Chapter 2

Introduction: Technological Change and the Older U.S. Population

Contents

Tables

Figures

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Introduction

Technology, in conjunction with economic, demographic, and social factors, affects the nature, impact, and course of social change. It plays, and will continue to play, a pivotal role in the aging of the U.S. population. The myriad approaches to understanding the interactive nature of technological, demographic, social, economic, and political processes are often onedimensional or narrowly focused, yielding parochial conclusions that take inadequate account of the effects that different variables have on each other.

Approaches to technology

In this report technology is viewed as complex and varied, not only in how it evolves, but in how it is applied to societal problems and goals. The broad scope of technology is exemplified by descriptions of its different forms, such as '(hard" or '(soft ," and "high" or "low." It can be a process (soft technology) such as research and the development of new knowledge, or products (hard technology) such as sophisticated new medical instruments and surgical procedures-which are also high technology-or simple in-home assistive devices and gadgets, which are low technology. Technology can, for example, be manifested in the ways in which health services are organized or new implements and devices created and utilized. ' In this report, the term technology encompasses each of these levels, types, and applications of knowledge to solving problems and accomplishing tasks.

The relationship between technological change and the welfare of society involves decisions about what in fact constitutes a problem,[2] Because these decisions include judgments about what is "good," the development of knowledge and its technological applications not only ***arise*** from cultural values but are themselves social institutions. Modern technology surpasses that of earlier periods in its power, scope, and pace of change. Its societal consequences are thus becoming both more profound and more pervasive, intensifying the importance of understanding and anticipating technological impact and change.

Aging and technology

The interaction between technology and society presents both opportunities and challenges to individuals and social institutions. Will technological change enhance the ability of older persons to work or to perform daily activities of living, or will it instead limit their capacity to be self-sufficient? The rapid growth in numbers of older Americans is focusing increased attention on the social and economic costs or benefits of technology for the elderly, and for society as a whole.

New types of housing units and their design may minimize or exacerbate the difficulties faced by older individuals who are functionally impaired. Improved biomedical technologies to treat acute illnesses will present new questions about the value of life and the choices made about living and dying. Advances in health care that reduce the incidence of chronic disease are likely to require decisions about allocation of resources and whether access to health care services is a right or a privilege. The list of relevant issues is long and complex, but it is clear that none of these changes is independent of the others.

'Another view is provided by physician and educator Lewis Thomas, who has proposed a three-level paradigm of technology: 1) nontechnology, such as personal supportive care services for dependent persons; 2) halfway technology, such as devices that compensate for disabilities (e.g., hearing aids, pacemakers, wheelchairs]; and 3) decisive technology, such as basic research and science.

[2]In discussing the cultural aspects of technology and its use in solving problems, economist John Galbraith defined technology as the "systematic application of scientific or other organized knowledge to practical tasks" (8).

During this century, the application of technologies in the workplace, the home, the hospital, and the environment has led to great improvements in life expectancy and health across all age groups, particularly the youngest. Most recently, medical and other technologies have accelerated the improvement of life expectancy among the oldest age groups. Technological developments have also improved contraceptive efficiency, contributing to the notably low birth rates of the 1970s. The annual fertility rate of American women aged 15 to 44 was lower during the last decade than in any previous periods

In combination, these changes in fertility and mortality will hasten the aging of the American population during the next few decades During the last 20 years the population aged 66 and over has grown twice as fast as the population under 65. The pace of technological change accelerated dramatically during this period, raising innumerable questions about the interaction of technology with the growing older population,

This assessment recognizes that technology involves the development of knowledge and its application to issues of aging in a variety of contexts, such as:

- ***the biology or chemistry laboratory,*** where new biotechnologies may enhance understanding of cellular aging and disease processes;
- ***the health care setting,*** where new diagnostic and treatment methods may prolong increasing numbers of lives;
- the ***workplace,*** where efficiency and productivity are new challenges for adult workers and for policymakers concerned with their physical, economic, and psychological well-being;
- ***the*** home, where functional independence is likely to be enhanced by new devices, information technologies, and differently organized long-term care service delivery systems; and
- the ***community,*** where public services, transportation systems, information technologies, and long-term care programs may enhance functional ability, or promote disease prevention, health promotion, and expanded options in daily living.

An examination of each of these broadly defined contexts led to the identification of issues that are of Federal concern in budgetary, regulatory, and oversight activities. Options that correspond to these issues, which will grow in importance as the elderly become a larger proportion of the U.S. population, are presented for congressional review.

[3]Fertility rates measure the frequency of live births within a given population, such as "number of live births per 1,000 women aged 15 to 44." These rates do ***not*** account for stillbirths and aborted pregnancies, whether induced or spontaneous.

[4]The aging of the population means an increasing proportion of the total population in the older (over 65) relative to the younger (under 65) ages. It is also measured by median age, the age at which 50 percent of the population is older and 50 percent is younger.

Organization of the report

Major areas of concern

Four major areas were selected for attention in this assessment. Their importance, both direct and indirect, is evident in existing Federal policy, programs, regulations, and budgetary activities related to older Americans. These areas are:

- chronic conditions and biomedical research;
- functional impairment and long-term care;
- housing and the living environment; and
- employment and the workplace.

It should be noted that this assessment does not focus on acute illness and its treatment in the elderly, which would considerably expand its scope. Treatment of acute illness has already received extensive study, including other OTA assessments of medical technologies and acute health cares This assessment concentrates on chronic health condition, biological factors and

[5]The OTA Health Program has published a series of case studies and technical memoranda on specific medical technologies for acute illness (22).

functional impairments of the elderly because of their growing significance to the independence of older persons and their ability to carry on various activities in the workplace, the home, and the community. Some of these areas are discussed in this chapter; many more are included in the chapters that follow.

The table of contents for this report indicates the breadth of subjects covered in the four general subject areas cited. Each chapter deals with the implications of technology and aging in a particular area. General themes include organization, financing, efficacy, regulation, safety, quality, education, and research. The congressional issues and options that conclude each chapter reflect many of these themes (e.g., the efficacy of medications for the elderly, the organization of long-term care, and the quality of housing and its design for the elderly). Areas for additional research are identified separately. Studies on the socioeconomic, attitudinal, behavioral, and other social scientific characteristics of the older population are not emphasized in the research priority sections unless they have a direct bearing on questions related to technological change.

Chapter topics were chosen in response to congressional requests and upon the advice of the project's Advisory Panel. The intent of this assessment is not to provide a comprehensive review of all aspects of technology and aging, but rather to examine the most important technological factors related to the physical and mental health status—and independence-of the older population.

Appendixes are included to provide detailed data and background information for several important areas, including morbidity and mortality, labor force participation, and biotechnology. The appendixes amplify information that is provided in the chapters.

The following section reviews the demographic phenomenon known as the aging of the American population. It discusses the changing characteristics of the older population and major trends in mortality and morbidity. Technological change and its relevance to these trends is assessed in relation to the report's four general subject areas, which give rise to key policy issues.

Where appropriate, the experiences of other Western industrialized countries with similar characteristics are cited as instructive models that may suggest possible policy options for the United States. Detailed comparisons of aging and public policy in these nations are, however, not included in this assessment.

Demographic background

Definitions

These definitions are central to discussion of the demographic aging of the American population and the future implications of current trends in U.S. population growth and change.

