# Projecting the Older Population of the United States: Lessons from the Past and Prospects for the Future

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PROJECTIONS OF LIFE EXPECTANCY AND TOTAL population size made over the past 50 years have received considerable attention and have been influential in the creation of public policy. These population projections have been utilized by a variety of government agencies for predictions as diverse as the size of the labor force, housing and educational needs, and health care utilization. As the population continues to expand, and especially as the number of older persons continues to grow rapidly, the importance of being able to project accurately the total size as well as the age and sex structure of the future population will increase substantially.

This article will examine previous and current projections of the population of the United States, with a particular focus on older age groups. The increase in the older population has been dramatic and rapid growth is expected to continue into the future. Those aged 65 and older made up only 4 percent of the total population at the turn of the century, but increased to 11.3 percent by 1980. U.S. Bureau of the Census (1984) projections estimate that the elderly will comprise from 20 to 24 percent of the total population in 2040. Furthermore, among those aged 65 and older, the proportion of those in the groups aged 75 to 84 and 85 and over is expected to increase significantly.

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For example, while those aged 85 and older made up just 4 percent of the population aged 65 and older in 1900 and 9 percent in 1980, it is projected that in the year 2040 over 19 percent of elderly persons will be aged 85 or older (U.S. Bureau of the Census 1984). Therefore, there are two important issues involved in the aging of our population: (1) the growth of the number and proportion of the total population which is elderly and (2) the increase in the number and proportion of persons at the oldest ages.

Population projections depend on both analytic methods and judgment. We now know the accuracy of projections made in the past and can, in retrospect, identify where they succeeded and where they erred. A number of methodologies have been employed to analyze the accuracy of population projections (Siegel 1972; Stoto 1983; Long 1987). Our purpose is not to review these analytic methods but to present a historical perspective that highlights the pitfalls in making accurate projections and provides us with insight that may allow more realistic appraisals of future projections.

This article will first review the demographic methods used in generating population projections. Projections made in the past for the year 1980 will then be analyzed, followed by a description of projections made for future years. It will be demonstrated how alternative mortality assumptions may have a large impact on the projected size of the future elderly population. Finally, the potential impact of these alternative projections on society will be considered.

## Population Projection Methods

Most population projections are made by assigning values for future birth rates, death rates, and net levels of migration, and then these assumptions are applied to the current estimates of the population. The actual method used is known as the cohort-component method (Shryock and Siegel 1976). Population projections begin with available census data stratified by age, sex, and sometimes race. For the first year of projection, projected age-, sex- and race-specific survival rates are applied to the base population to carry each age/sex/race group forward one year. These same survival rates are then applied to the projected immigrants for that year. Surviving immigrants are then added to the overall surviving population. Finally, the population

under the age of 1 is created by applying projected age- and race-specific fertility rates to the projected female population of childbearing ages. This same process is then repeated year by year until the ultimate desired year of projection is reached.

The size and age structure of a population is strongly influenced by fertility rates. For example, when fertility is high, as in many developing countries, the population tends to grow rapidly and is generally composed of a high proportion of young persons. Assumptions for future fertility are made by considering the recent level of fertility, the proportion of women at different childbearing ages (aged 15 to 49 years), and social and economic factors that affect women's expectations of future births. These factors include age at marriage, educational attainment, and the participation of women in the labor force. Fertility surveys, which query women of childbearing age about birth expectations, have proven quite useful in predicting the fertility rates of these women (Long and Wetrogan 1981). Birth expectations are particularly good predictors for women who are currently married or will be married in the next 5 years. Those who do not marry, when queried after five years, will adjust their expectations down sharply. As these women now make up one-fifth of the female population in these surveys, there is a need to adjust survey estimates for this group (U.S. Bureau of the Census 1984).

The main assumption now employed for fertility is the ultimate cohort-fertility rate. This is the projection of total number of births for women in a particular cohort over the full range of their childbearing years. In the most recent U.S. Bureau of the Census (1984) projections, three alternative ultimate cohort-fertility rates were used. The middle-level assumption is that ultimate completed fertility would be 1.9 births per woman, as compared to the current level of 1.8 births per woman (U.S. Bureau of the Census 1984). The high and low assumptions in the Census Bureau's projections are for 2.3 and 1.6 births per woman, respectively. In addition to ultimate fertility rates, the timing of the age of childbearing can have an effect on future population size. The most recent Census Bureau projections assume that mean childbearing age will increase from 25.9 years in 1982 to 26.5 years in 2040.

Mortality rates are calculated by dividing the number of deaths during the year by the mid-year population. In projecting future populations, age-, sex- and race-specific death rates are estimated for

past years and are projected into the future. Projections of future mortality rates take into account long-term and recent trends in mortality, along with prospects for future medical advances and changes in personal health habits, such as smoking and dietary practices.

In the past, only one set of mortality assumptions was made by the Census Bureau in projecting future populations. Several sets of assumptions of fertility rates were created, however, because of their unpredictability and large impact on total population size and structure (Siegel 1979). In recent years, with fertility rates remaining relatively stable, an increasing proportion of the error in projections has been related to mortality assumptions. Additionally, Census Bureau mortality projections have tended to underestimate declines in mortality. For these reasons, the U.S. Bureau of the Census (1984) now generates three alternative mortality assumptions. Census Bureau projections of future declines in mortality lead to projected life expectancies in 2040 for males and females, respectively, of 77.8 and 86.7 years under the low-mortality assumption, 72.7 and 80.3 years under the high-mortality assumption and about halfway between these values in the middle-mortality assumption. This compares to the estimated life expectancy in 1980 of 70.0 for males and 77.4 for females (National Center for Health Statistics 1986).

