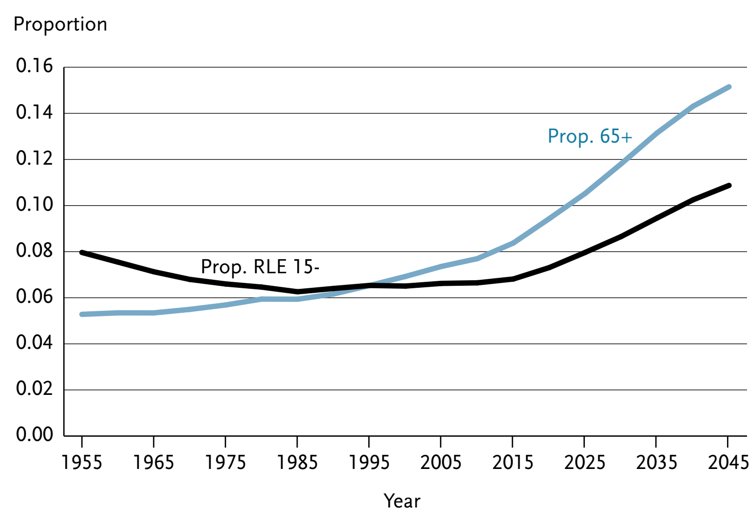
In this section, we analyze old-age dependency ratios. The Conventional Old-Age Dependency Ratio (OADR) is defined here as the ratio of the number of people 65 years or older to the number of people ages 20 through 64:

$$\text{OADR} = \frac{\text{Number of people 65 years or older}}{\text{Number of people ages 20 to 64}}$$

Minor variations of this definition for the old-age dependency ratio are found in demography. Sometimes the proportion of people 60 or older is used in the numerator, sometimes 15 is used as the lower bound on the ages of people in the denominator, or sometimes the ratio is multiplied by 100.[13]

The ideas that we have discussed can be used to produce a new old-age dependency ratio that accounts for life expectancy change. We call this new measure the Prospective Old-Age Dependency Ratio (POADR). To define it, we first find the old-age threshold—the age at which remaining life expectancy falls below 15 years. POADR is

Figure 4
Proportion of the World's Population 65+ vs. the Proportion at Ages With Remaining Life Expectancies of 15 Years or Less



Sources: United Nations (UN), Department of Economic and Social Affairs, Population Division, *World Population Prospects: The 2004 Revision* (2005); and authors' calculations.

Table 2
Conventional and Prospective Measures of Population Aging for Major World Regions, 2005 and 2045