AGING AND THE AGED

For purposes of this report, the elderly are defined as all persons aged 65 and over (or '(over 65"). Although"65 is a chronological definition of the onset of old age, there is no scientific "marker" of old age. In the United States and most Western industrialized countries, 65 years is the age of eligibility for full retirement income benefits. Some countries vary in this regard. In Japan the eligibility age for women is 55 and for men is 60; in Norway neither men nor women become eligible for full benefits until age 67. Age 65 was established as the eligibility age for full Social Security benefits at the US. retirement program's inception in 1935.[6]

It is important to note, however, that aging is a gradual biological process that differs among individuals; people do not suddenly "become old" at 65, Indeed, the older population tends to be

[6]Age 65 has a historical basis; for example, it was used by Germany's Chancellor Bismarck in the late 19th century to establish eligibility for military pensions. Although the Chancellor lived past 80, one of his intentions appears to have been to limit the number of pension beneficiaries in an era when average life expectancy at birth was less than 45 years,

more, rather than less, heterogeneous in its social, political, economic, health, and other characteristics than those under 66. A chrono= logically based label is convenient for defining population groups, but is a poor descriptor of biological function or need for various types of assistance. Further ambiguity is seen in the different age criteria for the "elderly" in Federal programs and public statutes. Federal housing assistance programs for the elderly use age 62, while programs under the Older Americans Act are available to those 60 and over. The Internal Revenue Service allows an elderly credit on personal income taxes for Americans 65 and over, but the one-time capital gains allowance from the sale of a primary residence is available to anyone over 55. The Age Discrimination in Employment Act (ADEA) protects workers 40 and over, although no inference is made that workers in their 40S are "old. " Thus, social values and policy-relevant definitions concerning old age vary widely, and often depend on the issues, programs, needs, and constituents involved.

"The aged" as a group must be distinguished from "aging" as a process that varies both in different species and across subgroups within the same species. The great variation in average life expectancies across species is illustrated by the fact that mice live an average of 3 years and humans an average of 74 years. There is growing evidence that aging and the incidence of diseases associated with age also vary within species. These differences are associated with genetic factors, biological differences, environmental influences, and, for humans, socioeconomic status. For example, average life expectancies at birth range from as low as 45 in some developing countries (Gambia, Niger, and Somalia) to as high as 76 in some developed countries (Norway, Sweden, and Japan). In the United States, the average life expectancy at birth for a white female (78.7 years) is almost 12 years greater than for a black male (66.5 years).[7]

Given these variations, definitions of "the elderly" based on chronological age are artificial. Individual variation within each age group is great. Although it is convenient and often necessary to use chronological age (e.g, in formulating pub lic policy), such boundaries must be used with caution when making inferences about the elderly as a group. Both technology and aging can affect individuals or subgroups of the same chronological age differently, depending on such other factors as their functional capabilities and the social or environmental characteristics that influence their interaction with society.

Because the over-65 group is so heterogeneous, some segments of this report identify those between 65 and 74 as the ***young-old*** and those 75 and over as the ***old-old.*** When it is necessary to make still finer distinctions, persons over 85 are referred to as the very ***old.*** In certain policy-related issues, such as older workers' employment and the ADEA, the "elderly" can also include those 40 to 64; these exceptions to the report's basic definitions are noted as they occur.

The aging of a population is a gradual process in which the proportions of adults and elderly increase while the proportions of children and adolescents decrease. This results in a rise in the median age (i.e., the age at which 50 percent of the total population is older and so percent is younger). Aging occurs when fertility rates decline or remain constant, while mortality rates remain constant or improve, especially at the older ages.

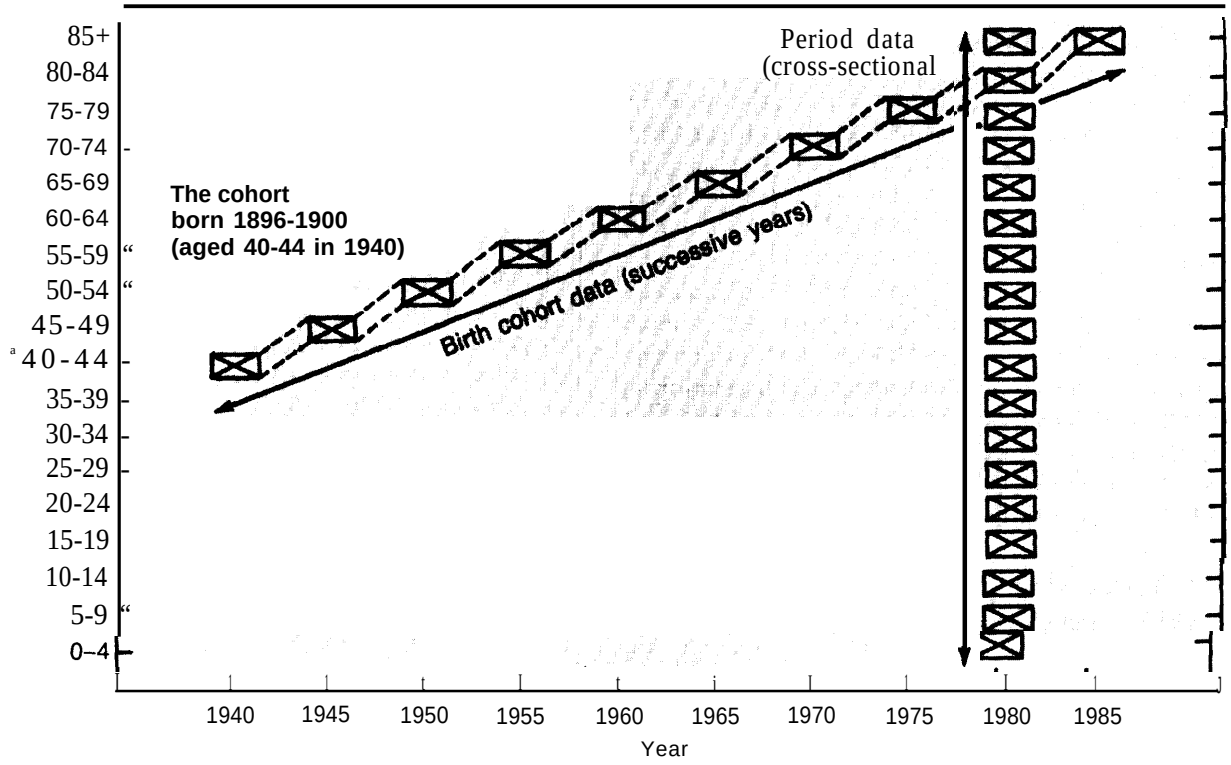
COHORT V. PERIOD DATA

In discussing population aging and demographic trends, two main types of data can be utilized: period data and cohort data. period, or "cross-sectional)" data describe variables or events that occur across a population within a specified time period. Cohort data, by contrast, follow the experiences of a particular population group over a long time period. The major difference is that period data present a "snapshot" of different age groups in a short time period or at one point in time, while cohort data provide a "lifetime picture" of a particular group over many years (see fig. 5).

The most useful cohort in demography is the "birth cohort"–a group of individuals born within a certain time period, usually a calendar year or

7Data on racial categories used in this report are technically differentiated as "white" or '(black and other." For convenience, "black" is used in the text, rather than "black and other. "

Figure 5.—Schematic Representation of Cohort Data and Period Data



NOTE Birth cohort data describe the events expetienced over time by a group born in the same year(s), ie , as the group "ages" period data describe the events across age groups at one point m time

SOURCE Office of Technology Assessment

a 5-year interval.[a] The experiences of this birth cohort can be "followed" through its lifetime. Each birth cohort experiences a set of events over time that is characteristic of its aging and the historical period during which this aging occurs, the consequences of which are called "cohort effects. "

Cohort analysis is important in gerontological study because it measures change within a group over time, as in panel or longitudinal studies. Because actual birth cohort data are not readily available for long time periods, age-specific cross-sectional data over many years are often used to ***approximate*** the cohort experience. But they do not provide comparable information.

