Four

Demography of Aging

A Century of Global Change, 1950–2050

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The Baby Boom cohort in the ethos of the United States has come to signify a rapid and imminent aging of the population. Media reports abound emphasizing the impending challenges to Social Security and Medicare once the Baby Boom enters prime retirement ages at the middle of the next decade. Explosive growth in the size of the elderly population is juxtaposed with concerns about whether elders will also be living longer in better or worse health. The challenges of population aging to American social institutions are mirrored in the perceptions and expectations of everyday Americans. Many Americans lack confidence that Social Security will provide for them in old age, anticipating a breakdown in the social contract between their parents and grandparents and the federal government (e.g., Roper Starch Worldwide, 1999). Population aging frequently is seen and portrayed as the demographic villain disrupting basic social institutions and the social contracts linking individuals to these institutions (Schulz, Borowski, & Crown, 1991).

Despite news media stories and popular perceptions, the American experience with population aging is neither unique nor extreme in the context of other countries' experiences with population aging (Easterlin, 1991; Schulz et al., 1991). Here, our basic goal is straightforward—to demonstrate that many countries will experience levels and rates of population aging unlikely to be experienced in the United States. How these countries face this demographic challenge may have implications for adapting pension and health care policy in the American context. In addition, we emphasize that population aging has become a worldwide phenomenon. The prior 50 years—the period since 1950—was the period in which demographic changes spanning at least 100 years resulted in relatively mature populations in Europe and Northern America. The next 50 years, however, are likely to bring extraordinary changes in age of populations in the developing nations—the pace of which is unprecedented in world history. The fertility and mortality revolutions that have spawned population aging will occur at a much more rapid pace in developing countries than in the developed nations that have led the trend. (For a review of the mortality and fertility revolution worldwide, see Easterlin, 1997.) As we show here, there is

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evidence pointing toward a worldwide convergence in population aging, characterized by populations containing large numbers of older persons and relatively stable in size. Whether this trend also foretells a parallel trend in the extension of the years persons can expect to live in good health is also considered.

I. Population Aging: An International Demographic Phenomenon

The year 1999 marked the period of time in world history in which the six billionth person was added to the world's population. Not surprisingly, much of the media attention was directed at the world's growing population and the comparatively high rates of fertility in developing nations. The population problem of the year, according to a variety of media, was burgeoning and young populations—especially in developing parts of the world.

Although the world added its sixth billionth citizen, a relatively quiet demographic revolution has been occurring worldwide. It is the revolution from a demographic regime of high fertility and relatively low mortality to a regime of low fertility and low mortality. Demographic regimes with high fertility and low mortality give rise to fast-growing, young populations. Demographic regimes with low fertility and low mortality result in slow growing or stable populations with a comparatively old age structure. As we will illustrate later, a number of European nations have had a demographic regime of low fertility and low mortality in place for some time, resulting in very slow growing and aged populations.

The significance of the spread of the demographic revolution from developed to developing nations was recognized by the United Nations in its declaration of 1999 as the International Year of Older Persons. Thus, while 1999 saw the addition of its six billionth citizen, this year also marked the recognition that the world as a whole is entering a phase in which populations are maturing. The United Nations designation recognized a

> '"society for all ages," in recognition of humanity's demographic coming of aging and the promise it holds for maturing attitudes and capabilities in social, economic, cultural and spiritual undertakings, not least for global peace and development in the next century'. (United Nations, 1992, 47/5 annex)

These themes were also echoed in the United Nation's Programme of Action of the International Conference on Population and Development in 1994 (United Nations, 1994).

As we suggest in this chapter, what some demographers might consider to be the last demographic revolution (i.e., the transition to a mature and stable population) is projected to occur at a pace in developing nations in the next 50 years never experienced by the developed nations who led the revolution. We illustrate past and expected future patterns of the demographic revolution worldwide by comparing demographic changes in developed and developing nations for two periods—the prior 50 years of experience and the next 50 years of projected experience. We make use of demographic data and demographic projections provided by the United Nations (United Nations, 1996a, 1996b) for the 100-year period.

Understanding the portents of the demographic revolution, particularly the declines in mortality, for international trends in the health and functioning of the older population is vital for anticipating the global demands on health-care systems and health-care costs (Robine & Romieu, 1998; Waidmann & Manton, 2000; World Health Organization, 2000). A guiding aim of the United Nations Principles for Older Persons is "to add life to the years that have been added to life" (United Nations, 1991). Does declining mortality over a number of decades within a country signify that members of population are living longer healthier lives? Or does the mortality revolution foster the lengthening of ill health prior to death? What can we learn from the experiences of developed nations in the past 50 years that can be projected to developing nations who will be aging in the next 50 years?

The answers to these questions are not as straightforward as one might presume. Conceptually, the correspondence between mortality changes and morbidity in a population is ambiguous (see Crimmins, 1996, for an overview). If mortality declines because diseases are prevented or their onset is delayed, population health will improve with the change in mortality. However, if mortality declines occur because of declines in the mortal consequences of diseases, population health is expected to decline (Crimmins, Hayward, & Saito, 1994). This idea was the impetus for Verbrugge's (1989) conceptual model to account for an apparent rise in mild disability in the United States during the 1970s—a period in which mortality was falling. Complicating this relationship between mortality and morbidity, however, is the fact that population health is multidimensional. Much of disability, for example, is a product of nonfatal chronic conditions such as arthritis and vision impairment. Among Americans at older ages, for example, about 50% of disability is an outcome of nonfatal conditions (Verbrugge & Patrick, 1995). Understanding historical changes in disability thus necessitates attention to changes in the mix of fatal and nonfatal conditions experienced by the population, and it requires knowledge of where in a disease process improvements in health are occurring.