The net level of immigration to the United States is determined by a number of variables that are difficult to predict, including changes in American immigration legislation and economic, social, and political conditions in the United States and abroad. Changes in net immigration can have a substantial impact on future populations, as the large proportion of immigrants who are of reproductive age or younger will produce descendants who will be added to the total population. Past estimates of net migration did not incorporate illegal aliens into the assumptions. All persons residing in the U.S., whether legally or illegally, are to be counted by the census, however, and in the most recent series of projections the U.S. Bureau of the Census (1984) made allowances for illegal alien migration. Unlike many past projections, the most recent projections make three different assumptions about net migration, taking into consideration a wide range of uncertainty not only in illegal aliens but also in possible changes in legislation, the future course of refugee movements, and undercounting of emigrants. Current Census Bureau projections of net yearly immigration are for

250,000 persons under the low assumption, 450,000 under the middle assumption, and 750,000 under the high assumption.

## Past Projections for the Year 1980

> "Business executives, editors, college presidents, scientists, and men in other walks of life have been making predictions, not deterred by the unfortunate way in which actual population growth has usually erred from the predictions of earlier forecasters" (Whelpton 1928).

One more fortunate forecaster was Francis Bonynge, who in 1852 published *The Future Wealth of America*, which contains projections of the population of the United States which differed by less than 5 percent from actual census estimates for the next 50 years. His method, however, greatly overstated the population for the distant future, with predictions of 452 million Americans in 1980 and 703 million in 2000.

It is instructive to examine the success of modern population-projection techniques by assessing projections made for a year for which actual estimates of the population are available. To this end, we have selected four representative projections of the 1980 population, starting in 1937. Prior to that time, projections were often created by so-called "curve artists," who attempted to fit a curve to the past pattern of population growth and then projected the future population by simply extending this line.

Table 1 displays the assumptions used in population projections in 1937, 1958, 1967, and 1975. These projections were selected because they specifically projected the 1980 population and were generated at times when important demographic changes in fertility and mortality were occurring or about to occur. This will permit the observation of some of the problems and pitfalls of population projection.

Several different projections were done in 1937 by the Scripps Foundation for the National Resources Committee (1937), each having a separate set of mortality, fertility, and migration assumptions (see table 1). The alternative projections made by the Census Bureau in 1958, 1967, and 1975, however, differed only in the assumptions made for fertility (U.S. Bureau of the Census 1958, 1967, 1975) (table 1). Net migration rates for these projections were about the

TABLE 1
Assumptions Used in Past Population Projections for the Year 1980 and Actual Total Fertility Rate, Net Immigration, and Life Expectancy, 1980

| Published projection | Assumptions | | |
|---|---|---|---|
| | Lifetime births per 1,000 women | Net immigration per year | Life expectancy M: Male F: Female |
| PROJECTION | | | |
| NRC, 1937 | (1980)* | | (1980)** |
| Highest | 2,177 | 200,000 | 73.0 |
| Middle | 1,900 | 100,000 | 70.0 |
| Lowest | 1,500 | -0- | 67.0 |
| CB No. 187, 1958 | (1980) | | (1975/1980) |
| Series A | 4,040 | 300,000 | M: 69.0 |
| Series B | 3,680 | 300,000 | F: 76.0 |
| Series C | 3,160 | 300,000 | |
| Series D | 2,640 | 300,000 | |
| CB No. 381, 1966 | (2000) | | (2000) |
| Series A | 3,350 | 400,000 | M: 69.0 |
| Series B | 3,100 | 400,000 | F: 75.4 |
| Series C | 2,780 | 400,000 | |
| Series D | 2,450 | 400,000 | |
| CB No. 601, 1975 | (2050) | | (2020) |
| Series I | 2,700 | 400,000 | M: 69.9 |
| Series II | 2,100 | 400,000 | F: 78.0 |
| Series III | 1,700 | 400,000 | |
| ACTUAL | | | |
| 1980 | 1,827 | 450,000 | M: 70.0 F: 77.5 |

* Years in parentheses are the ultimate year in which assumption is reached and becomes constant.
** Life expectancy assumptions by the NRC was for males and females combined.
*Sources:* National Center for Health Statistics 1937. Census Bureau (CB) sources refer to *Current Population Reports*, series P-25 publication numbers and years. Numbers for 1980 are from U.S. Bureau of the Census 1984.