Most events in a population are influenced by both cohort and period effects. For example, the educational attainment of the elderly in 1980 is largely a result of the educational attainment of the pre-1915 birth cohorts during their "school-age years." Successive birth cohorts had higher levels of education (a period effect). As the cohorts aged and became part of the future elderly population, the average level of the total older population's educational attainment increased. In this way, earlier period effects are combined with the aging of the birth cohorts to yield new cross-sectional data at a later time. For example, from 1970 to 1980 the proportion of persons over 65 who had completed 1 or more years of high school increased sharply from 30 to more than so percent. This large change was primarily due to the cohort effect of a more highly educated group aged 55 to 64 who had entered the over-65 category by 1980.[9]

[a]For example, persons aged 64 in 1984 belong to the 1920 birth cohort. A birth cohort can also be defined for a longer period of time For example, the 1915-19 birth cohort was aged 61 to 65 in 1980

[9]The difference between cohort and period effects is illustrated by more detailed comparison of the data on educational attainment. In 1970 only 30 percent of all persons over 65 had completed 1

For certain analyses, cross-sectional and cohort data are combined to create "synthetic cohorts," which are hypothetical groups that substitute for real birth cohorts. A synthetic cohort is created by using cress-sectional demographic data and applying them to a birth cohort over its future lifetime. These hypothetical cohorts are the basis for the most commonly used life expectancy tables. Synthetic cohorts are essential because a real cohort's mortality experience requires observations dating back 100 years, and such data are not generally available. The fertility and mortality characteristics of synthetic cohorts are the basis for most population projections developed by Federal agencies. The role of these characteristics in creating synthetic cohorts is an important factor in evaluating projections of the future elderly population.

Demogaphic projections of the elderly population

The two major U.S. national population projections are provided by the Bureau of the Census and by the Social Security Administration (SSA). The SSA projections are primarily used for future planning of the Social Security system and its long-term financing obligations. The Census Bureau projections include all age, sex, and race subgroups of the total population and are the most commonly used population forecasts. The word "forecast" is used intentionally to emphasize that demographic projections are ***not*** predictions.

Projections are developed in three "series" that differ according to the basic demographic assumptions used to create the synthetic cohorts that form the "new" populations. The three series use low, middle, and high estimates of each type of age-specific vital rate for l-year birth cohorts (called the cohort component methodl").

The accuracy of demographic projections has improved during the last few decades with the application of more sophisticated methodologies. The most recent projections use the latest population base from the final counts of the 1980 census, revised by estimates of the population as of July 1, 1981 (see table 1). In general, the middle-series assumptions are considered the most likely to occur, and the low and high assumptions define a reasonable rate of error around the middle series. Each of these components will vary from expectations because of unpredictable cultural, economic, and biological factors.

The least predictive component is fertility, which is most likely to be influenced by exogenous factors (e.g., economic conditions, government policy), to be controlled by personal choice, and to be influenced by the adequacy of contraceptive methods. The "baby boom" following World War II was not projected for the 1945-60 period, either in terms of the birth rate or the number of years during which fertility remained high. Nor was the precipitous decline in fertility since the early 1960s expected. Both of these fertility trends have an impact on the short- and long-term changes in the aging of the population.

Mortality is less difficult to estimate, barring no ***major*** short-term deviations in age-, race-, and sex-specific trends in death rates. However, recent changes in health and medical care technologies have added an element of uncertainty to age-specific mortality rates for cohort projections. Assumptions about changes in age-specific death rates have been lower than reality in most projections during the past 30 years (19). The unprecedented increases in life expectancy at the ***oldest***

(continued from p. 37)

or more years of high school, compared with 55 percent of those 25 to 64. By 1980, the survivors of the 1970 cohort of persons over 65 had become the over-75 group. In 1980, 28 percent of those over 7.5 had 1 or more years of high school. Because most persons do not add to their formal education after age 30—much less after age 65—the educational level of this elderly cohort did not change as it aged during the 1970-80 decade. The cohort effect produced a slight decrease in 1980 in the proportion of those over 65 with 1 or mom years of high school (probably due to bias in educational level of the cohort survivors or a statistical artifact).

Period (i.e., cross-sectional) data provide different information. By 1980 more than 50 percent of all persons over 65 had completed 1 or more years of high school, an increase of 20 percentage points for that age group between 1970 and 1980. The major reason for this increase in the ***period*** rate was the movement of the cohort aged 55 to 64 in 1970 into the over-65 category in 1980. The younger age group brought with it notably higher educational attainment levels, thereby increasing the average for the new over-65 group in 1980 (i.e., not the same birth cohort).

'The "cohort component method" separately projects age-specific fertility, mortality, and immigration rates for each l-year birth cohort, using the three alternative levels of each demographic component. These "scenarios" are then played out over the remaining lifetime of each birth cohort to yield the projections for future decades.

Table 1.—Growth of the Population Aged 55 and Over, by Selected Age Groups, 1900-2050 (numbers in thousands)

Year	Total population, all ages		55 years and over		55 to 64 years		65 to 74 years		75 to 84 years		85 years and over		65 years and over	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
1900.....	76,303	[illegible]	7,093	9.3%	4,009	5.3%	2,189	2.9%	772	1.0%	123	0.2%	3,084	4.0%
1910.....	91,972	[illegible]	9,004	9.8	5,054	5.5	2,793	3.0	989	1.1	167	0.2	3,950	4.3
1920.....	105,711	[illegible]	11,465	10.8	6,532	6.2	3,464	3.3	1,259	1.2	210	0.2	4,933	4.7
1930.....	122,775	[illegible]	15,031	12.2	8,397	6.8	4,721	3.8	1,641	1.3	272	0.2	6,634	5.4
1940.....	131,669	[illegible]	19,591	14.9	10,572	8.0	6,375	4.8	2,278	1.7	365	0.3	9,019	6.8
1950.....	150,697	[illegible]	25,565	17.0	13,295	8.8	8,415	5.6	3,278	2.2	577	0.4	12,270	8.1
1960.....	179,323	[illegible]	32,132	17.9	15,572	8.7	10,997	6.1	4,633	2.6	929	0.5	16,560	9.2
1970.....	203,302	[illegible]	38,588	19.0	18,608	9.2	12,447	6.1	6,124	3.0	1,409	0.7	19,980	9.8
1980.....	226,505	[illegible]	47,244	20.9	21,700	9.6	15,578	6.9	7,727	3.4	2,240	1.0	25,544	11.3
1990.....	249,731	[illegible]	52,889	21.2	21,090	8.4	18,054	7.2	10,284	4.1	3,461	1.4	31,799	12.7
2000.....	267,990	[illegible]	58,815	21.9	23,779	8.9	17,693	6.6	12,207	4.6	5,136	1.9	35,036	13.1
2010.....	283,141	[illegible]	74,097	26.2	34,828	12.3	20,279	7.2	12,172	4.3	6,818	2.4	39,269	13.9
2020.....	296,339	[illegible]	91,629	30.9	40,243	13.6	29,769	10.0	14,280	4.8	7,337	2.5	51,386	17.3
2030.....	304,330	[illegible]	98,310	32.3	33,965	11.2	34,416	11.3	21,128	6.9	8,801	2.9	64,345	21.1
2040.....	307,952	[illegible]	101,307	32.9	34,664	11.3	29,168	9.5	24,529	8.0	12,946	4.2	66,643	21.6
2050.....	308,856	[illegible]	104,337	33.8	37,276	12.1	30,022	9.7	20,976	6.8	16,063	5.2	67,061	21.7

SOURCES: U.S. Bureau of the Census, "America in Transition: An Aging Society," *Current Population Reports*, Series P-23, No. 128, September 1983; base data from U.S. Bureau of the Census, *Decennial Censuses of Population, 1900-1980* and Projections of the Population of the United States: 1982 to 2050 (Advance Report), *Current Population Reports*, Series P-25, No. 922, October 1982. Projections are based on middle-series assumptions.

ages during the 1970s were not anticipated in projections during that time.1*

Net immigration figures tend to be most easily estimated, given the relationship of immigration rates to Federal policy, quotas, and registration procedures. However, immigration rate assumptions do not take account of the high annual total of undocumented immigrants who enter the United States. Estimates of their numbers vary greatly because no accurate data are available.