	Median age		Prospective median age (PMA) (U.S. in 2000 as a reference)		Percent of the population 65+ (Prop. 65+ x 100)		Percent of the population at ages with remaining life expectancy 15 years or less (Prop. RLE 15- x 100)		Age at which remaining life expectancy is 15 years		Conventional age dependency ratio (OADR) x100		Prospective age dependency ratio (POADR) x100	
	2005	2045	2005	2045	2005	2045	2005	2045	2005	2045	2005	2045	2005	2045
WORLD	**28.1**	**37.1**	**27.5**	**31.8**	**7.4**	**15.2**	**6.6**	**10.9**	**66.3**	**69.8**	**13.3**	**26.5**	**11.9**	**17.7**
More developed regions	38.6	45.5	37.9	39.8	15.3	25.3	11.8	16.2	68.7	72.8	25.1	47.0	18.2	25.7
Less developed regions	25.6	35.7	25.1	29.7	5.5	13.5	5.6	10.2	64.8	68.9	10.3	23.4	10.5	16.8
Least developed countries	18.9	26.1	18.3	17.0	3.2	5.8	4.3	5.5	61.9	65.6	7.3	10.7	10.0	10.1
Other less developed countries (excluding least developed countries)	26.8	38.3	26.2	32.4	5.9	15.6	5.9	11.6	65.0	69.2	10.7	26.5	10.7	18.6
Less developed regions (excluding China)	23.3	33.6	22.8	26.7	4.8	11.3	5.0	8.5	64.5	68.6	9.5	19.5	9.9	13.9
Sub-Saharan Africa	**18.0**	**24.6**	**18.9**	**14.2**	**3.1**	**4.7**	**4.3**	**4.8**	**61.6**	**65.0**	**7.4**	**8.8**	**10.4**	**8.9**
AFRICA	**18.9**	**26.1**	**19.5**	**16.6**	**3.4**	**5.8**	**4.4**	**5.3**	**62.2**	**65.9**	**7.7**	**10.7**	**10.1**	**9.8**
Eastern Africa	17.5	24.3	17.4	12.2	3.0	4.5	3.9	4.4	62.0	65.2	7.2	8.5	9.8	8.3
Middle Africa	16.8	21.6	16.7	12.8	2.9	3.5	4.3	3.9	60.8	63.9	7.3	7.0	11.1	7.9
Northern Africa	23.0	34.6	22.3	28.9	4.6	12.0	5.0	9.3	64.0	67.9	8.9	20.3	9.7	15.1
Southern Africa	23.0	28.6	41.4	29.1	4.2	8.3	5.4	7.5	62.4	66.7	8.1	14.5	10.7	12.8
Western Africa	17.6	25.6	18.0	15.3	3.0	4.9	4.4	5.1	61.1	64.6	7.3	8.8	10.9	9.3
ASIA	**27.7**	**39.0**	**26.9**	**33.4**	**6.4**	**16.2**	**6.3**	**12.2**	**65.3**	**69.2**	**11.4**	**27.7**	**11.1**	**19.5**
Eastern Asia	33.5	45.5	32.5	40.4	8.7	24.1	7.7	17.9	66.4	70.3	14.0	43.5	12.3	29.2
South-central Asia	23.5	35.6	22.8	28.8	4.9	12.0	5.5	9.4	63.8	68.1	9.5	19.9	10.7	14.8
Southeast Asia	25.7	38.8	24.8	32.4	5.3	15.3	5.7	12.0	64.1	68.1	9.6	25.7	10.5	19.1
Western Asia	23.6	34.0	22.9	28.2	4.5	11.5	4.9	8.8	64.1	68.2	8.8	19.4	9.5	14.3
EUROPE	**39.0**	**47.2**	**38.3**	**41.4**	**15.9**	**26.6**	**13.4**	**18.0**	**67.5**	**71.8**	**25.9**	**49.7**	**20.9**	**29.0**
Eastern Europe	37.5	47.3	37.1	41.1	14.2	24.0	15.0	19.0	64.0	68.4	22.7	42.4	24.4	30.9
Northern Europe	38.9	43.8	38.1	38.5	15.8	23.7	12.3	15.6	68.8	72.7	26.4	43.5	19.5	24.9
Southern Europe	39.8	50.4	39.1	45.6	17.5	31.8	13.1	19.6	69.5	73.3	28.3	63.8	19.7	31.5
Western Europe	40.7	46.7	40.0	41.7	17.4	27.6	12.3	18.2	69.9	73.5	28.8	53.0	18.8	29.6
LATIN AMERICA AND THE CARIBBEAN	**25.9**	**38.5**	**24.9**	**32.8**	**6.1**	**16.7**	**4.6**	**10.0**	**68.5**	**72.0**	**11.2**	**28.7**	**8.2**	**15.5**
Central America	24.0	38.9	23.1	34.1	5.1	16.6	3.6	9.6	69.1	72.1	9.9	28.7	6.8	14.8
South America	26.4	38.4	25.4	32.4	6.3	16.6	4.8	10.0	68.3	72.0	11.5	28.5	8.5	15.5
NORTH AMERICA	**36.3**	**41.1**	**35.7**	**36.5**	**12.4**	**20.8**	**9.1**	**13.3**	**69.8**	**72.8**	**20.7**	**37.1**	**14.3**	**21.0**

Sources: All our data, including those at www.prb.org/Publications/PopulationBulletins/2008/globalaging.aspx, are based on the UN, Department of Economic and Social Affairs, Population Division, *World Population Prospects: The 2004 Revision*, (2005), volumes 1, 2, and 3. We used the *2004 Revision* because this was the latest year for which the past and future life tables were available to us. Users should be cautious about interpreting the results for developing countries with poor quality statistical data, including many in sub-Saharan Africa and a few in Asia. The data follow all the UN naming conventions and cover all the countries and regions included in the *2004 Revision*. The UN data cover the period 1950 to 2050. The UN provides life expectancies for five-year periods. The first is 1950–55 and the last is 2045–50. The information that we use for 1955, for example, is based on an interpolation between figures for 1950–55 and 1955–60. Because we have to use interpolated information, we lose the earliest and latest UN dates.