Another important component in understanding the conceptual link between population-level mortality and morbidity is the differential progress in understanding the etiology of various diseases and associated lifestyle changes and medical interventions in disease diagnosis and treatment. Progress in one disease sphere need not be mirrored by progress in all disease spheres. Indeed, this is what should be expected given the societal decisions about the allocation of health-care resources, scientific discoveries that aid in fighting one disease but not others, and changes in population composition. These factors, as well as other sociopolitical forces, contribute to uneven changes in disease and disability prevalence in a population—changes that need not be uniformly downward (Bonneux, Barendregt, Meeter, Bonsel, & van der Maas, 1994).

Further clouding our understanding of the relationship between morbidity and mortality changes is the lack of consistent, high-quality, and nationally representative health data for a lengthy time period. The United States has the longest times series—over three decades—of the prevalence of chronic conditions available for a national population, the National Health Interview Survey (NHIS). However, changes in survey design and methodology have challenged researchers' ability to use these data to document historical trends in population health within the United States. Similar time series are unavailable for other countries. Since the 1980s, a number of longitudinal studies of health have also been fielded within the United States (e.g., the National Long-Term Care Survey, the Longitudinal Study of Aging, and the Health and Retirement Survey). These surveys are characterized by substantial differences in survey design, content, and health measurement, making it difficult to develop a precise picture of recent changes in population health. At a very general level, the bulk of these studies point to a decline in the prevalence of disability in the population during the 1980s and 1990s accompanying mortality declines for the period (Crimmins, 1998; Crimmins, Saito, & Ingegneri, 1997; Freedman & Martin, 1998; Manton, Stallard, & Corder, 1995), although the magnitude and origins of the decline remain ambiguous.

Internationally, there is growing attention to the implications of long-term declines in mortality for the health of the surviving population (e.g., Murray & Lopez, 1996; Robine & Romieu, 1998). Similar to the problems discussed above for the United States, international differences in survey design, content, the measurement of health, and calculation methods have frustrated international comparisons of population health—particularly comparisons based on the expected number of years lived in good or bad health—an indicator of population health that integrates the mortality and morbidity experiences of a population. Although a growing number of countries are calculating these types of measures, efforts to institutionalize ongoing monitoring of changes in population health are thus far largely restricted to the developed nations (e.g., Robine, Jagger, & Egidi, 2000). In large part, these efforts have been sparked by the International Network on Healthy Life Expectancy (REVES). Recognized officially by the World Health Organization (WHO), REVES is an independent organization of scholars and policymakers dedicated to promoting international consistency in the design, measurement, and calculation of health expectancy measures used in monitoring population health. An alternative approach is that by the Global Burden of Disease Group—a collaborative effort between Harvard University, WHO, and the World Bank (e.g., Murray & Lopez, 1996). This latter approach focuses more on the use of vital statistics data and demographic modeling techniques in assessing cross-national differences in population health (see Waidmann & Manton, 2000, for a more comprehensive review).

In some sense, these efforts to document the association between changes in mortality and the health of the surviving population have produced some important lessons for anticipating how global changes in population aging will influence the health of surviving populations (Crimmins, 1996). Foremost is the recognition that methodological factors are likely to cloud assessments of changes in population health—particularly when making cross-national comparisons. Methodological issues aside, international differences in health-care systems, public health goals and policies, and progress in disease fighting are likely to result in a high degree of cross-national variability in trends in population health (Murray & Lopez, 1996; World Health Organization, 2000). These factors, in combination, make it difficult to project future population health; such estimates are likely to be even more unreliable than mortality projections. Later in the discussion we review the available evidence to assess the general implications of projected trends in cross-national differences in mortality for cross-national differences in the health of the surviving population.

II. Fertility and Mortality Data for United Nations Estimates and Projections

The population estimates and projections referenced in our discussion of population aging were obtained using two educational software packages, DemoGraphics '96 and DemoTables '96. These software packages are an educational tool from the United Nations Population Fund (UNFPA), developed in association with the Netherlands Interdisciplinary Demographic Institute (NIDI) by Gerhard K.

Heilig (IIAASA), Vienna, Austria (Heilig, 1998a, 1998b). The data for the two software packages were provided by the Population Division of the United Nations Department for Economic and Social Information and Policy Analysis, and are from the *United Nations World Population Prospects, The 1996 Revision* (United Nations, 1996a, 1996b). A 1998 revision became available in 1999. Although some of the estimates differ slightly between the two revisions, the population aging trends shown here are unaffected.

We focus primarily on two major regions of the world to compare historical changes in population aging—more developed regions and less developed regions. More developed regions encompass Europe, Northern America, Japan, Australia and New Zealand. Less developed regions include all countries of Africa, Latin America and the Caribbean, Asia (excluding Japan), Melanesia, Micronesia, and Polynesia. We also provide region-specific estimates (e.g., Africa and Europe) and subregion information to demonstrate how international differences in population aging shift over the historical period 1950–2050. When pertinent to the discussion, we provide demographic estimates and projections of specific national populations.

Our analyses make use of demographic estimates of population age structures and vital rates to document the historical record since 1950. Changes in the demographic estimates over an approximately 50-year period are used to reference changes in population aging, and the sources of these changes. United Nations projections of population structure and vital rates are used to describe population aging as it is expected to be in the year 2050. Comparisons of the demographic estimates for 1995 and the projected estimates for 2050 provide the basis for making inferences about changes in population aging over the next (approximately) 50-year period. Details regarding the quality of the demographic estimates and the ways in which the projections were made can be found in *United Nations World Population Prospects, The 1996 Revision* (United Nations, 1996a, 1996b). Although the United Nations projections provide low, middle, and high variant estimates, all of our analyses in this chapter make use of the middle variant population projections for 2050.