These factors illustrate the need for caution in the use and interpretation of population projections. The longer the interval covered by a projection, the greater the degree of uncertainty and error in the estimates. Each successive year following the decennial census compounds the inaccuracy of the estimates for the basic populations in the projections. Projections of the *numbers* of older people are more reliable than those that yield percentage figures; percentages depend on the number of persons in *every* other age group, which depend largely on fertility trends over time (the least predictable variable for projections).

projections of elderly households are even less reliable, because household formation and size are influenced by factors such as marital status, income, health, extended family structure, tax policy, and other variables that are themselves difficult to project. A final source of potential inaccuracy in projections is the base population (or baseline data) from which future cohorts are developed. As shown in chapter 9, for example, the 1979 estimates of tenure (i.e., owners v. renters) for elderly households were very different from the totals enumerated by the 1980 census .*2

Taking these caveats into consideration, the following section reviews the demographic trends that have had the greatest influence on the aging of the U.S. population, and looks at current projections of the older population.

[11] Projections based on the increased rates of decline in age-specific mortality rates for the older population subgroups (by age, race, and sex) during the 1968-77 period yield a total older population in 2000 that is almost 4 million persons more than was officially projected by the Census Bureau in 1977–an underestimate of more than 10 percent. The most recent official projections have been adjusted upward to account for this dramatic change.

[12] New household projections based on 1980 census counts have not been officially generated; because the most recent official projections use 1978 estimates from the Current Population Survey, the potential for error remains strong.

Demographic trends

Among the population changes experienced by the United States during this century has been unprecedented growth in the number and proportion of older Americans. Demographic aging, its changing pace, and the technological factors that have both created it and responded to it point to substantial challenges and opportunities for American society. Improved understanding of these trends is important in enabling both the public and private sectors to anticipate and thus respond appropriately to the needs of future cohorts of elders and to benefit from the resources they possess.

The most significant demographic trends are:

- rapid growth of the over-65 population during most of this century and its continued high rate of growth during the next 50 years (the aging of the baby boom generation, resulting in the "elderly boom" during 201o to 2025);
- changes in life expectancy at birth and at the older ages, especially the most recent increases in the rate of improvement for the very old; and
- aging of the older population itself, with the fastest rates of growth among the oldest subgroups (sometimes referred to as an "aging implosion").

The growth of the older population

In 1900 only 4 percent of the total U.S. population was over 65. By 1980 this proportion had risen to 11.2 percent and the number of older Americans exceeded 25 million (see table 1). In

1983 the elderly population was estimated to have surpassed 27 million, and to account for 11.6 percent of the total. The growing proportion of older persons has boosted the median age significantly in less than three generations—from just under 23 years in 1900 to over 30 by 1980.

This growth in the number and proportion of the elderly is expected to continue, but at a slower pace, through the end of the century. The most recent projections indicate that the ranks of the elderly will increase by at least 30 percent by the year 2000, when they will constitute more than 13 percent of the total population. By recent standards, this projected growth is relatively small, due largely to the effect of the small birth cohorts and relatively high infant mortality rates during the Depression and World War II period of 1925-45. Both of these factors will limit the number of older persons in future decades (when net immigration is held constant).

The effect of the baby boom birth cohorts on the future older population will be felt after 2010, when America's elderly boom begins. By 2020, the elderly population is expected to exceed 51 million and to account for more than Ii' percent of the Nation's population .13 The projected increase in numbers of older Americans between 2010 and 2020—more than 12 million—is only slightly less than the number of those expected to join the over-65 population during the entire 30-year period from 1980 to 2010 (see table 1).

Changes in average life expectancy

During most of this century, gains in the life expectancy of Americans have occurred because of improvements in public sanitation, hygiene, control of infectious diseases, prenatal maternal and postnatal infant care, and, since the 1940s, antibiotics. These improvements have sharply reduced infant mortality, which began to fall in the early 1930s, resulting in higher survival ratios for successive birth cohorts.

only 41 percent of infants born in 1900 survived to reach age 65; by 1980 this proportion had risen to more than three-fourths .14 In 1900, average life expectancy at birth was 47,3 years; those who reached 65 could expect to live another 11.9 years. By 1983, average life expectancy at birth had increased by more than 27 years—to 74.7. The change in life expectancy at age 65, however, has been far less impressive for most of this century. In 1983 this figure was just 16.8 years, on average, for those aged 65—an increase of only 4.9 years since 1900.

More notable is the ***recency*** of the increase in life expectancy at older ages. The average life expectancy of those aged 65 in 1950 was 13.9 years—only 2 years higher than in 1900, reflecting an improvement of only 17 percent during the entire half-century (see table 2). Since 1950, however, the corresponding figure has already risen by 2.9 years (to 16.8 for 1983), a 20-percent improvement in just 33 years. Yet this dramatic improvement in old age survivorship masks still more recent advances in age-specific mortality. Of the 2.9 years gained since 1950, 1.6 years were added between 1970 and 1983. This increase is the largest change ever recorded in life expectancy at age 66 in such a short period of tim~more than one-half of the total gain since 1950 occurred in the last 13 years of this 33-year period.

The aging of the older population

This improvement occurred at the same time that the older population ***itself*** was aging, most notably since 1960. The growth of the very old population coincides with improvements in medical technologies, especially lifesaving measures in acute care (e.g., coronary bypass surgery and cardiac pacemakers) and life-sustaining technologies (e.g., diagnosis and treatment of hypertension). The survival of increasing proportions to the very old ages also coincides with the establishment of the Medicare program, which gave older people greater access to medical technology.

[13]These projected figures are based on the most recent middle-series assumptions: 1.9 total births per woman by 1985 and constant thereafter; life expectancy at birth increasing to almost 80 years for whites by 2050 and for blacks by 2080; and net annual immigration of 450,000 persons,

[14]Infant mortality has dropped sharply from 56 deaths per 1,000 live births of infants under 1 year of age in 1935 to a rate of about 11 in 1982 (24).

Table 2.–Life Expectancy at Birth and at Age 65, by Race and Sex, United States, Selected Years, 1900-82 (average number of years remaining)

	Total			White			Black and other		
Age and year	Both sexes	Male	Female	Both sexes	Male	Female	Both sexes	Male	Female
At birth:									
1900	47.3	46.3	48.3	47.6	46.6	48.7	33.0	32.5	33.5
1950	68.2	65.6	71.7	69.1	66.5	72.2	60.8	59.1	62.9
1960	69.7	66.6	73.1	70.6	67.4	74.1	63.6	61.1	66.3
1970	70.8	67.1	74.7	71.7	68.0	75.6	65.3	51.3	69.4
1980	73.7	70.0	77.5	74.4	70.7	78.1	69.5	65.3	73.6
1981	74.1	70.3	77.9	74.7	71.0	78.5	70.3	66.1	74.5
1982	74.5	70.8	78.2	75.1	71.4	78.7	70.9	66.5	75.2
At age 65:									
1900	11.9	11.5	12.2	—	11.5	12.2	–	10.4	11.4
1950	13.9	12.8	15.0	–	12.8	15.1	–	12.5	14.5
1960	14.3	12.8	15.8	14.4	12.9	15.9	13.9	12.7	15.2
1970	15.2	13.1	17.0	15.2	13.1	17.1	14.9	13.2	16.4
1980	16.4	14.1	18.3	16.5	14.2	18.5	15.5	13.5	17.3
1981	16.7	–	—	—	—	—	—	—	—
1982	16.8	—	—	—	—	—	—	—	—

SOURCES: National Center for Health Statistics, Health: *United States, 1982*, DHHS publication N0.(PHS)83-1232, Public Health Service (Washington, DC: U.S. Government Printing Office, 1982); and "Annual Summary of Births, Deaths, Marriages, and Divorces: United States, 1982," *Monthly Vital Statistics Report* 31:13, DHHS publication No. 83-1120 (October 1983) and 32:4, DHHS publication Supplement No. 83-1120 (Hyattsville, MD: Public Health Service, August 1983).