the ratio of the number of people above the old-age threshold to the number from age 20 to the old-age threshold:

$$\text{POADR} = \frac{\text{Number of people older than the Old-Age Threshold}}{\text{Number of people ages 20 to the Old-Age Threshold}}$$

Figure 5 shows conventional OADRs and POADRs for the world, more developed countries, less developed countries, and least developed countries. The numerators in the conventional OADR are the same numbers as in Prop. 65+, but the denominators differ. Similarly, the numerators in the POADR are the same as the numbers in the numerator of Prop. RLE 15-. In the conventional OADR, people are counted in the numerator if they are 65 or older, regardless of the remaining life expectancy at that age. In the POADR, only those people who are in age groups with 15 or fewer years of remaining life expectancy are counted. As we would expect from the similarities in their formulas, the patterns are similar to those described above for the proportion of elderly.

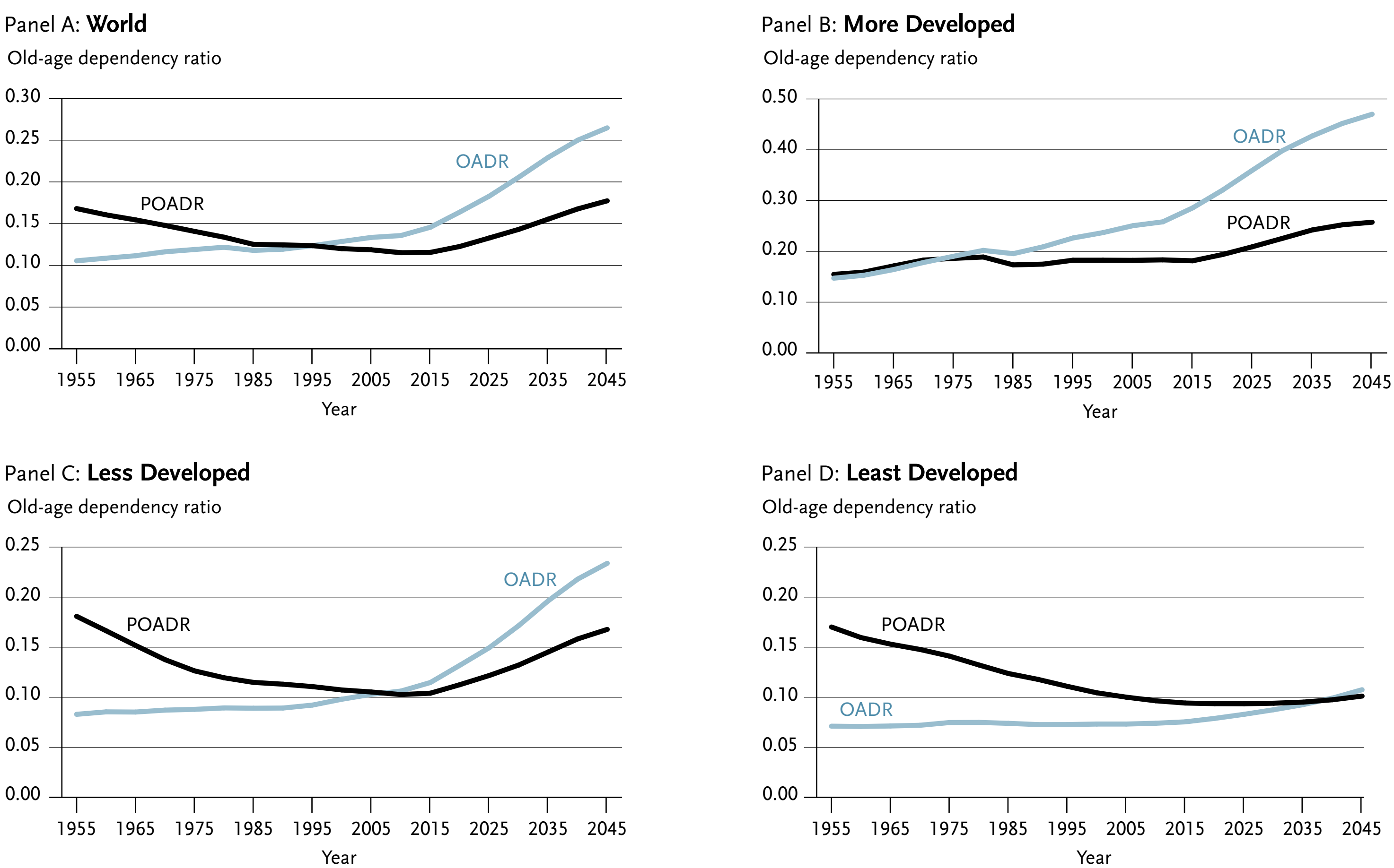
Table 2 provides data on the two old-age dependency ratios for major world regions. Europe is the oldest region. The conventional OADR in Europe rises from 0.150 in 1955 to a predicted value of 0.497 in 2045. The POADR starts at about the same level in 1955, but increases to a much more modest 0.290 by 2045. (Data for 1955 are not in Table 2 and may be found at www.prb.org/Publications/PopulationBulletins/2008/globalaging.aspx.)