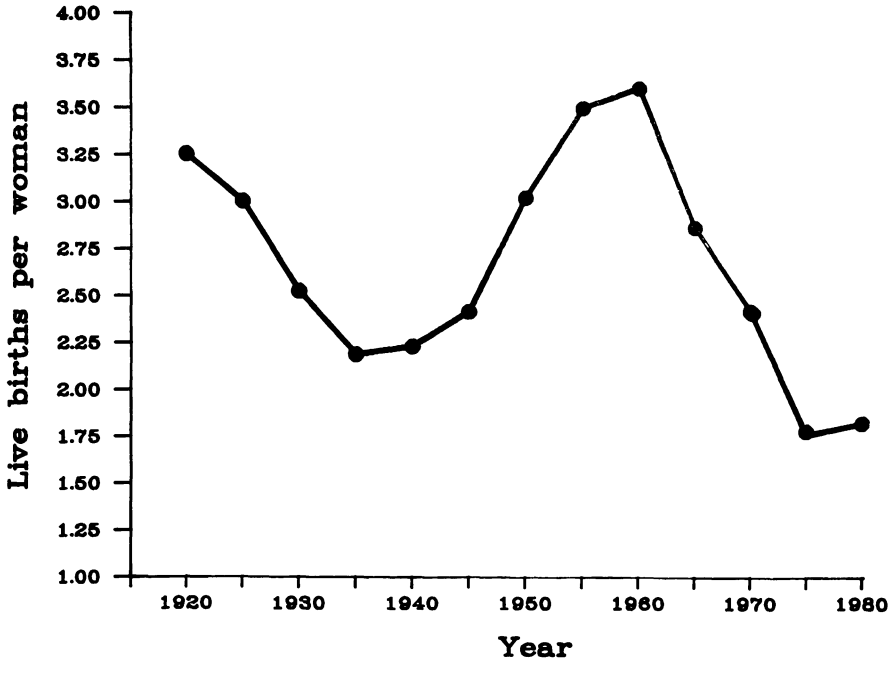


FIG. 1. Total Fertility Rates, United States, 1920 to 1980.
*Source:* U.S. Social Security Administration 1985.

same and did not take into account the large immigration of illegal aliens.

The accuracy of projections of total population are affected to a large extent by fertility assumptions. These fertility assumptions are generated from recent fertility levels and expectations of future trends. Fertility rates have changed radically in this century, however, as demonstrated in figure 1, and this unanticipated change has contributed to substantial errors in projections of the 1980 population (table 2). The 1937 projections were all extreme underestimates of the total 1980 population. It was assumed at that time that fertility rates would remain at the low levels of the Depression and the baby boom of the 1950s and 1960s was not anticipated. For the same reason, projections made during the 1940s also underestimated the 1980 population (U.S. Bureau of the Census 1975). By contrast, the 1958 projections, made at the peak of the baby boom, overestimated, in all their alternative assumptions, the low fertility rates of the late 1960s and 1970s (table 2). This led to an overprojection of the total

TABLE 2
Projected and Actual Population for the Year 1980 (numbers in thousands)

| Published projection | Total population | 65 years and over | | 65 to 74 years | | 75 to 84 years | | 85 years and over | |
|---|---|---|---|---|---|---|---|---|---|
| | | Number | Percentage of total | Number | Percentage of 65 + | Number | Percentage of 65 + | Number | Percentage of 65 + |
| PROJECTION | | | | | | | | | |
| NRC, 1937 | | | | | | | | | |
| Highest | 185,823 | 25,739 | 13.9% | 16,159 | 62.8% | 8,086 | 31.4% | 1,494 | 5.8% |
| Middle | 158,335 | 22,289 | 14.0 | 14,370 | 64.8 | 6,590 | 29.7 | 1,229 | 5.5 |
| Lowest | 127,570 | 18,994 | 14.9 | 12,682 | 66.8 | 5,308 | 27.9 | 1,004 | 5.3 |
| CB No. 187, 1958 | | | | | | | | | |
| Series A | 272,557 | 24,526 | 9.0 | 15,300 | 62.4 | 7,377 | 30.1 | 1,849 | 7.5 |
| Series B | 259,981 | 24,526 | 9.4 | 15,300 | 62.4 | 7,377 | 30.1 | 1,849 | 7.5 |
| Series C | 245,509 | 24,526 | 10.0 | 15,300 | 62.4 | 7,377 | 30.1 | 1,849 | 7.5 |
| Series D | 230,834 | 24,526 | 10.6 | 15,300 | 62.4 | 7,377 | 30.1 | 1,849 | 7.5 |
| CB No. 381, 1966 | | | | | | | | | |
| Series A | 250,489 | 23,063 | 9.2 | 14,457 | 62.7 | 6,945 | 30.1 | 1,661 | 7.2 |
| Series B | 243,291 | 23,063 | 9.5 | 14,457 | 62.7 | 6,945 | 30.1 | 1,661 | 7.2 |
| Series C | 235,212 | 23,063 | 9.8 | 14,457 | 62.7 | 6,945 | 30.1 | 1,661 | 7.2 |
| Series D | 227,665 | 23,063 | 10.1 | 14,457 | 62.7 | 6,945 | 30.1 | 1,661 | 7.2 |
| CB No. 601, 1975 | | | | | | | | | |
| Series I | 225,705 | 24,523 | 10.9 | 15,411 | 62.8 | 7,041 | 28.7 | 2,071 | 8.4 |
| Series II | 222,769 | 24,523 | 11.0 | 15,411 | 62.8 | 7,041 | 28.7 | 2,071 | 8.4 |
| Series III | 220,356 | 24,523 | 11.1 | 15,411 | 62.8 | 7,041 | 28.7 | 2,071 | 8.4 |
| ACTUAL | | | | | | | | | |
| 1980 | 227,738 | 25,709 | 11.3 | 15,655 | 60.9 | 7,782 | 30.3 | 2,272 | 8.8 |

*Sources:* Same as for table 1.
*Note:* Projections published prior to 1960 excluded Alaska and Hawaii.

population in all 1958 projections. The highest series, projecting 273 million in the U.S. population by 1980, was nearly 20 percent above the actual Census Bureau estimate. From 1958 through 1975, fertility estimates were consistently revised downward as the high fertility rates of the baby boom era continuously declined. These downward revisions of fertility rates, however, were still not adequate in the 1967 projections, when all series except the lowest series overprojected the total population. These differences in projections clearly demonstrate the importance of fertility assumptions on projection of the total population.