Analysts must always approach demographic projections with skepticism. The fact that the United Nations projections were recently mirrored in projections made by the United States Census Bureau (U.S. Bureau of the Census, 1999) suggests the use of similar assumptions and data inputs rather than the calculation of reliable forecasts. Missing in the two sets of projections is a sense of the likelihood of one demographic future over another. Lee and Carter (1992) have developed a stochastic approach that provides upper and lower bounds for projections, although their approach has not been applied to the problem of forecasting global population aging into the next century. Lee and Tuljapurkar (1994) discuss the differences between their stochastic approach and the idea of uncertainty expressed in the demographic tradition of high, medium, and low variant projections. In the context of this recent methodological work, our use of the middle variant projection should not be interpreted as the most likely demographic future. It represents one of many possible futures. (Unanticipated epidemics, for example, have the potential to alter the demographic future. The HIV epidemic has led the United Nations to reduce projected declines in mortality in countries with high sero-prevalence of HIV. It is important to recognize, however, that these adjustments were done based on a strong set of assumptions rather than on a scientific model of the association between HIV prevalence and age-specific mortality rates. The anticipated increase in life expectancy in sub-Saharan Africa, for instance, could well be lower than projected—or higher.)

III. Population Age Structures around the World

In 1950, the world's population reached 2.5 billion people (see Table 4.1). The world was a place populated largely by children and adolescents—almost 44% of the total population was less than 20 years of age. Approximately 8% was 60 years of age and older, and only about 3% were 70 years of age and older. Worldwide, the elderly constituted only a small fragment of the world's population.

In 1950, however, the world was far from homogeneous with respect to population aging. The data in Table 4.1 show a number of substantial differences across countries and regions in terms of the percentage of a population that was older. More developed regions (i.e., Europe, Northern America, Japan, and Australia and New Zealand) had significantly more elderly persons in their populations relative to less developed regions (persons 60 years and older constituted 11.7% of the population in more developed regions compared to 6.4% in less developed regions).

By 1995, roughly the midpoint in the 100-year span of time we are considering, the percent of the world's population ages 60 years and older had grown only slightly from 8.1% to 9.5%. What had grown markedly since 1950, however, was the cross-national gap in population aging. Persons ages 60 years and older constituted 18.3% of the population in developed countries in 1995 compared to 11.7% in 1950—an increase of about 56%. Less developed regions, however, had aged only slightly. The percentage of persons younger than 20 years of age in 1995 was 44%—down from about 48% 50 years earlier. The percent of persons ages 60 years and older changed hardly at all—from 6.4% to 7.3%.

These figures underscore why population aging is currently viewed primarily as a social problem of developed nations. Historically, over much of the 20th century, population aging has been concentrated in more developed regions of the world. Within the more developed regions, Europe especially shows evidence of the demographic revolution to a mature population. Approximately 20% of Western and Southern Europe's populations in 1995 were 60 years of age or older. On a worldwide basis, Greece had the greatest percentage of persons older than age 60 in 1995—22.1% (results not shown). Sweden and Italy followed closely behind with 21.8% of their populations aged 60 years and older. Canada and the United States lagged significantly behind Europe—about 16% of the North American population was 60 years of age and older in 1995.

Projections to 2050 show that the percent of the world's population aged 60 years and older is expected to be about 21%—about the level of Europe presently. The percent of older persons in developed nations is expected to grow over a 50-year period from 18.3% to 31.2%—almost a third of the population. The elderly population in the United States is projected to comprise 27.1% of the nation's total population, indicating that the United States will experience much less extreme population aging compared to the majority of developed nations. The percent of older persons in developing nations is expected to grow from 7.3% to 19.2% over the same period. Less developed parts of the world in 2050 will have populations that have roughly the same age structure as developed nations in 1995 have. Developed nations are moving toward having very old populations while less developing nations are moving toward old populations.

Table 4.1
Population Distribution by Age Groups, 1950, 1995, and 2050[a]

Geographic area	Population (1000s)	1950 (% of total population)					1995 (% of total population)					2050 (% of total population)				
	Total	0–19	20–59	60+	70+	80+	0–19	20–59	60+	70+	80+	0–19	20–59	60+	70+	80+
World total	2,523,878	43.9	48.0	8.1	2.9	0.5	40.4	50.1	9.5	4.0	1.1	27.4	51.9	20.7	10.4	3.4
More developed regions	812,687	35.7	52.6	11.7	4.8	1.0	26.5	55.2	18.3	8.9	3.0	22.6	46.2	31.2	18.6	8.0
Less developed regions	1,711,191	47.8	45.8	6.4	2.1	0.3	44.0	48.8	7.3	2.7	0.6	28.0	52.7	19.2	9.2	2.8
Least developed countries	197,572	51.2	43.4	5.4	1.8	0.3	54.4	40.8	4.8	1.7	0.3	32.8	55.6	11.6	4.5	1.0
Africa	223,974	52.7	42.2	5.1	1.7	0.3	54.3	40.7	5.0	1.8	0.3	32.7	55.6	11.8	4.8	1.1
Asia	1,402,021	46.6	46.6	6.7	2.2	0.3	41.0	50.8	8.2	3.1	0.7	26.4	51.7	21.9	10.8	3.4
Eastern Asia	671,156	44.0	48.6	7.4	2.3	0.3	33.3	56.4	10.3	4.1	0.9	24.4	48.7	26.9	14.5	5.0
Europe	547,318	34.6	53.3	12.1	5.1	1.1	26.1	55.0	18.9	8.9	3.0	21.6	45.6	32.8	19.2	7.9
Southern Europe	109,012	36.9	51.8	11.3	4.7	1.1	24.4	55.4	20.2	9.5	3.1	19.5	43.3	37.2	24.3	10.6
Western Europe	140,916	30.6	54.4	15.0	6.2	1.2	23.5	56.4	20.1	10.3	3.8	21.0	44.7	34.2	21.4	10.1
Latin America and Caribbean	166,337	49.8	44.2	6.0	2.1	0.4	44.0	48.5	7.5	3.1	0.8	26.8	50.9	22.2	11.7	4.0
Northern America	171,617	34.4	53.2	12.4	4.8	1.1	28.6	55.0	16.3	8.8	3.0	24.7	47.9	27.4	16.1	7.4
Australia/New Zealand	10,127	33.8	53.6	12.6	4.9	1.1	28.8	55.7	15.5	7.9	2.4	24.5	47.8	27.7	16.6	7.1