Africa is the youngest region. The conventional OADR in Africa rises slowly from 0.071 in 1955 to 0.107 in 2045. According to the POADR, the figure falls from 1955 to 2005 and then roughly stabilizes. However, the quality of the data for some African countries is poor and may have affected these estimates.

North America is an example of a region between the two extremes of Europe and Africa. Using the conventional OADR as an indicator of population aging, we find it rising from 0.159 in 1955 to 0.207 in 2005 and then to 0.371 in 2045. The POADR falls from 0.188 in 1955 to 0.143 in 2005 and then rises to 0.210 in 2045. We expect to see aging in North America regardless of which

Figure 5

Conventional and Prospective Old-Age Dependency Ratios by Major Region, 1955–2045



Sources: United Nations (UN), Department of Economic and Social Affairs, Population Division, *World Population Prospects: The 2004 Revision* (2005); and authors' calculations.

Table 3
Conventional and Prospective Old-Age Dependency Ratios, Selected Countries, 1955, 1980, 2005, 2025, and 2045

	1955	1980	2005	2025	2045
China					
OADR	0.093	0.097	0.122	0.219	0.410
POADR	0.215	0.117	0.122	0.174	0.298
Germany					
OADR	0.180	0.272	0.308	0.411	0.548
POADR	0.201	0.267	0.198	0.233	0.326
Japan					
OADR	0.103	0.150	0.323	0.540	0.750
POADR	0.103	0.117	0.160	0.254	0.269
Russia					
OADR	0.114	0.171	0.220	0.290	0.369
POADR	0.111	0.182	0.249	0.277	0.296
United States					
OADR	0.160	0.196	0.206	0.311	0.360
POADR	0.191	0.173	0.145	0.170	0.207

Sources: United Nations (UN), Department of Economic and Social Affairs, Population Division, *World Population Prospects: The 2004 Revision* (2005); and authors' calculations.

old-age dependency ratio we use. But using the POADR, we would expect the burden of old-age dependency to be only marginally greater there in 2045 than it was in 1955.

To make comparison easier, we present data for five countries in Table 3. Japan is now one of the oldest countries in the world, and using conventional measures it is expected to remain so through 2050. In 2045, the predicted conventional OADR for Japan is 0.750. In other words, the UN predicts that by 2045, for every four Japanese ages 20 to 64, there will be three Japanese age 65 or older. The nearest competitor included in the table (but not among all countries, as noted in Box 3) in 2045 is Germany, which has a much lower conventional OADR of 0.548. At this rate for every two Germans in the age range 20 to 64, there will be around one German age 65 or older. The next two oldest countries in the table using the conventional measure are China and Russia.