While fertility assumptions played a major role in the errors of the projection of the total population in the first three projections seen in tables 1 and 2, mortality assumptions strongly affected more recent projections. In contrast to the 1958 and 1967 projections, which generally overprojected the 1980 population, all three 1975 projections were lower than the actual 1980 population. Fertility assumptions in the 1975 projection were adjusted substantially downward from the 1958 and 1967 projections and more closely approximated the actual 1980 rate of 1,827 births per 1,000 women. The mortality assumptions did not adequately project the rapid decline in mortality, however, resulting in an underprojection of the total population. In addition to total population projections, table 2 also displays various projections for the populations aged 65 and older and 85 and older for 1980. For these age groups, only one Census Bureau projection resulted in 1957, 1968, and 1975, since only one mortality and one migration assumption were made at these times, when all those destined to be aged 65 and over in 1980 were alive.

Projections made between 1937 and 1975 for older populations reflect assumptions that were based on mortality trends which were occurring at the time those projections were created. These trends in mortality for males and females during four periods in this century are summarized in table 3. The 1937 projections by the National Resources Committee are particularly interesting since they employed three different mortality assumptions. The high mortality assumption (lowest population series in tables 1 and 2) projected a life expectancy in 1980 of 67 years, which reflected a moderate improvement in life expectancy from the preceding years (62.4 years from 1930 to 1934). Under this assumption, a moderate improvement in mortality was projected at the younger ages but little improvement was projected

TABLE 3
Average Annual Changes in Mortality Rates, 1900–1982*

| Years | Males | Females |
|---|---|---|
| 1900–1936 | −0.9% | −1.0% |
| 1936–1954 | −1.7 | −2.6 |
| 1954–1968 | +0.1 | −0.8 |
| 1968–1982 | −1.8 | −2.1 |

* Rates are percentage changes in central death rates, adjusted to take into account the age distribution of the population.
*Source:* U.S. Social Security Administration 1983.

for the middle and older ages, particularly in reducing deaths from chronic diseases. The lowest mortality assumption (highest population series) projected that there would be a greater improvement in mortality rates in the younger ages than in the highest mortality assumption. The major difference in these projections, however, is in the middle and older ages where the lowest mortality assumption projected a substantial improvement in mortality (Whelpton 1936). Under this assumption, life expectancy for men and women combined was projected to reach 73 years in 1980, which turned out to be very accurate.

The same lowest mortality assumption, which was more optimistic than mortality trends at that time, also produced the most accurate projection of the population aged 65 and older for 1980. The 1937 middle and highest mortality assumptions, reflecting the modest mortality improvements prior to that time, underprojected the 1980 elderly population. The 1958 Census Bureau projections for older populations were made after twenty years of rapid decline in mortality rates and project greater numbers of older people than the medium or low 1936 projections. The 1967 projection was made after a period of over 10 years in which mortality rates for women declined much less than in prior years and mortality rates for men rose for the first time in the century. At that time, it was thought that mortality rates might have attained the lowest possible levels and that the natural limit of life expectancy had been reached. Consequently, the 1967 and 1975 projections underestimated both the increase in life expectancy and growth of the older population for 1980. The latter projection,

made just 5 years prior to 1980, estimated that life expectancy would increase to 69.9 years for males and 78.0 years for females by the year 2020. Both of these figures were actually surpassed by the year 1982 (National Center for Health Statistics 1986).

Within the older age group, the error in population projections increases with increasing age. In all projections, the proportion of the elderly population aged 85 and older was underprojected (table 2). Even the 1937 lowest mortality projection, which was extraordinarily accurate in projecting the total number of those aged 65 and older, underestimated the size of this group by 34 percent. In the projection made just five years before 1980, the errors in projecting the populations aged 75 to 84 and 85 and above were six times greater than the error for the population aged 65 to 74. Thus, there has been a consistent underestimation of the substantial improvement in mortality rates in the oldest groups. In evaluating past projections, an important technical issue that should be considered is the overcount of the older age groups in the 1980 census coverage (U.S. Bureau of the Census 1982; Siegel 1983). Demographic analysis has estimated that the cohort aged 65 years and older sustained a 1.4 percent net overcount in 1980. The overcounting of the elderly population is due to such factors as overstatement of age, counting some people twice, and errors in the estimation process (Siegel 1983). In the 1970 census, when this cohort was aged 55 years and older, it is estimated that they sustained a 2.2 percent undercount. The difference in coverage in these two census counts would alone lead to a 1.2 million person underprojection of the 1980 elderly population when basing the projection on the 1970 census. Although the overcount of the elderly in the 1980 census makes the accuracy of past projections difficult to judge, the life expectancy assumptions used in these projections can still be compared with the actual life expectancy in 1980. Projections made as recently as 1975 (7 years after the dramatic mortality decline beginning in 1968) still underestimated 1980 life expectancy.

Demographers have the difficult assignment of trying to be accurate in their projections in the face of a variety of uncertainties. In projecting future populations, the assumptions they make must be based on a series of assembled facts, such as past population parameters and trends in medical science and lifestyles. The errors in projections demonstrated here are not meant as criticism of the techniques of population projection. They are meant to demonstrate that sudden and unexpected changes

can and have occurred in both fertility and mortality rates. When this happens, projections using seemingly reasonable assumptions can turn out to be quite inaccurate.

## Current Projections for the Population in the Twenty-first Century

The future growth of the elderly population in the next century will have an impact on almost all aspects of American life. To examine the potential magnitude of this growth, published projections of the Census Bureau will be considered, as well as a projection that employs an assumption of greater decline in mortality. From 1954 to 1968, mortality rates remained stable in men and barely declined in women (U.S. Bureau of the Census 1984). After decades of declines in mortality, it was thought that mortality rates had reached a lower limit and that there was little likelihood of any further decline. If, in fact, mortality improvements had come to a halt, projections of the elderly population in the next century would have been radically different than what is now anticipated. In 1968, mortality rates started to decline rapidly again, however, indicating that mortality had not reached any limit (table 3). Current projections are based on the assumption that recent declines in mortality rates will not continue. Just as the mortality declines of the past two decades have been unexpected, future declines of this same magnitude are unexpected but must be contemplated. As demonstrated in our analysis of previous population projections, unexpected changes occurred in both fertility and mortality rates. In this section we will demonstrate how a continuation of the current trend in mortality rates would result in a much larger elderly population, and with a greater proportion of the very old, than projected by published series.