[a]From United Nations (1996a, 1996b).

This point can be seen in Figures 4.1, 4.2, and 4.3 which show the age–sex pyramids (age–sex structures) for more developed regions and less developed regions of the world for 1950, 1995, and 2050. The young age of the population in less developed nations in 1950 is indicated by the pyramid's broad base in Figure 4.1. Note also that the pyramid quickly tapers with age, indicating proportionately fewer people at adult ages in the population—particularly past age 60. The pyramids for 1995 in Figure 4.2 show the relatively mature population of the more developed nations. The pyramid has achieved a squared look compared to that for 1950. The size of the very young age groups no longer exceeds the sizes of the prime adult population and in fact is smaller than these age groups. The pyramid for the less developed regions, however, remains distinctly broad based much like that shown for 1950.

By 2050, the pyramid for the more developed regions (see Figure 4.3) shows a projected completion of the demographic revolution as indicated by the relatively square age–sex structure. Although not indicated in Table 4.1, many countries in more developed regions are projected to stabilize and then lose population in the next 50 years. This pattern is expected to characterize countries such as the United Kingdom, Spain, Greece, Germany, the Netherlands, France, and Finland. Note that this is only a partial list. Note also that population loss will be confined nearly exclusively to Europe. The American population is expected to continue to grow, although relatively slowly during the next 50 years. By 2050, the American population is projected to be 347.5 million people—up from 267 million in 1995.

Although the projected population pyramid for less developed regions in 2050 does not match the squared shape of that for the more developed regions, its shape nonetheless indicates the remarkable achievement of a mature population. Note particularly the squared base extending into prime adult ages. The shape of the pyramid is reminiscent of that for more developed nations in 1995. Clearly, these projections reinforce the idea that the demographic revolution toward an older and more stable population will no longer be confined to more developed countries.

IV. Fertility and Mortality Changes Driving Changes in Age Structure

World fertility levels in 1950 were very high as indicated by a total fertility rate (TFR) of 5.0 (see Table 4.2). The TFR can be roughly translated as the expected number of children in a completed family. Mortality rates were also relatively high in 1950 as indicated by life expectancies at birth of 45.1 years for males and 47.6 years for females. Approximately 156 infants died out of 1000 births at that point in history.

More developed nations in 1950 were already in the midst of the fertility and mortality revolutions, having relatively low fertility and mortality rates. More developed regions had an expected completed family size of 2.8 in comparison with 6.2 in less developed regions. Life expectancy differences across the two regions also were stark. Male life expectancy in more developed regions was 63.9 and female life expectancy was 69.0. These expectancies exceeded those for less developed regions by 23.8 and 27.2 years respectively!

By 1995, world fertility had dropped precipitously with an expected completed family size of three children. Mortality also dropped considerably over the 50-year period. Life expectancy increased considerably on a worldwide basis to 62.2 years for males and 66.5 years for females. When comparing the major regions of the world, one can observe that