What should we conclude from these conventional old-age dependency ratios? Would the old-age dependency burden in 2045 be much greater in Japan than in Germany and would China and Russia have lower old-age dependency burdens? Not necessarily. The picture changes when we take life expectancy changes into account. In 2045, the oldest country in Table 3 is no longer Japan. According to the POADR, the oldest country is Germany. China and Russia are virtually tied for second and third place. Japan comes in fourth. Now, for every four Japanese adults in 2045 who are not old, there will be around one Japanese elderly person to care for, not the three that we would expect on the basis of the conventional OADR.

From a purely demographic point of view, Japan is not expected to have a particularly high old-age dependency ratio once life expectancy changes are taken into account. Using POADR, the Germans have even more cause for worry about population aging than the Japanese do.

Another interesting comparison is between Russia and the United States. According to the UN, the conventional OADRs in the two countries would be about the same in 2045, but the POADR is considerably lower in the United States than in Russia. This is a reflection of higher adult mortality rates in Russia.

Median Age

The third common measure of aging is median age, where half the people in a country are younger than the median age and half are older. Changes in median ages are often used to chart how fast a country or region is aging. The distinction between chronological and prospective age made earlier in this *Population Bulletin* can immediately be applied to median ages.

Imagine a country where the median age in 1960 is 30. If the prospective age of a 30-year-old in 1960 is 40, the prospective median age of the country in 1960 would be defined to be 40. To find prospective median age, first find the median age in a country and then find the prospective age corresponding to that age. The prospective median age of a country in a particular year is simply the prospective age of median-aged persons in the country in that year.

Because there are no cohort life tables for every country in the world, we compute prospective median ages here using period life tables. In an earlier publication, we show that prospective median ages are very close to the same regardless of whether they are measured using period or cohort life tables.[14]

Just as economists can compute the outputs of many countries using a common currency in order to compare them properly, demographers can calculate prospective median ages of different countries using a common life table as a reference, in this case that of the United States in 2000.When we computed RLE 15- and POADR, we did not use a common life table as a reference. Those figures can be meaningfully compared across countries without such a standard. For example, the proportion of the population in ages where remaining life expectancies are 15 years or less in one country can naturally be compared to the same ratio in another country. The computation of RLE 15- and POADR do not require the choice of a standard life table. On the other hand, to compute prospective median age we have to choose a standard life table. If we took two different life tables as standards, one for each country, no informative comparison could be made because any difference would depend on how the standard tables compared to one another.

Box 3

The 10 Oldest Countries in the World, 2005 and 2045

Using the conventional old-age dependency ratio (OADR), the three oldest countries in the world in 2005 were Italy, Japan, and Germany (see tables). In 2045, Germany drops out of the list and is replaced by Spain. The conventional OADRs of Italy and Japan roughly double over the 40-year period.

When we look at the oldest countries in the world adjusting for differences in life expectancy, we get an entirely different view of the situation in 2005. Instead of Italy and Japan being the oldest countries, Ukraine and Bulgaria are. They combine old populations and comparatively low life expectancies. Only two countries, Croatia and Latvia, are on both top 10 lists in 2005. Using the POADR, we see that the oldest countries in the world in 2005 were all in eastern Europe.

Ukraine and Bulgaria are forecasted to remain the oldest countries in the world using the POADR in 2045. Italy reappears in the list in third place. In addition, Singapore, Cuba, Slovenia, and the Czech Republic are also expected to be among the 10 oldest countries in the world regardless of which measure is used.

What does it mean when countries such as Ukraine or Bulgaria have the highest POADRs, but not the highest OADRs? In these cases, low life expectancies at older ages make the difference. The UN forecasts of remaining life expectancies of 65-year-old men in Bulgaria and Ukraine in 2005–2010 are 13 years and 12 years, respectively. In the UN's southern Europe region in 2005–2010, the corresponding remaining life expectancy was 16.3 years. Bulgaria and Ukraine have older populations, according to their prospective ages, because of the two countries' shorter remaining lifetimes of the elderly.

Eastern European governments, in their drive to increase the legal age for receiving full public pensions, often use the argument that in many western countries the legal ages are higher. One possible policy reform would be to raise the full public pension age for men in Ukraine to 65. Here is a case where presenting a prospective age measure could be informative. A 65-year-old Ukrainian male in 2008 would have around the same prospective age as a 69-year-old American male in that year, and immediately raising the age at receiving a full Social Security pension in the United States to 69 is certainly out of the question. This international comparison is also relevant in policy formulation.