Table 3 shows the increasing proportion of those over 85 in the total older population since 1960 and the expected growth of the very old population through 2020. In 1960 about 1 in 20 older persons was over 85; by 1980 that proportion had grown to 1 in 11 (8.8 percent). During the same period the proportion aged 65 to 74 fell from 66 to 61 percent of the total. Because of the small birth cohorts during the 1926-35 Depression period, the 65 to 74 group is expected to be just one-half of the total older population at the turn of the century, while those 75 to 84 are likely to constitute more than one-third of all elderly persons, and those over 85 to reach their highest proportion, close to 15 percent.

Despite the possibility of small errors in these projections, the "implosion," or aging of the older population itself, promises to be as important as the sheer growth in total number of older persons. The positive and negative impacts on society of the growth of this aging elderly population, brought about in large part by increasingly rapid technological change during the last half-century, will inevitably spawn additional new technologies.

The dimensions of this dramatic transformation and its implications for society are not easily comprehended. Recent changes in the age composition of the older population tend to obscure the

Table 3.—Relative Distribution of the Population Aged 65 and Over, by Selected Age Groups, Selected Years, 1960-2020[a]

	Population age 65 and over		Percent distribution by age group		
Year	Number (in millions)	Percent	65-74	75-84	85 and over
1960	16.6	100%	66.4%0	28.O%	5.60%
1980	25.5	100	61.0	30.2	8.8
2000	35.1	100	50.5	34.8	14.7
2020	51.4	100	57.9	27.8	14.3

[a]Projections for years 2000 and 2020 are based on middle-series assumptions

SOURCE: U.S. Bureau of the Census, Projections of the Population of the United States: 1982-2050 (Advance Report), Current *Population Reports, Series P-25, No. 922,* October 1982.

actual improvement in elderly survivorship when data are reported for the older population as a whole. This problem is avoided by using age-specific, as well as age-adjusted, death rates .15

From 1940 to 1978 the age-adjusted death rate for the elderly decreased by more than 37 percent—n percent *more* than indicated by unadjusted rates for the same period. Similarly, age-adjusted death rates for older women and men decreased by greater proportions than indicated by the overall rate (5). These age-adjusted declines in mortality among the older age groups for both sexes are primarily due to the improved technologies that have contributed to the growth of the very old population.

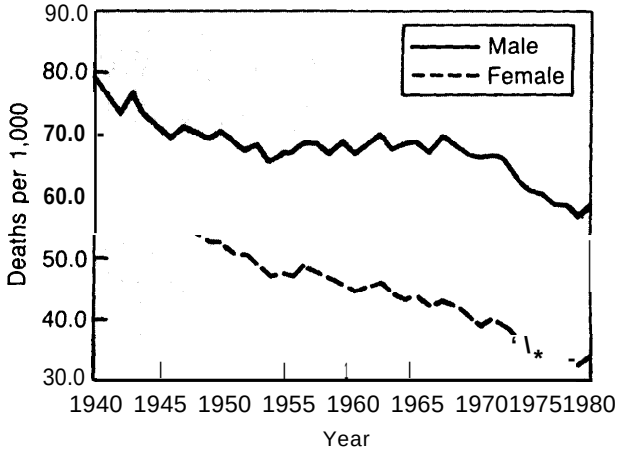
When plotted on an annual basis, elderly death rates for the 1955-67 period form a plateau, with relatively little change in real mortality rates (i,e, age-adjusted) in the older population. But during the 1968-80 period, sharp reductions in elderly mortality rates occurred. Average annual reductions in age-adjusted death rates for this period were 1.5 percent for older males and 2.1 percent for older females. The nature of this recent trend in real mortality decreases among the elderly is shown in figure 6. The post-1967 mortality declines among the elderly have been greater than for any previous period in American history, and suggest a new era characterized by continued decreases in age-adjusted elderly death rates during the rest of the century (see also table 4).

Trends in life expectancy by sex and race

Figure 7 shows that sex differences in age-specific life expectancy have become increasingly greater than ***racial*** differences since the 1930s. Life expectancy at birth for women has increased far more rapidly than for men; the most dramatic improvements have been for black women, whose life expectancy at birth surpassed that of white men for the first time in 1967. This demographic change began at the turn of the century, when female survivorship rates started to improve more rapidly than male survivorship rates. In 1900 life expectancy at birth was distinguished by a great disparity between blacks and whites, rather than between the sexes, as shown in figure 7. By the 1930s the life expectancy of black women clearly began to accelerate relative to that of men of both races. By 1980 black women's life expectancy approached that of white women, who have the highest level. As a whole, newborn girls can now expect to live, on average, 8 years longer than newborn boys. [16]

This life expectancy difference by sex is consistent with the rates in many industrialized countries, particularly those of Northern Europe. Average life expectancies at birth in Denmark,

Figure 6.-Age-Adjusted Death Rates for the Population Aged 65 and Over, by Sex, United States, 1940-80



SOURCE: US Senate, Special Committee on Aging, *Developments* **in** *Aging 1983, Volume 1,* **Washington, DC, Feb 29, 1984. Based on unpublished tabulations by L Fingerhut, National Center for Health Statistics**

[15] Age-asjusted demographic rates providetrue indicatiors rates provide true indicators of age-specific change, because they control for the effects of changes in population age composition that can have a biasing effect on vital rate data over time. The age-adjusted rates for two or more points in time are directly comparable, because they indicate hat the rates *Would be* if the populations had the same age composition at those points in time, Measures using age-adjusted rates in demography are the same as measures using "constant dollars" in economic researrh. The "base year" for age-adjusted rates is usually **30 to 40 years earlier** in order to show a definite trend over time,

[16] Note that life expectancy figures are derived from life table calculations that utilize age-specific *period* death rates by race and sex. The life table '(population" begins with a synthetic (or hypothetical) birth cohort whose mortality experience over its entire "future lifetime" is based on *current* age-, sex-, and race-specific death rates. It is possible that these rates for the synthetic cohort of overestimate e the mortality experience of the real birth cohort as it ages during the next 85 years, thus *underestimating* actual improvdernents in future life expectancy.

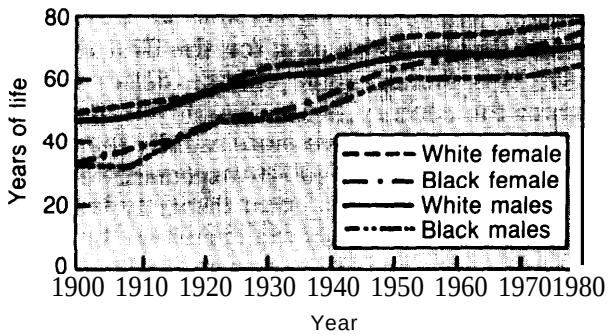
Table 4.—Average Annual Percent Change in Age"Adjusted Death Rates for Persons Aged 65 and Over, by Sex and Age, United States, Selected Periods of Years, 1940-80

Sex and Age	Years 1940-54	1955-67	1968-80
Males:			
Age 65 and over	-1.1 "/0	0.2%0	– 1 .7%
65-69	-0.7	0.1	-2.1
70-74	-1.0	0.2	-1.6
75-79	-1.1	0.2	–1.7
80-84	-1.3	-0.4	-1.3
85 And over	-1.5	0.9	-1.4
Females:			
Age 65 and love	-2.0	-1.0	-2.3
65-69	-2.3	-1.1	-2.3
70-74	-2.2	-1.3	-2.1
75-79	-1.9	-1.2	-2.6
80-84	-1.9	-1.1	-2.3
85 And over	-1.3	0.0	-2.1

a Age **adjusted to the United states population aged 65 and Over as Of 1940**

SOURCE: National Center for Health Statistics, "Changes in Mortality Among the Elderly: United States, 1940-78'' Supplement to 1980.' *Vital* **and** *Health Statistics, Series 3, No.229,* **DHHS publication No. (PHS)64-1406a, Public Heatth Service (Washington, DC: U.S. Government Printing Office, 1964)**