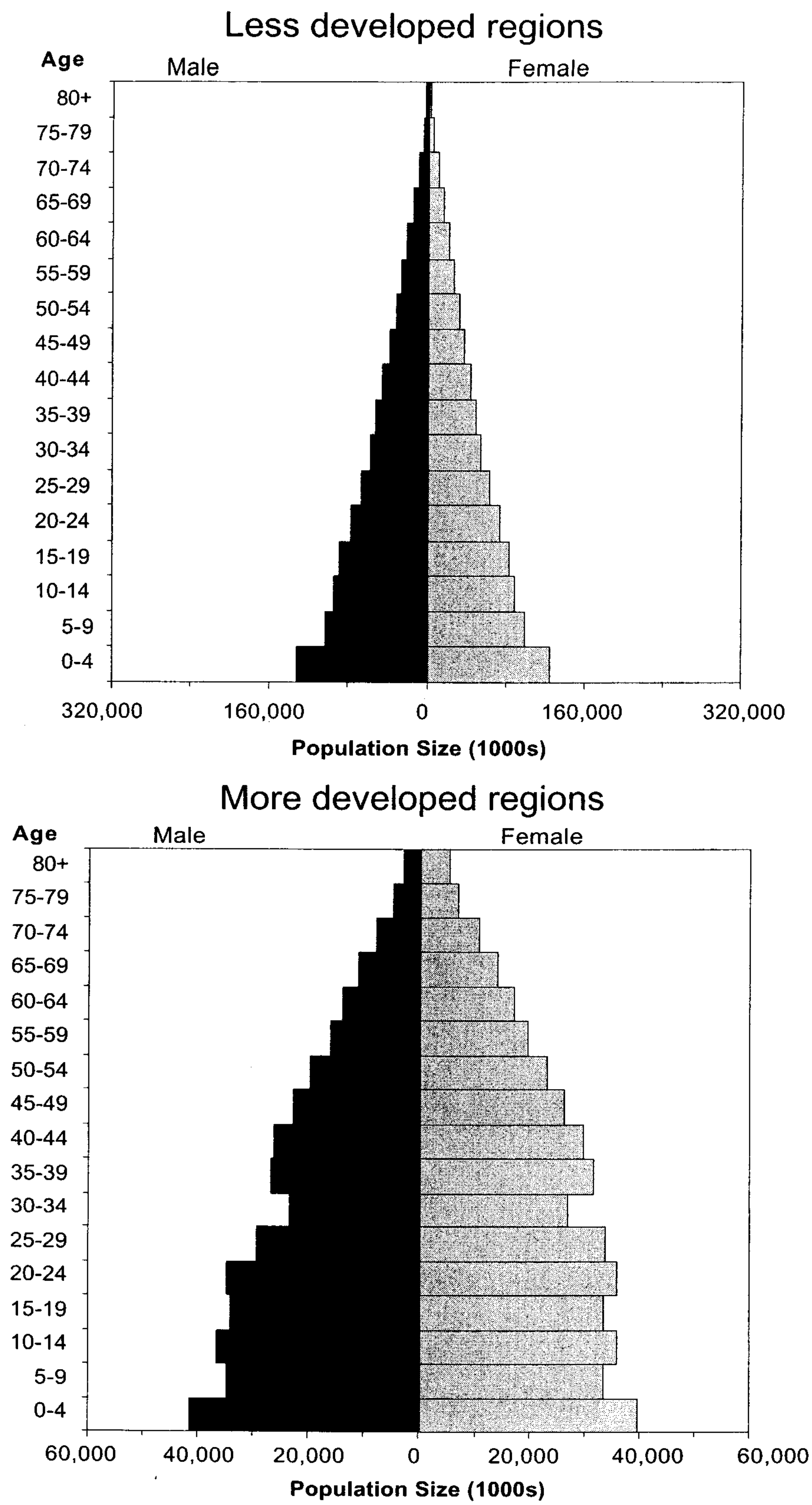

Figure 4.1 Estimates of population by age groups and sex, 1950. (From United Nations, 1996a, and 1996b.)

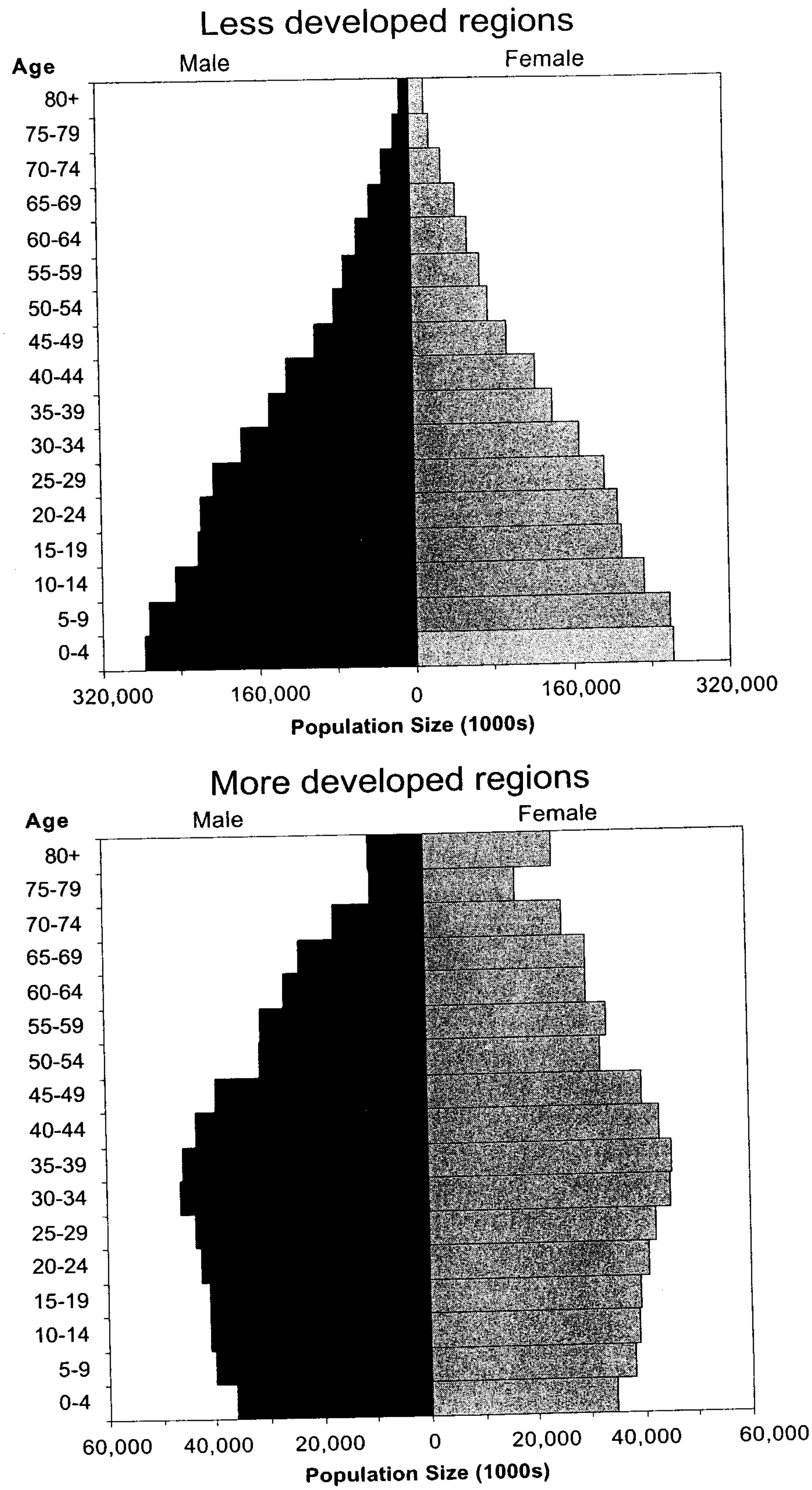

Figure 4.2 Estimates of population by age groups and sex, 1995. (From United Nations, 1996a, 1996b.)