One way to deal with high OADRs is to increase the eligibility age for various public programs, such as pensions. The comparison of the OADRs and POADRs teaches us a different lesson. One important set of polices in countries such as Bulgaria and Ukraine is to make their older population effectively younger by improving their health and longevity, which are currently low by international standards.

The 10 Oldest Countries in the World According to the Conventional Old-Age Dependency Ratio

2005	OADR	2045	OADR
Italy	0.327	Italy	0.757
Japan	0.323	Japan	0.750
Germany	0.308	Spain	0.678
Belgium	0.294	Republic of Korea	0.634
Greece	0.293	Singapore	0.619
Sweden	0.293	Cuba	0.599
France	0.282	Slovenia	0.598
Croatia	0.282	Austria	0.584
Latvia	0.280	Czech Republic	0.582
Portugal	0.278	Portugal	0.576

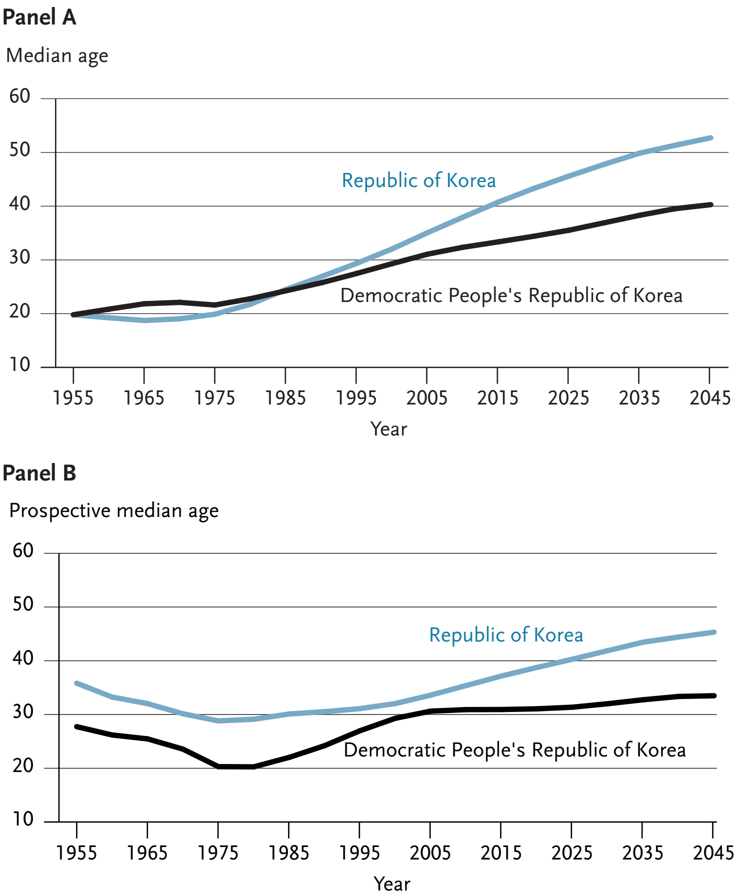
The 10 Oldest Countries in the World According to the Prospective Old-Age Dependency Ratio

2005	POADR	2045	POADR
Ukraine	0.294	Ukraine	0.364
Bulgaria	0.283	Bulgaria	0.363
Belarus	0.265	Italy	0.359
Estonia	0.254	Singapore	0.353
Croatia	0.254	Cuba	0.353
Russian Federation	0.249	Romania	0.340
Georgia	0.246	Bosnia and Herzegovina	0.339
Romania	0.245	Georgia	0.335
Latvia	0.241	Slovenia	0.330
Serbia and Montenegro	0.232	Czech Republic	0.329

Sources: United Nations (UN), Department of Economic and Social Affairs, Population Division, *World Population Prospects: The 2004 Revision* (2005); and authors' calculations.

Figure 6

Conventional and Prospective Median Ages, North and South Korea, 1955–2045



Sources: United Nations (UN), Department of Economic and Social Affairs, Population Division, *World Population Prospects: The 2004 Revision* (2005); and authors' calculations.