The two main federal agencies currently making projections of the future population size are the Census Bureau and the Actuary's Office of the U.S. Social Security Administration (SSA). They have both recently published projections through 2080 (U.S. Bureau of the Census 1984; U.S. Social Security Administration 1985). These projections are related in that the Census Bureau adapts, with modifications, the SSA mortality assumptions, and the SSA adapts Census Bureau assumptions of fertility rates and net migration (Siegel 1983). The

base populations of the two projections are different. Both count the population of the United States and the United States armed forces overseas, but the SSA population also includes Puerto Rico, the Virgin Islands, Guam, American Samoa, and overseas federal civilian employees and their dependents.

The recent Census Bureau projections use three mortality assumptions, three fertility assumptions, and three net migration assumptions. Thirty different series of projections represent each possible combination of high, middle and low assumptions plus three zero migration series. The most commonly quoted Census Bureau projection is the middle series, which uses all middle-level assumptions. The SSA has three levels for each type of assumption, but uses specific combinations of these in publishing three alternative projections.

Multiple series of projections that encompass different assumptions of fertility, migration, and mortality yield a range of future population levels. It must be kept in mind, however, that the creation of alternative assumptions is a somewhat arbitrary process and it is difficult to attach a confidence interval with a specified probability to particular high and low projections. In an attempt to evaluate the amount of error in future population projections, several investigators have attempted to compute confidence intervals of past projections (Sykes 1969; Keyfitz 1972; Stoto 1983). Stoto estimates the 95 percent confidence interval of total population for the year 2000 to be between 224 million and 302 million and that the high and low Census Bureau projections only represent approximately the 66 percent confidence interval. In a second estimate, Stoto projects an even wider 95 percent confidence interval, approximately twice as wide. While estimates of the error for projections of the elderly population have not been made, they are likely to be smaller since they are made when all persons have already been born who will be aged 65 and over in the year of the projection.

The three SSA mortality assumptions form the basis for the Census Bureau projections. In the SSA "Alternative III" (low mortality), the rate of mortality decline is projected to decrease from the 1968–1980 rate of decline to a 1.2 percent per year decline in 2008 and to continue then at that level. In making these projections it was assumed that, relative to declines seen from 1968 to 1980, the magnitude of decline in younger individuals will be considerably less than the decline in persons aged 65 and older. The mortality decline projected

for "Alternative III" is approximately the average annual mortality decline for the years 1900 to 1983 but is considerably less than the annual reductions seen in 1968 to 1982 (1.8 percent for males, 2.1 percent for females). The SSA "Alternative II" (middle mortality) projects mortality declines of about one-half the magnitude of "Alternative III" (low mortality). When the Census Bureau adapted the SSA assumptions, the low-mortality assumption was felt to reflect too large a reduction in mortality and a more conservative projection was substituted, which represents an annual decline rate of just under 1 percent.

The SSA mortality assumptions were created by projecting the future declines in mortality for 10 general disease groups. Examination of these disease-specific mortality projections is of interest since the changes in mortality have varied between diseases in the past and these variations are likely to continue in the future. The SSA middle-series projections of yearly rate of mortality decline after 2008 for 10 disease groups are presented in table 4. The average rates of mortality decline between 1968 and 1980 are also shown for these disease groups. It was assumed that rates of decline would gradually change from the 1968–1980 average to the projected rate of decline in 2008 and would remain stable thereafter.

In creating projections for the next century, Census Bureau and SSA population experts made the reasonable assumption that the high annual rate of mortality decline seen recently would not be maintained. They reasoned that persistence of this kind of decline is difficult to sustain over the long term since the major determinants of this decline are heart disease and stroke and they saw little opportunity for mortality from these two diseases to continue to decline at previous rapid rates. Their prudent approach may reflect experience with past projections. As indicated in the previous section, projection errors in the past were made when recent trends, such as the low fertility rates during the 1930s or the stable mortality rates of the 1950s, were assumed to be permanent changes. In a sense, it may be a lesson well learned from the past, to avoid the assumption that current mortality declines will become permanent.

There are good reasons, however, to consider alternate projections which assume that the mortality declines observed in the past two decades will continue. Table 4 records the comparison between recent rates of decline for ten disease groups and the SSA middle-series