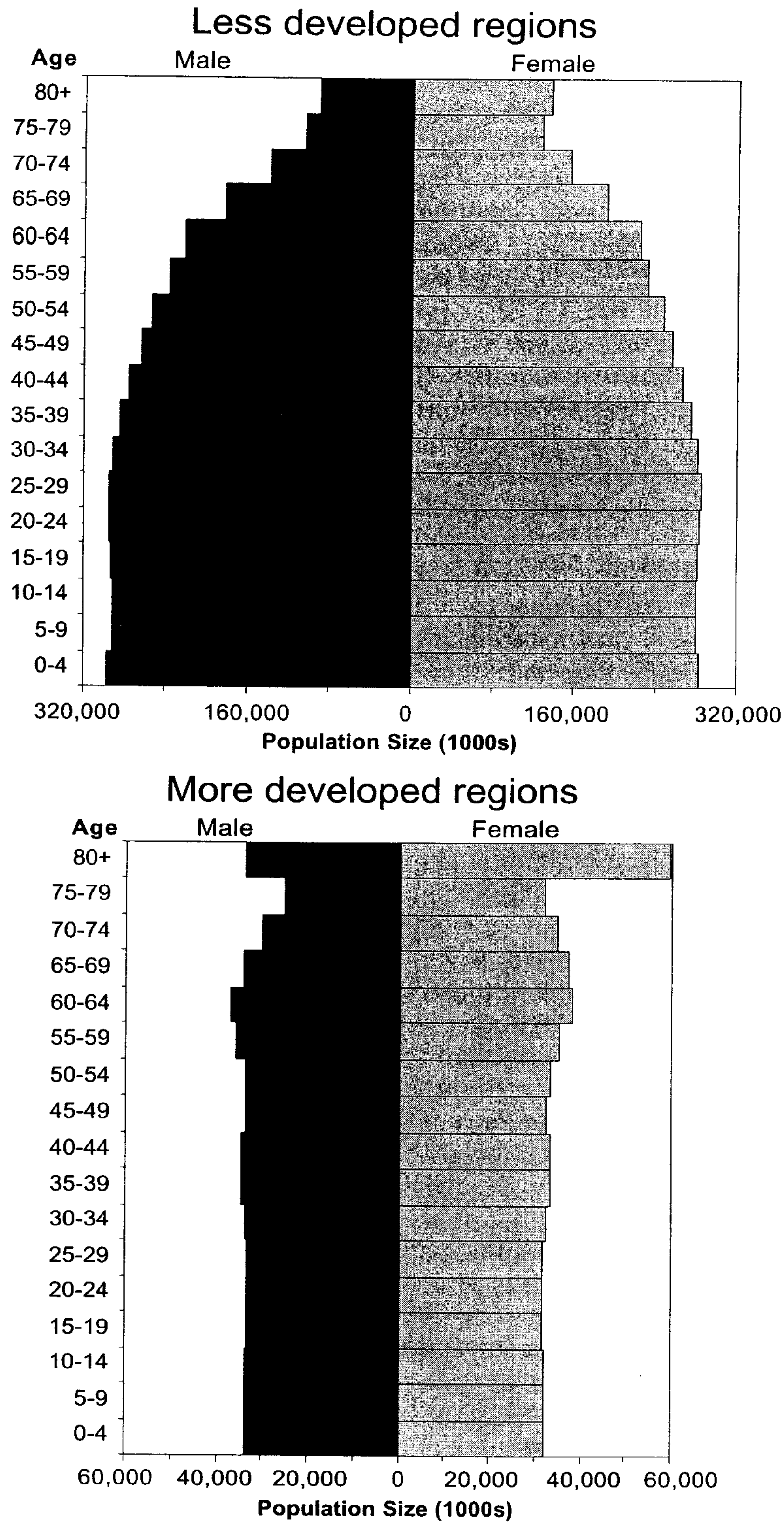

Figure 4.3 Projections of population by age groups and sex, 2050, medium variant. (From United Nations, 1996a, 1996b.)

Table 4.2
Vital Rates, 1950, 1995, and 2050[a]