We illustrate the effects, over time and place, of adjusting median ages for life expectancy increase by contrasting the Democratic People's Republic of Korea with the Republic of Korea.

The Democratic People's Republic of Korea (North Korea) and the Republic of Korea (South Korea) were a single country until the end of World War II in 1945. Figure 6 shows the history and possible future of aging in the two countries. In 1955, the median ages of the two countries were about the same (Panel A). North Korea initially ages more quickly, but soon South Korea begins to age more rapidly. This continues throughout the period and by 2045, South Korea would have a median age more than 10 years higher than the one in North Korea.

Contrast the trajectory of median ages with the view that we would get using prospective median ages (Panel B). The chronological median ages of the two countries are similar in 1955, but in the same year, South Korea's prospective median age is already eight years higher than North Korea's. The prospective median ages of the two countries follow a similar pattern until 1980. Between 1980 and 2005, the difference between their prospective median ages diminished. After 2005, the prospective median ages are expected to drift further apart.

New Thinking Applied to Policy

Older people today are more active than in previous generations. Athletes are now playing at close to the top of their game at later ages, and 70-year-olds are climbing Mt. Everest. Advertisements by financial planners now tell people that they have to save more to help finance a lengthening period of retirement.

Until recently, demographers and policymakers have been stuck with measuring aging without taking into account the "40 is the new 30" phenomenon. None of the tools available to them, such as the proportion of elderly in the population, the old-age dependency ratio, or the median age, adjust for increases in life expectancy. When improvements in health and longevity are not taken into account, 65-year-olds in 1900 are effectively considered to be as old as 65-year-olds in 2000.

But the new measures described in this *Population Bulletin* take life expectancy differences into account. Using UN data, we have calculated those measures for every country, major region, and the world as a whole over the period 1955 to 2045. A subset of the data is in the center table, and the full data is online at www.prb.org/Publications/Population Bulletins/2008/globalaging.aspx.

What use are new concepts like prospective age? Some researchers suggest that prospective ages could be used in government programs affecting the older population.[15] The interesting question is how to do this.

A fixed chronological age for receiving a normal pension is unfair to younger generations. As life expectancies increase, generations pay into the pension system for a fixed number of years, but receive benefits over ever-lengthening periods of retirement. But a fixed prospective age for receiving a normal pension is unfair to older generations. As life expectancies increase, they would have to pay into the pension system for more and more years, only to receive benefits over a fixed average period. Averaging chronological and prospective ages can produce an intergenerationally fair normal pension age.[16] This guarantees that additional years of life expectancy are shared between an increasing number of years of pension receipt and an increasing number of years of pension contribution.

Right now, the age for receiving a full Social Security pension in the United States is increasing. As it happens, this increase is generally quite consistent with ages suggested by averaging chronological and prospective ages. However, current legislation calls for increases in the normal pension age to end with the cohort born in 1960. But with changes in life expectancy, there should be shifts in the age of eligibility for full pension receipt even among cohorts born after 1960, if the pension system is to remain fair to younger and older generations.

Formulating policies for the elderly using prospective ages has an important benefit because longevity increases are uncertain and can even reverse. In the United States, the age for receiving a normal Social Security pension is going to increase regardless of whether or not the life expectancies of the recipient groups increase or decrease. If the obesity and diabetes epidemics in the United States cause the remaining life expectancies of older people to decrease, then those unfortunate generations would be doubly hit by the combination of declines in remaining life expectancies and increases in normal pension ages. If the normal pension age took prospective age into account, this problem would not occur. Decreases in remaining life expectancies would result in decreasing ages at a full Social Security pension. Each year of decrease in life expectancy would result in both the number of years of pension contribution and the number of years of pension receipt being reduced by less than one year.