TABLE 4
Recent and Projected Mortality Improvements for Major Causes of Death

| Cause of death | ICD Code (9th revision) | 1968–1980 annual mortality improvement rate (%) | | SSA projected annual mortality improvement rate (%) (series II) after 2008 | | Percentage of all deaths 1980 | |
|---|---|---|---|---|---|---|---|
| | | Males | Females | Males | Females | Males | Females |
| Disease of the heart | 390–398, 402, 404–429 | 2.22% | 2.55% | 0.7% | 0.7% | 37.7% | 38.9% |
| Malignant neoplasms | 140–208 | −0.79 | −0.22 | 0.2 | 0.3 | 21.0 | 20.8 |
| Vascular diseases, including hypertension and stroke | 400, 401, 403, 430–459, 582–583, 587 | 4.67 | 4.79 | 1.0 | 1.0 | 9.5 | 14.5 |
| Accidents, suicide and homicide | E800–E989 | 1.72 | 2.39 | 0.2 | 0.2 | 10.8 | 4.8 |
| Disease of the respiratory system | 460–519 | 1.60 | 2.19 | 0.1 | 0.2 | 7.2 | 5.6 |
| Congenital malformation and disease of early infancy | 740–779 | 5.25 | 4.66 | 1.0 | 1.0 | 1.9 | 1.8 |
| Disease of the digestive system | 520–570, 572–579 | 3.10 | 2.47 | 0.6 | 0.6 | 2.0 | 2.5 |
| Diabetes mellitus | 250 | 2.84 | 3.88 | 0.4 | 0.5 | 1.3 | 2.2 |
| Cirrhosis of the liver | 571 | 1.11 | 1.59 | 0.2 | 0.2 | 1.8 | 1.2 |
| All other causes (residual) | — | 0.34 | 0.15 | 0.2 | 0.2 | 6.8 | 7.7 |

*Sources:* U.S. Social Security Administration 1983; National Center for Health Statistics 1985.

projections of future rates of decline. In recent years, the SSA has refined its process of projecting mortality by considering trends in cause-specific mortality rates as well as overall mortality rates. To indicate the relative impact each disease group has on total mortality, the proportion of deaths due to each of these groups in 1980 is also listed in table 4.

There are large differences between the recent and projected rates of decline for nearly all of the disease groups in table 4. Approximately one-half of all deaths are due to heart and vascular diseases, including stroke and hypertension. Recent mortality declines in these diseases have had a great impact on overall mortality reduction. Even after these declines, rates of heart disease mortality in Japan continue to be substantially lower than for the United States (Takahashi 1984), and there is no known biological reason why this country cannot reach Japanese rates. Improved preventive health practices by today's younger population should have a beneficial effect on mortality in the next century. In a recent study, the excess mortality resulting from known risk factors for heart disease was estimated for the cohort of men initially screened for the "Multiple Risk Factor Intervention Trial" (Stamler 1986). It was estimated that only 13 percent of deaths due to coronary heart disease in this cohort would have occurred if all 356,222 men initially screened had, at baseline, the most beneficial risk-factor profile in terms of serum cholesterol, smoking, blood pressure, and diabetes. Since these four risk factors are all modifiable, it may be possible to continue to make substantial inroads into cardiovascular mortality. Furthermore, the accelerating pace of biomedical research is likely to provide both preventive and therapeutic approaches to atherosclerosis that might have a profound effect on mortality from heart and vascular diseases.

As shown in table 4, malignant neoplasms was the only disease category that showed an annual rise in mortality rates between 1968 and 1980. The SSA projection for the next century is for a relatively modest annual improvement of 0.2 percent for men and 0.3 percent for women. This group of diseases accounts for over 20 percent of all deaths. The nation has invested heavily in biomedical research on cancer, which is rapidly approaching an understanding of the molecular mechanisms of these disorders. A research breakthrough in cancer research could lead to annual mortality reductions far in excess of those projected and would have a major effect on overall mortality

rates. If reductions in cigarette smoking continue or accelerate, there will be substantial declines in lung cancer and other smoking-related cancers as well as cardiovascular disease.

For the fourth and fifth leading causes of death in table 4, accidents, suicides, and homicides and diseases of the respiratory system, the projected rates of decline for the next century are quite pessimistic in comparison to recent rates of decline. Improved interventions and preventive measures in these areas could well lead to future declines in mortality that are of similar magnitude to recent declines. As an example, it is likely that in the next 50 years new safety devices will be developed for automobiles that significantly reduce accident mortality.

In assessing the likelihood of recent overall mortality declines continuing into the future, it may not be necessary for declines to continue at recent levels for all disease categories. Major breakthroughs in one or more causes of death that contribute to a significant proportion of deaths could sustain the overall rate of mortality decline even if other diseases do not maintain their recent rates of decline. In addition to the scenario that the elimination of a major cause of death will significantly increase life expectancy, Olshansky (1985) has convincingly demonstrated that simply delaying mortality from the important chronic diseases can have an equal or greater impact on life expectancy. Using a simultaneous/multiple cause-delay method, he modeled the large mortality changes from 1960 to 1978 as a function of delayed mortality from major cardiovascular diseases, diabetes, and some cancers (Olshansky 1987). The application of this model to the future indicated that a delay in these diseases of 7 years would lead to a projected increase in life expectancy by 2020 of the same magnitude that could be expected from the complete elimination of all diseases of the heart (Olshansky 1985). There are thus a number of different pathways by which medical advances might play a role in sustaining recent mortality declines.

Having reviewed the rationale for the Census Bureau low-mortality series, we find there is room for even greater declines in future mortality rates. The alternative projection presented here assumes that mortality will continue to decrease through the middle of the next century at a 2 percent annual rate of decline for both sexes. Compared to the mortality declines of the last two decades, the 2 percent rate is slightly lower than that observed for women and slightly higher for men (table 3) and is consistent with the recent narrowing of the male/female

differential in mortality rates (National Center for Health Statistics 1986). This assumed 2 percent rate of decline is the same as that applied by Vaupel and Gowan (1986) in an article that compared the effects of this steady rate of mortality decline with other scenarios. The projections resulting from this 2 percent decline assumption are more conservative than a recent projection by Siegel and Taeuber (1986), in which they extrapolated recent life-expectancy improvements and projected a life expectancy for women in 2050 of 100 years.

The population projections created from the 2 percent decline assumption must be interpreted with some caution. In offering this alternative projection, we are not claiming that it is better or more accurate than the Census Bureau projections. It is presented to permit further discussion of future possibilities for population growth. Even if others find the assumptions behind this projection too optimistic, there is still much value in making a theoretical projection of this nature (Siegel 1979). Alternative projections may serve as a reference point by which to evaluate the principal series of projections (Siegel 1979) and are also helpful for purely illustrative purposes.