Figure 7.–Average Life Expectancy at Birth, by Race and Sex, United States, 1900-80



SOURCE: **National Center for Health Statistics,** ***VitaL Statistics UnitedStates,*** *1980.' Life Tab/es, vol. II, sec* **DHHS publication No. (PHS) 84-1104 (Hyattsville, MD Public Healh Service, May 1984)**

Sweden, Norway, the Netherlands, and other European countries are slightly higher (by l.0to 1,5 years) than in the United States, and have similar differences in life expectancies by gender. But most of these industrialized countries have life expectancies at age 65—both average and for men and women—that are either equal to or slightly below those of the United States. This anomaly is partly explained by the older age structure of most of these European countries relative to that of the United States, as measured by median age or by the proportion of the total population over 75.17 The Sex differences in life **expectancy at** birth suggest that the united States can expect continued discrepancy between the survival ra" ties of men and women, even as the proportion of older women increases in future years,

The sex- and race-specific changes in life expectancy during the last half-century have greatly affected the composition of the older population. By 1983 there were over 5 million more women than men over 65, a ratio of 3 older women to every 2 older mem As recently as 1960 this ratio was 5 to 4. This discrepancy increases notably for the very old; among those over 85 there are almost 6 women for every 2 men (42 men for every 100 women. There are no indications that this general pattern will change for the ensuing decades into the 21st century.

Yet the ***rate*** at which women's life expectancy at birth and, in particular, at age 65 increases relative to that for men is not expected to grow at

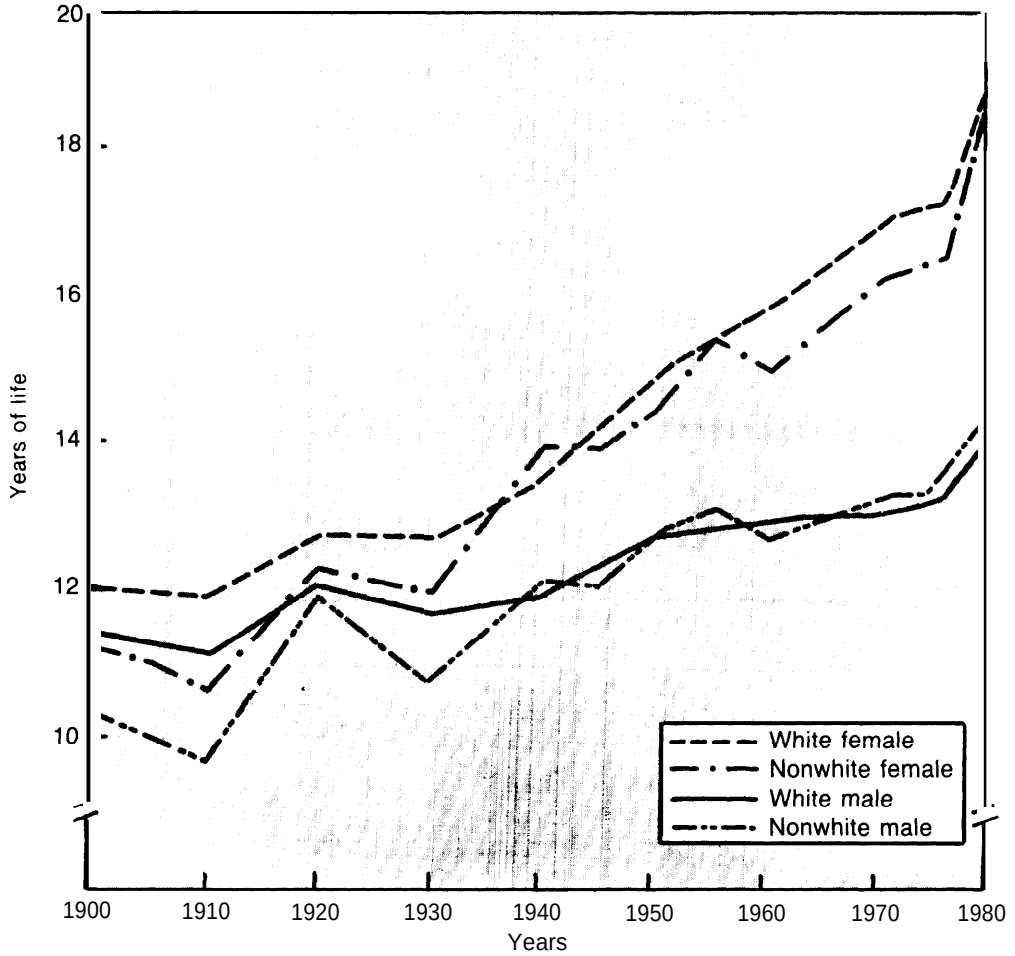
'The proportions of persons over 75 in most Northern European countries range from 0.5 to 2.3 percent higher than in the United States, a demographically large difference, Higher age-specific death rates at the oldest ages partly explain the similarity in life expectancy at age 65 between these countries and the United States. But higher life expectancies at birth, despite the older age structures, indicate that both female and male life expectancies at ages under 65 are usually higher than in the United States.

the same pace that it has for the last four decades (14). As shown in table 2 and figure 8, the 1970-80 increases in life expectancy at age 65 have been only slightly lower for white men than for white women, while slightly higher for black men. In general, older men and women are now benefiting similarly from the recent decreases in death rates from most causes of mortality, but the large sex differentials in life expectancy at birth and at age 65 remain.

These trends in age-specific mortality for both sexes indicate that more people will not only be living to older ages, but will also be living considerably longer after age 65 than ever before in the United States. A visual image of how the demographic structure of the U.S. population is expected to change emphasizes the potential impact of these trends. Although not directly representative of the most recent projections from which table 1 was developed, figure 9 presents a recent set of population pyramids [18] based on projections made in 1980. The baseline data for the projections assumed higher total fertility rates, lower

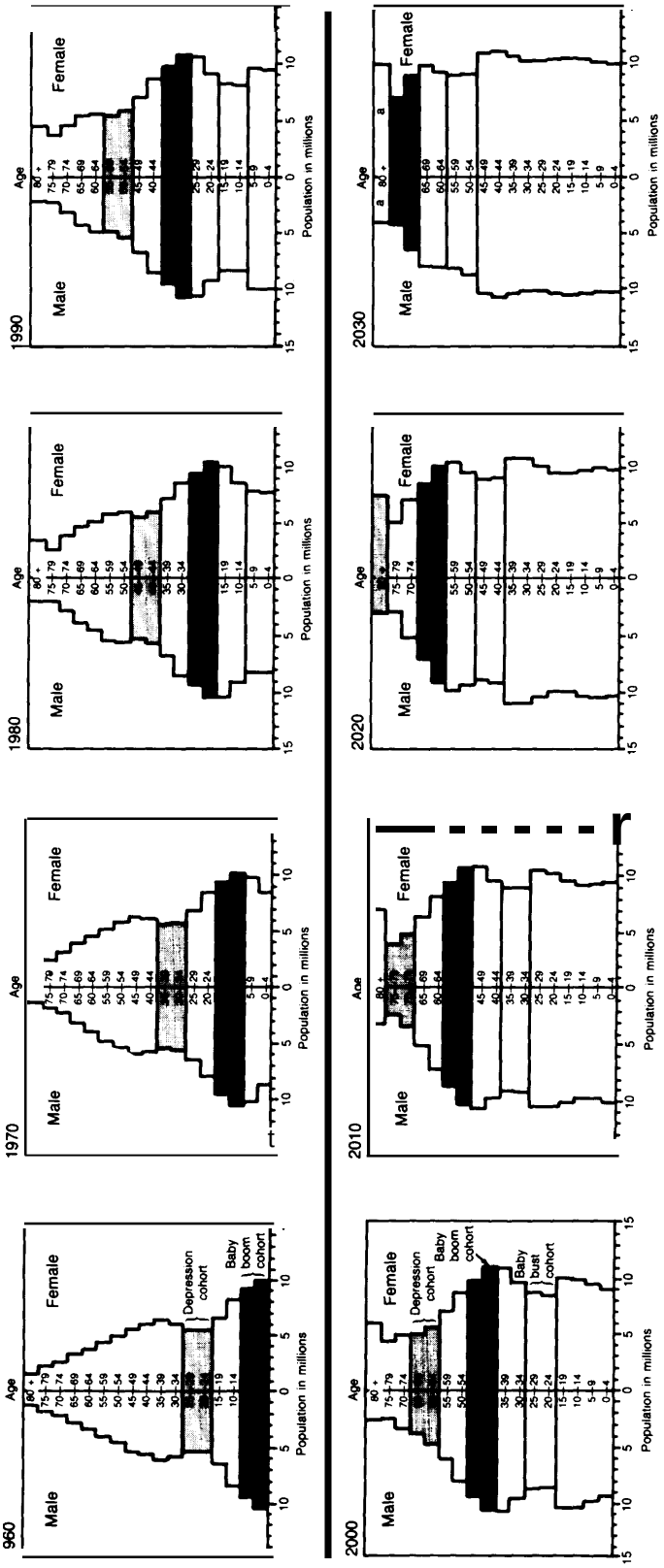
[18] Population pyramids are graphic representations of the sex and age composition of a population, using either 1- or 5-year age intervals for each sex to age 85 and over. The diagram is called a pyramid because the structure of most populations in earlier periods closely resembled the tapering form of a pyramid, with decreasing numbers and proportions in successively older age groups. The measure used for the horizontal axis can be either absolute numbers, as in fig. 9, or percentages of the total.