Geographic area	1950–1955 TFR	IMR	e(0)M	e(0)F	1990–1995 TFR	IMR	e(0)M	e(0)F	2045–2050 TFR	IMR	e(0)M	e(0)F
World total	5.0	156.0	45.1	47.8	3.0	62.0	62.2	66.5	2.1	16.0	74.2	79.1
More developed regions	2.8	58.0	63.9	69.0	1.7	11.0	70.4	78.0	2.1	5.0	78.0	84.0
Less developed regions	6.2	179.0	40.1	41.8	3.3	68.0	60.6	63.7	2.1	17.0	73.6	78.2
Least developed countries	6.5	194.0	34.9	36.2	5.5	109.0	48.7	50.8	2.1	25.0	69.9	73.5
Africa	6.6	185.0	36.4	39.2	5.7	94.0	50.4	53.3	2.1	22.0	70.4	74.5
Asia	5.9	180.0	40.6	42.0	2.8	62.0	63.2	66.0	2.1	15.0	74.8	79.3
Eastern Asia	5.7	181.0	41.4	44.6	1.9	41.0	67.6	71.9	2.1	7.0	76.4	81.1
Europe	2.6	72.0	63.4	68.5	1.6	13.0	68.5	76.9	2.0	5.0	76.9	83.3
Southern Europe	2.7	76.0	61.5	65.1	1.4	11.0	72.7	79.3	2.0	6.0	79.1	85.0
Western Europe	2.4	45.0	65.1	69.9	1.5	7.0	73.2	80.2	2.0	5.0	79.1	85.5
Latin America and Caribbean	5.9	126.0	49.8	53.1	2.9	40.0	65.3	71.8	2.1	10.0	75.2	81.5
Northern America	3.5	29.0	66.2	71.9	2.0	9.0	72.8	79.5	2.1	5.0	79.1	84.7
Australia/New Zealand	3.3	24.0	67.0	72.3	1.9	7.0	74.5	80.3	2.1	5.0	79.9	85.4

[a]TFR, total fertility rate. IMR, infant mortality rate. e(0)M and e(0)F reference the life expectancy at birth of males and females, respectively. From United Nations (1996a, 1996b).

the fertility and mortality declines were greatest in less developed countries. Fertility rates almost halved, and more than 20 years were added to life expectancy in less developed countries. Declines in fertility and mortality were also experienced in more developed countries although to a lesser extent. The TFR in developed countries was 1.7—a fertility rate significantly below that needed for population replacement and life expectancy grew to over 70 years for both males and females. Fertility and mortality rates of this magnitude account for the advanced aged structures of more developed countries, and in some instances the expected declines in the overall size of these nations' populations between 2025–2050. Note that among the developed nations, the TFR for North America was 2.0 in 1995—slightly higher than most European countries.

By 2050, the TFR is projected to be 2.1 worldwide. Note that the projection implies *no differences separating the fertility experiences of more and less developed regions of the world*. Note, also, that although a mortality gap is expected to exist between more and less developed regions of the world, the mortality of less developed countries in 2050 is expected to be lower than that experienced by developed nations in 1995! Not surprisingly, therefore, the expected age structures of less developed countries in 2050 are indicative of mature populations converging on those of more developed nations (see Figure 4.3).

Assuming the plausibility of the projected vital rates, the pace of change in the vital rates for the less developed region of the world over the 100-year period is extraordinary given the fertility and mortality rates of 1950. In the projection shown here, fertility rates are expected to drop from 6.2 to 2.1 between 1950 and 2050, and life expectancy is expected to grow from about 40 years to about 74 years for males and 78 years for females.

If this demographic future occurs, or one similar, these revolutionary demographic changes will foretell dramatic shifts in the age structure of the world's population over time.

The pace of expected change in the vital rates in more developed regions is also noteworthy although much less dramatic. Fertility between 1950 and 2050 is expected to decline somewhat, from 2.8 to 2.1; this relatively small change is due primarily to the already low fertility in 1950. Note also the expected rebound in fertility by 2050 from the very low rates experienced in the 1990s. Mortality over the same 100-year period also declines, but again, the declines are not expected to be of the magnitude experienced in less developed countries. This is due, however, primarily to a key assumption in the projection (i.e., that mortality has far less to fall in developed nations). The idea behind this assumption has generated considerable debate in the demographic literature (see Manton, Stallard, & Tolley, 1991; Olshansky and Carnes, 1994; Wilmoth, 1997) and there is little consensus. The key lesson from the estimates is that the demographic revolutions going on in less developed countries are already dramatic, and, assuming that the trend continues, will exert profound effects on the age structures of those countries. The demographic revolution occurring in more developed countries, although no less important, is much quieter and part of a longer historical trend that began well before 1950.

V. Implications of the Demographic Revolution for Population Health

The prior discussion regarding the ambiguous link between mortality changes and the health of the surviving population makes clear the difficulty in making projections of population health. This most likely explains the paucity of population health projections in the demographic and public health literatures. Kinsella (2000) and Waidmann and Manton (2000) review the available evidence on cross-national differences in "trends" in population health, relying typically on estimates from two points in time to make inferences about the general patterns of health changes in the population. These two studies are careful to note the limitations of these data (i.e., two points in time do not necessarily imply a trend). Based on available evidence, it appears that there is a generally positive association between improvements in life expectancy and the years individuals can expect to live in good health. The data for eleven developed nations indicate either improvements or relative stagnation in healthy life expectancy as overall life expectancy has improved; no countries experienced a decline in healthy life expectancy with improved life expectancy. Nonetheless, the scarcity of estimates points to the difficulties in making strong inferences about the relationship between mortality changes and future changes in population health.

Murray (1997; Murray & Lopez, 1996) has developed projections of population health for a 40-year period (1990–2020) based on a measure called disability-adjusted life years (DALYs). The DALY measure references the years of life lost in a population from premature mortality combined with the years of life lost due to disability. (The conceptual framework behind the DALY, as well as a discussion of its computation, can be found in Murray & Lopez, 1996.) Increases in the value of DALYs over time denote a decline in the health of a population, (i.e., this denotes an increased departure from life in perfect health). Declines in the value of DALYs reference improvements in the health of the population. Murray (1997) discusses the procedures used to make the projections, with careful attention given to the assumptions made in developing the projections.

Summarizing Murray's results, there is no clear pattern of change in overall levels of population health for the 1990–2020 period. DALYs in which all major conditions (i.e., communicable diseases, noncommunicable diseases, and injuries) are grouped are expected both to increase and decrease, depending on the region of the world. European nations, for example, are expected to experience very little change in population health, while improving health is expected in India and Asia (except China). Worse population health is anticipated in the remaining parts of the world.