Another area where prospective age can enter the policy dialogue is in the discussion of political attitudes. Jackson and Howe write: "The graying of the developed world's electorates could . . . have more consequences . . . than the graying of their economies."[17] As populations age, will politicians tend to shy away from investments that have a payoff farther in the future and concentrate more on those with shorter-term payoffs? At first glance, this might seem likely. The median age of the voting population in the United States will increase from 43.3 years in 2000 to around 50.5 years in 2050.[18] One interpretation is that this increase of 7.2 years in median age could potentially translate into less concern for policies with long-run payoffs. But this interpretation ignores life expectancy change and therefore ignores the effects of possible changes on the time horizons of voters. Using the prospective median age of the U.S. voting-age population, we find that the median age will decrease from 43.3 years in 2000 to 41.7 years in 2050. In other words, although the U.S. electorate will be older in 2050 than it was in 2000, the median-aged voter will have a longer remaining life expectancy and therefore a longer time horizon than the median-aged voter had in 2000.

Some policymakers already recognize the need for measures based on prospective age. A UN review of the Madrid International Plan of Action on Aging calls for factoring increases in remaining life expectancy into the pension formula and, thus, raising the retirement age automatically with rising life expectancy:

"New concepts of prospective age and standardized median life expectancy (Sanderson and Scherbov, 2005) need to be adopted, to enable recalculation of age not chronologically from birth, but biometrically from the end of life . . . Such a reframing would permit conceptualizing the paradox that ageing societies like the ones in the ECE (European Commission for Europe) region might nevertheless grow 'younger' at the same time, if residual life expectancy at median age rises despite a simultaneous increase in the median age."[19]

This brief discussion of the applications of life expectancy-adjusted measures of age and aging is far from complete. The new indicators presented here offer choices about assumptions that underlie measures. These indicators also open up new avenues of research. We are now in a position to rethink what we thought we knew about age and aging. And it is about time.

Suggested Resources

University of California, Berkeley and Max Planck Institute for Demographic Research, *Human Mortality Database*, www.mortality.org.

Warren Sanderson and Sergei Scherbov, "A New Perspective on Population Aging," *Demographic Research* 16, no. 2 (2007): 27-58.

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8. Wolfgang Lutz, Warren Sanderson, and Sergei Scherbov, "The Coming Acceleration of Global Population Ageing," *Nature* 451, no. 7179 (2008): 716-19.
9. We do this for a pragmatic reason. Life tables for many countries are estimated on the basis of highly incomplete data. These estimates are likely to be more inaccurate at the highest ages. Choosing a remaining life expectancy of 15 years or less instead of, say, 10 years, makes our results less sensitive to those inaccuracies.
10. Michael Fuchs et al., *List of Indicators* (2008), accessed online at www.monitoringris.org/documents/tools_reg/indicators_full_list.pdf, on Aug. 7, 2008.
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13. The UN rescales the old-age dependency rate given here by multiplying it by 100.
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Glossary

Chronological age is the number of birthdays a person has already had.

Conventional Old-Age Dependency Ratio (OADR) is defined here as the ratio of the number of people 65 years or older to the number of people ages 20 through 64.

Life expectancy at birth is the average number of years members of a population can expect to live after birth.

Life expectancy at age 65 is the average number of years that members of a population can expect to live after surviving to age 65.

Median age is the age at which half the people in a country are younger than the median age and half are older.

Prospective age is the age of a person in the standard life table who has the same remaining life expectancy as the person of interest.

Prospective median age of a country in a particular year is simply the prospective age of median-aged persons in the country in that year.

Prospective Old-Age Dependency Ratio (POADR) is the ratio of the number of people above the old-age threshold to the number from age 20 to the old-age threshold.

Prospective proportion of elderly in the population (Prop. RLE 15-) is the ratio of those in age groups where remaining life expectancy is 15 years or less to the total population.

Proportion of elderly in the population (Prop. 65+) is the ratio of people 65 or older to the total population.

Remaining life expectancy refers to life expectancy at an age other than at birth.

RLE 15 is the age at which remaining life expectancy is 15 years.

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Rethinking Age and Aging

Demographers study aging using a number of indicators. Three of the most widely used are the proportion of the population ages 65 and older, the old-age dependency ratio, and the median age of the population. Until recently, demographers and policymakers have been stuck with measuring aging without taking into account the fact that older people today are, in general, more active and healthier than in previous generations. None of the usual indicators available adjust for increases in life expectancy. With advances in health and life expectancy, measuring population aging presents a problem to demographers because the meaning of the number of years lived has changed. New measures described in this *Population Bulletin* take life expectancy differences into account.

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