Figure 8.—Average Life Expectancy at Age 65, by Race and Sex, United States, 1900-80



SOURCE: Office of Technology Assessment, based on data from the National Center for Health Statistics, Vital Statistics of the United States, 1980 Life Tables, vol II, sec 6 DHHS pub No. (PHS) 84-1104 (Hyattsville, MD: Public Health Service, May 1984)

Figure 9.—Population Pyramids, by Age and Sex, United States, 1960–2030



SOURCES: Adapted from L. Bouvier, "America's Baby Boom Generation: The Fateful Bulge," *Population Bulletin*, vol. 35, no. 1 (Population Reference Bureau, Inc., Washington, DC, 1980); 1960-1970: U.S. Bureau of the Census, *1970 U.S. Census of Population: General Population Characteristics, United States Summary*, vol. 1, PC(1)-B1, 1972, Table 52; and 1980-2050: Special unpublished tabulations prepared by L. Bouvier for the Select Commission on Immigration and Refugee Policy, 1980.

NOTE: 1980-2050 projections assume a total fertility rate rising to 2.0 births per woman by 1985 and constant thereafter; life expectancy at birth rising to 72.8 years for males and 82.9 years for females by 2050; net immigration constant at 750,000 persons per year.

ultimate life expectancies, and higher levels of net immigration than more recent projections. The aging of the populations in these pyramids, as depicted by the degree to which they become "squared" in ensuing decades, is less than the most recent projections would anticipate. They therefore reflect the ***minimum*** aging that is expected to occur in the U.S. population structure during the next 50 years.

The "wave" of the large baby boom cohort in 1960 (ages 0 to 9 in the pyramid) continues to exert its influence as it ages into the years 2010-30. The squaring of the population's structure is accompanied by the rapid rate of growth in numbers of older women in successive decades. Even if mortality rate reductions at the older ages become similar for both sexes in ensuing years, the current higher survival ratios of women over 55, who presently outnumber men in this age group by almost 7 million, will produce higher numbers of surviving women for at least the next 30 to 40 years.

Major causes of death in old age

Dramatic percentage decreases in death rates have been occurring in all older age subgroups, as shown in table 4. Indeed, persons reaching 85 can expect to live, on average, beyond 92. As is true of mortality declines for the elderly in general, the major contributor to these decreases in death rates of the very old has been the age-specific decline in cardiovascular deaths. As has been noted, there is no clear evidence to explain these dramatic improvements among all older age groups, but the most likely factors include:

- recent technological advances in the care of acute illnesses that might otherwise have led to death;
- improved monitoring and control of risk factors such as high saturated fat and cholesterol diets, cigarette smoking, and hypertension; and
- changes in long-term care of the chronically impaired, both in institutions and in the community.

Underlying these newly emerging improvements in life expectancy at the older ages are recent declines in age-specific mortality from acute episodes of infectious diseases (e.g., pneumonia and influenza) and the major chronic diseases, especially diseases of the heart and cerebrovascular diseases (stroke). The latter two disease categories, plus malignant neoplasms (cancers), currently account for three out of every four deaths among the elderly,[19] an overall proportion that has remained unchanged since World War II. However, the ***relative*** proportion of deaths from each of the three leading causes of elderly mortality has changed over the last 30 years, in part explaining the recent improvements in life expectancy at older ages.

HEART DISEASE MORTALITY

Coronary heart disease remains the Nation's leading cause of death, both among the elderly and in the total population. Although 46 percent of all deaths among persons over 65 in 1980 were due to cardiovascular diseases, age-specific death rates from these causes have steadily declined among the elderly during the past three decades, particularly since 1970. Between 1970 and 1979, the death rate from heart disease for persons 65 to 74 declined 22.7 percent-the most substantial decrease ever recorded in a decade for this disease category and this age group. For those 75 to 84, the decrease was 14.5 percent; the over-85 age group had an 18.7-percent decrease during this same period. The relative risk of death from heart disease increases with age, even among the elderly. In 1980, heart disease accounted for less than 41 percent of deaths for persons 65 to 74, but almost 49 percent of deaths among those over 85,

The variations in heart disease mortality within these age groups by race and sex are noted in appendix A, In general, proportional improvements have been highest for women and blacks, except for increases among blacks 75 to 84.

[19]"Cause of death" data utilized by the National Center for Health Statistics (NCHS) are based on information contained in death certificates. In general, the cause of death in NCHS tabulations reflects the underlying cause or event that led to death. This cause may differ from the "immediate" cause of death that is reported on the death certificate (e.g., a death from a skull fracture due to an automobile accident would usually be reported as due to the accident rather than the skull fracture). In 1978 nearly 75 percent of all death certificates listed more than one condition and 15 percent had four or more. Cause of death data generally indicate the underlying condition, but not the complicating ones that may have contributed to the death (23).

There are no definitive explanations for the heart disease mortality differences within or between the racial groups. Similar differences are also seen in other causes of death and in morbidity rates. Some gerontological studies show that elderly blacks face the "double jeopardy" of old age and minority status; the problems of aging are compounded for minorities by lifelong confrontations with lower social, economic, psychological, and physical health status. These disadvantages are reflected in their greater incidence of chronic and acute disease throughout life.

These health and social disadvantages disappear only among the very old, as shown by lower death rates by sex for blacks in the over-85 group. One hypothesis suggests a "leveling effect," which reduces race differences in health and functional ability at the oldest ages (18). Mortality differences change in the same manner; beyond age 75, blacks have higher life expectancies than whites (19).[20] For heart disease mortality, this leveling effect occurs beyond age 85.

CEREBROVASCULAR DISEASE MORTALITY

Cerebrovascular disease (stroke) is a major cause of death for the very old. Although only 7 percent of deaths to persons aged 65 to 74 are due to strokes, this proportion reaches 14 percent for those over 85. However, remarkably high rates of decrease in deaths from strokes among the elderly occurred during the 1970s, averaging 3 to 5 percent per *year*.

Key factors in reducing death rates from stroke are increased awareness, diagnosis, monitoring, and control of hypertension and levels of serum cholesterol. Recent reports from longitudinal studies suggest that improvements in diet, exercise, and other lifestyle habits also contribute to falling death rates from stroke (see ch. 4).