Increases in DALYs for noncommunicable diseases (e.g., the major chronic diseases) are projected by Murray's approach for much of the world; the lone exception is the developed countries where chronic diseases currently represent the vast majority of health problems in the population. Much of the expected increase in the DALYs caused by noncommunicable diseases is due to the aging of the population into the high-risk ages for these diseases. The forces of population aging (i.e., changes in the age structures of populations) appear to outweigh epidemiological improvements (i.e., pathological changes in the aging process at the individual level)—at least in this model.

We suggest a cautious approach in interpreting Murray's projections, and Murray himself agrees with our concern. Moreover, we think it worthwhile to develop projections of health expectancies along the lines proposed by REVES such as disability-free life expectancy and life free of functional limitations. These expectancies are based on the International Classification of Diseases and Disability (ICIDH) and avoid the sometimes controversial assumptions that go into constructing DALYs. The health expectancies also are less subject to the effects of changing population composition, providing for a cleaner assessment of the association between changes in overall life expectancy and expectancies of the years individuals will experience major health problems.

VI. Summary

Many Americans view population aging as a uniquely American experience. Frequently cast as a social problem, population aging is seen as the culprit threatening Social Security and Medicare. The phenomenon of the "sandwich generation," middle-aged and older persons providing care to very elderly parents, has also been laid at the feet of population aging. Demographic determinism rather than the inadequacies of social, economic, and political policy garners much of the public's attention.

Here, we have shown that the United States experience parallels that of more developed nations. And, in fact, the population of the United States is expected to be younger than many European countries and continue to grow over the next 50 years. In stark contrast, among the more developed countries, most European populations will stabilize (i.e., the number of deaths will roughly equal the number of births), and some European countries will experience a decline in population size as the number of deaths in the aged populations exceeds the number of births. Some scholars have characterized this trend as "a profound development in industrial societies" (Davis, Bernstam, & Ricardo-Campbell, 1987, p. x). As Davis (1987) observes,

> Looked at in the long-run perspective of human evolution, the below-replacement fertility now characterizing most of the industrial countries is anomalous. Never before in recorded history—not in the Great Depression, not in the eighteenth and nineteenth centuries, and not in ancient times—has fertility been so low for whole societies as it is now

in the industrial world. And never has it been so low during the millions of years of hominid evolution. (p. 48)

Others have cast a more negative spin on this development, inferring "disastrous demographic consequences" and "population 'implosion'" (Bourgeois-Pichat, 1987, p. 25). This perception has contributed in no small degree to the plethora of pronatalist policies in many European countries—none of which appear to have substantially altered the trend of below-replacement fertility.

Until recently, much of the demographic community's attention was directed at population aging in more developed nations, frequently characterized as industrialized nations. Viewed in a larger historical context, however, the demographic experience of the more developed nations can more accurately be viewed as the leading edge of a worldwide demographic revolution. In general, the mortality revolution began in more developed nations in the mid-19th century with the advent of disease-control technologies (Easterlin, 1997). With the noted exception of France, sustained fertility declines began in Western European countries in the latter part of the 19th century. With the spread of the mortality and fertility revolutions in the 20th century to Latin America, the Middle East, Asia and lastly to Sub-Saharan Africa, the estimates shown here illustrate that the large gap in fertility rates and life expectancy eroded somewhat between 1950 and 1995. This erosion is expected to continue such that by 2050 very few international differences in fertility and mortality are likely to remain. At the end of the 100-year period, therefore, current projections indicate that the demographic revolution to older, stable populations will be very close to completion. Globally, the elderly will constitute a significant portion of the overall population, with few substantial differences expected in this pattern across national populations.

Current projections of future trends in population health point to an optimistic future for some countries and a somewhat less optimistic future, in terms of the burden of disease, for other countries. Although these population health projections are clearly preliminary, one characteristic of these projections will almost certainly characterize future trends in population health—cross-national variability. Over an extended period of time, it is likely that we will observe a variety of changes in population health. Some countries might well experience improvements, subsequent declines, and then future gains, while other countries will experience completely different patterns of change. National differences in public health priorities, health-care infrastructure, population composition, and progress in disease fighting will almost certainly lead to different rates of improvement, and perhaps declines, in population health.

Neither improvements nor declines in population health necessarily imply success or failure in improving the health of a population. This point is important to underscore, since indicators of population health are frequently used to assess the population's demand for health-care services, evaluate the effectiveness of health-care infrastructures, and gauge progress toward public health goals. Under conditions of falling mortality, a decline in population health, for example, is an

expected epidemiological stage that can occur when increases in life expectancy are greater than reductions in the incidence of health problems. In addition, at any one time we are likely to see improvements in some indicators of health and not others, and improvements in some age groups and not others. (Crimmins, 1996, p. S224.)

Success in improving health is most appropriately gauged by using a range of indicators of population health that encompass changes across the various domains of health.

Some individuals might question the inevitability of the demographic changes described above. Our reasoning is based on the fact that fertility and mortality changes are sweeping the world. No part of the world is untouched, and no return to the patterns of high fertility and mortality is anticipated. The universality of the demographic changes and their lack of reversibility do not stem from some intrinsic demographic law. Rather, the mortality and fertility revolutions driving population aging are "rooted in breakthroughs in human knowledge about methods of... disease control, and, short of a global catastrophe, this knowledge will not be lost" (Easterlin, 1997 p. 145). Seen in this context, the worldwide march toward an older population marks the triumph of scientific contributions in enhancing the health and well-being of individuals, and symbolizes the demographic coming of age on a global scale.

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