The alternative assumption we apply here assumes a continuation of the high rate of mortality decline seen between 1968 and 1980. For certain age groups, however, a slowdown in this rate of mortality decline has occurred in the early 1980s. Between 1979 and 1984, no definite mortality decline was seen for males aged 75 years and older and females aged 55 years and older (National Center for Health Statistics 1987a). This recent trend in mortality rates may have been influenced by influenza epidemics and/or changes in Census Bureau population estimates (National Center for Health Statistics 1987a). The proposed assumption of an average annual mortality decline of 2 percent is made with the understanding that declines in the past have not been uniform (table 3). Of interest to our 2 percent assumption, mortality declines for two important causes of death have not slowed in the period of 1979 to 1984. During this period, ischemic heart disease mortality declined an average of 2.3 percent per year for males aged 65 and older and 1.1 percent per year for females in this age group. Even more impressive were the average annual mortality declines for cerebrovascular disease in those aged 65 and older of 4.1 percent and 3.1 percent for males and females, respectively (National Center for Health Statistics 1987a).

We will compare this alternative projection with three Census

Bureau projections: the Census Bureau series 23 (middle fertility, middle migration, and high mortality); the Census Bureau series 14 (middle series); and the Census Bureau series 5 (middle fertility, middle migration, and low mortality). All four projections employ the same fertility and migration assumptions but differ in mortality assumptions. The alternative projection using the 2 percent mortality decline assumption was created using the cohort-component method (Shryock and Siegel 1976). Life tables were constructed separately for males and females for each 5-year period from 1980 through 2040 for 5-year age groups through age 100 and over.

Table 5 displays the four population projections for those aged 65 and older for the year 2040. All people who will be aged 65 and older in 2040 are currently alive, so these projections do not depend on fertility assumptions. The alternative mortality assumptions used in these projections lead to quite different life expectancies. Males in the 2 percent decline assumption would have a life expectancy of 85.9 years as compared to 72.7, 75.0, and 77.8 year life expectancies in the Census Bureau high, middle, and low series, respectively. The differences resulting from these alternative assumptions are not as great for females, with life expectancy being 91.5 years under the 2 percent decline assumption and 80.3, 83.1, and 86.7 years under the high, middle, and low Census Bureau mortality assumptions.

The Census Bureau middle series, which is the series almost always cited, projects that there will be nearly 67 million Americans aged 65 and older in 2040 (table 5). This is over two and one-half times the number of older persons than in 1980 (U.S. Bureau of the Census 1984). The Census Bureau low-mortality assumption projects 75 million people aged 65 and over and the 2 percent decline assumption projects 87 million people in this age range in 2040.

Although the three Census Bureau projections and our alternative projection use quite different assumptions, the projections of number of older people aged 65 to 74 in the year 2040 do not differ substantially. The 2 percent decline assumption projects approximately 10 percent more people in the group aged 65 to 74 than the Census Bureau middle series (table 5). The most striking difference between these projections are the numbers of people projected in the oldest age groups. Compared to the Census Bureau middle mortality assumption, the 2 percent assumption projects 25 percent more people aged 75 to 84 and 83 percent more people aged 85 and older. In fact, the

TABLE 5
Alternative Projections of Life Expectancy and Population Aged 65 and Older, 2040

| | Census Bureau, series 23 (high mortality) | | | Census Bureau, series 14 (middle series) | | | Census Bureau, series 5 (low mortality) | | | Assumption of 2% annual mortality decline | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Male | Female | Total | Male | Female | Total | Male | Female | Total | Male | Female | Total |
| Life expectancy from birth (years) | 72.7 | 80.3 | | 75.0 | 83.1 | | 77.8 | 86.7 | | 85.9 | 91.5 | |
| Population (thousands) | | | | | | | | | | | | |
| 65–74 | 12,170 | 15,257 | 27,967 | 13,533 | 15,739 | 29,272 | 14,376 | 16,220 | 30,596 | 15,366 | 16,709 | 32,075 |
| 75–84 | 8,915 | 13,697 | 23,612 | 10,093 | 14,790 | 24,883 | 11,385 | 15,920 | 27,305 | 13,975 | 17,237 | 31,212 |
| 85+ | 2,812 | 6,836 | 9,648 | 3,804 | 9,030 | 12,834 | 5,185 | 12,073 | 17,258 | 9,173 | 14,346 | 23,519 |
| 65+ | 24,437 | 35,790 | 60,227 | 27,430 | 39,559 | 66,989 | 30,946 | 44,213 | 75,159 | 38,513 | 48,291 | 86,805 |
| Percentage of 65+ population | | | | | | | | | | | | |
| 65–74 | 52.0% | 42.6% | 46.4% | 49.3% | 39.8% | 43.7% | 46.5% | 36.7% | 40.7% | 39.9% | 34.6% | 37.0% |
| 75–84 | 36.5 | 38.3 | 37.5 | 36.8 | 37.4 | 37.1 | 36.8 | 36.0 | 36.3 | 36.3 | 35.7 | 36.0 |
| 85+ | 11.5 | 19.1 | 16.0 | 13.9 | 22.8 | 19.2 | 16.8 | 27.3 | 23.0 | 23.8 | 29.7 | 27.1 |

*Source:* U.S. Bureau of the Census 1984.

total number of people aged 85 and older projected by the 2 percent assumption approaches the entire current population of people aged 65 and older.

The 2 percent decline assumption leads to a narrowing of the male/female mortality differential. The consequences of this can be seen by comparing the projected number of males and females in this projection to the Census Bureau middle series (table 5), which widens the sex differential (U.S. Bureau of the Census 1984). For each age group, the difference between these two projections is greater for males than for females. Once again, this is most pronounced in the group aged 85 and older. Compared to the Census Bureau middle-mortality assumption, the 2 percent assumption projects 141 percent more men aged 85 and older versus 59 percent more women.

## Impact of Alternative Population Projections

The Census Bureau low-mortality assumption results in a projection of over 8 million more elderly Americans in 2040 than the middle-series projection. The 2 percent decline assumption projects about 20 million additional elderly persons and about 11 million more persons aged 85 and older than the Census Bureau middle series. Most projections of the impact on society and the health care needs of the growing population of older Americans in the next century use the middle-level series of the Census Bureau or the SSA (Rice and Feldman 1983; Manton 1985; Brody 1985). Even with this middle projection, there is agreement that meeting the needs of older persons will be a difficult and challenging task. Our alternate projection serves to accentuate these problems and to make the point that the task ahead may potentially be even more difficult than previously projected. The greatest difference between these projections is for the "oldest old," those aged 85 and older, a group whose future needs will have an enormous impact upon our society.

Attempting to project future morbidity and health care utilization levels for a date as distant as 2040 is filled with numerous pitfalls. First, as demonstrated here, there is much uncertainty about the size of the future population. Second, there is even less certainty about how the age- and sex-specific rates of disease might change. Although

it seems very probable that mortality rates will continue to decline, the link between decreasing mortality and decreasing morbidity in the elderly population is more tenuous than might be expected. In the past two decades, at a time when mortality was declining rapidly, there is no strong evidence that the overall morbidity level in the population 65 years of age and older was also declining (Schneider and Guralnik 1987; Rice and Feldman 1983). It is thus conceivable that current morbidity rates will remain stable. On the other hand, it seems quite unlikely that mortality could continue to decline at the present rate for the next 50 years without at least some reduction in morbidity, especially in the younger segment of the elderly population. While we believe that a future decline in age-specific morbidity may occur for the population aged 65 to 84, declines in age-specific morbidity for those aged 85 and above will probably be of a lesser magnitude.

The population aged 85 years and older is likely to continue to have high rates of disability and health care utilization and it is in this group that future projections offer a sobering view of the enormous impact of the aging population in the future. While, for some, surviving into this age group will be the result of the postponement of morbidity, for others it will be the result of being sustained for many years with serious chronic diseases. There will also be a change in the age distribution of the oldest old, with larger percentages of this group surviving into their 90s, with the even greater health problems of people in that age group. For these reasons, current morbidity rates for those aged 85 and older may actually turn out to be conservative projections of future morbidity.

To illustrate the impact of the growth of the group aged 85 and older, future needs for institutional care will be considered. There are currently over 1.3 million individuals aged 65 and over in nursing homes, of which 600,000 are aged 85 and over (National Center for Health Statistics 1987b). If current rates of nursing home utilization by those aged 85 and older continue until 2040, there will be over 2.8 million individuals in this age range in nursing homes, based on the Census Bureau middle series versus 5.0 million based on the 2 percent decline series. Even if the need for institutionalization for those aged 65 to 74 years were reduced to zero, the tremendous growth of the oldest old would lead to a substantial overall increase in the need for long-term care in the United States. While this scenario

may seem far in the future, it should be noted that all individuals who will be aged 85 and older in 2040 were born prior to 1955 and as of 1987 were over 31 years old.

## Conclusion

The projection of future populations, especially those 50 years from now, is filled with uncertainty. In the past, well-conceived, yet ultimately inaccurate assumptions of fertility and mortality rates have led to errors in population projections. While we have learned from the past, there is no guarantee that assumptions that are now utilized in creating projections for the next century are immune from these same types of errors. Projections of the elderly population in the next century rely primarily on mortality assumptions, but the radical changes in mortality in the past 40 years make it a risky venture to anticipate future mortality change. A number of refinements may improve our ability in the future to make more accurate projections of the older population. These include (1) the establishment of a more accurate census of the base population with correct ages for those at the oldest ages, (2) the study of cohort effects, which take into account the aging of cohorts that have had different risk-factor exposures throughout their lives, and (3) the careful observation of trends in medical research, which may potentially have enormous impact on mortality trends.

The projections of the Census Bureau and the Social Security Administration have used the assumption that the mortality decline seen in the past two decades cannot continue. In this article, an alternative projection is presented that uses the assumption that the recent level of mortality decline could be sustained for the next half century as a result of continued advances in prevention and therapy of the common causes of death, as well as by potential biomedical breakthroughs.

All projections of the elderly population in the next century lead to substantially larger numbers and proportions of older persons, as well as a change in the age structure of the older population itself, with a much higher proportion of the population in the oldest age group. Depending on which assumption is utilized, there are vastly different numbers of projected older Americans. The population aged 85 years and older, now about 2.7 million, is projected by 2040 to grow to 12.8 million in the Census Bureau middle-series projection

and to 23.5 million in the alternative 2 percent mortality decline projection created for this article.

Regardless of which projection turns out to be accurate, the needs for health services, institutionalization, and care of disabled elderly at home will increase in the future, especially among the oldest old. Projecting just how large the older population might grow can be of value in preparing for the needs of older Americans. If mortality rates continue to decline at recent levels, as assumed in our projection, the needs for increased health care for our older population will be enormous and could overwhelm future health care resources. Our only long-term solution will be through research that results in preventing the diseases and disorders that disable older persons.

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