[20]Caution is advisable in discussions of race differences in death rates among the elderly, especially the very old. Age-reported data for blacks are likely to be less accurate than for whites at the oldest ages, due in part to less accurate birth records for older blacks. Death rates for older blacks have been found to be understated. Thus, differences in data on elderly mortality rates by race are likely to be artificially greater than in reality (15),

CANCER DISEASE MORTALITY

Cancers accounted for 19 percent of all deaths among the elderly in 1980.[21] Age-specific rates of this second leading cause of death among older persons (and among the general population) have increased in recent years, primarily due to a notable rise in the rates of lung cancer for older men and women of all races. In 1980 lung cancer among women aged 65 to 74 replaced breast cancer as the leading cause of female cancer mortality. older black men have the highest rates of death from cancer among those over 85. In contrast, older black women have had lower or very similar mortality rates from all cancers when compared with older white women.

Recent studies of racial differences in the incidence of specific types of cancers among the elderly from 1973 to 1978 show a leveling effect between race, age, and incidence of most cancers among older men (16). No clear pattern of cancer incidence by race and age was discerned for women.

Although death ***rates*** from cancer increase by age within the older population, the increases are small when compared with those for deaths due to heart disease. The likelihood of dying from cancer decreases with age; although 26 percent of all deaths among persons 65 to 74 in 1980 were due to cancer, this proportion sharply decreases-to just 10 percent-among those over 85. Cancer is far more likely to be a killer of the young-old than the very old.

Future life span and prevalence of chronic diseases

Because the elderly are becoming an ever-larger proportion of the U.S. population, their physical and mental health status is an increasingly important concern. Although recent decreases in death

[21]The proportion of deaths from cancer among persons over 65 is lower than for those 45 to 64. For the 45 to 64 age group, the proportion of deaths from heart disease is lower and the proportion of deaths from cancer is higher than for the elderly. Among persons 25 to 44, accidents are the major cause of death, followed by cancer and heart disease,

rates from heart disease and stroke among older Americans have ushered in a new period of increased old-age longevity, this quantitative increase has not been matched by qualitative improvements in the health status or functional abilities of the older population.

Chronological age continues to be directly associated with greater risk and incidence of most chronic diseases and functional impairments. Despite reductions in mortality rates from acute episodes of heart disease and stroke, the prevalence of chronic conditions associated with these and other diseases persists among the elderly. As populations age, they face an increasing prevalence of major mental diseases such as schizophrenia, affective disorders, brain syndromes associated with senile brain disease (e.g., Alzheimer disease) and arteriosclerosis, and epilepsy. This trend has been called the "rising pandemic of mental disorders and associated diseases" (11).

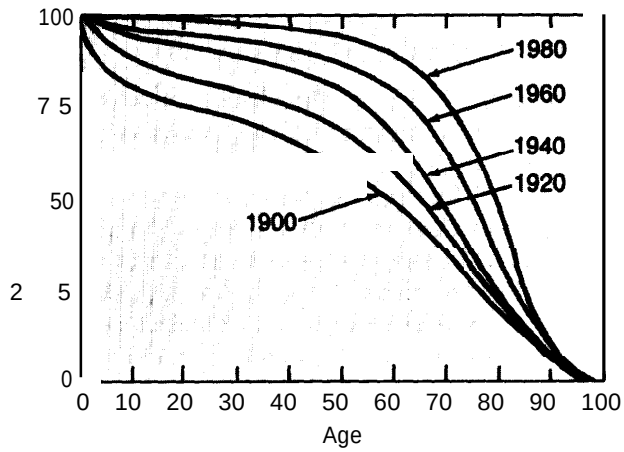
Pessimistic reviews of the prevalence of mental diseases in aging populations may be accurate in the short-term, but there is disagreement about their long-term persistence, their age of onset, new technologies that may alleviate or prevent them, and the consequences that can be expected at older ages in future decades (9).

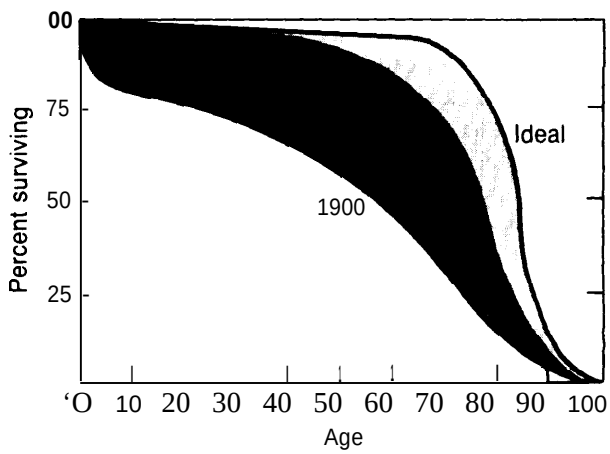
There is general agreement that although notable life expectancy improvements should be achieved during the next two generations, there is an upper limit for human longevity (1,12), based on the belief that most types of human cells have an internally determined limit to the number of times they can reproduce (10). Some theorists accordingly suggest that mortality is not necessarily linked to disease and that future technologies to control or eliminate disease will not yield an ever-increasing or even a major increase in human life span .[22]

[22]It is important to distinguish between the terms "life span" and life expectancy , " which are sometimes confused in discussions regarding longevity. *Life span* is best described as the biological upper age limit that any member of a species could possibly reach. Current estimates suggest a human life span of 110 to 115 years. As explained earlier in this chapter, *life* expectancy is a statistical measure of the expected average number of years to be lived for different subgroups of a population. For example, life expectancy at birth in 1983 was 74.7 years; for black males it was 65.2 years, while for white females it was 78,8 years. These two different constructs should not be used interchangeably.

Other researchers estimate that the control or elimination of all major chronic diseases could produce a 20-year increase in life expectancy before biological limits on longevity take effect (10). As the "ideal curve" in figure 10 indicates, this scenario presents a maximum life expectancy at birth of no more than 86 years, because most of what has been called "premature death" from chronic diseases has already been eliminated. The large decreases between 1970 and 1979 in older age mortality are sometimes viewed as the beginning of the final "era" of improvement in life expectancy, whether at birth or at age 65.

Figure 10.—Past, Current, and Projected Ideal Survival Cures for the Population, United States, Selected Years, 1900-80





SOURCE. Adapted from Fries, 1980; and Strehler, 1975.

Scenarios of the future also offer varying interpretations of the burden of chronic disease in the older population. One holds that although chronic disease incidence may increase, the average ***age at onset*** of these diseases and their disabling effects will increase faster than will life expectancy, producing a "compression of morbidity" in which the average period of chronic disease and disability in old age will be less than current levels. People would be ill or impaired for shorter periods of time before biological senescence led to death (7).

Another scenario projects longer average periods of disability and chronic illness in the future, based on the assumption that recent lifesaving and other health care technologies have had a greater impact on longevity than on the incidence of chronic disease, Increases in life expectancy would be accompanied by considerably longer periods of ill health and disability (-9).

Still other models of aging find no clear evidence of an absolute limit on the longevity of human cells or on their ability to reproduce. Proponents of this view feel that all deaths are due either to accidents or disease, rather than to biological senescence (12). Most reviews of available data indicate that recent advances in life expectancy at the oldest ages are due to technological advances in the diagnosis and treatment of chronic diseases and that the potential is high for further improvement in longevity from the control of chronic diseases

The experience of other countries with higher life expectancies, where the incidence and prevalence of the major killer diseases are notably different, is instructive. For example, Japan has a higher average life expectancy at birth than the United States (76.3 years as compared with 74.7), due in large part to much lower heart disease incidence and attendant mortality rates. But the major cause of death in Japan is stroke, which is ranked third in the United States. If Japan were to reduce its incidence of stroke to a level similar to that of the United States, additional years would be added to already high Japanese life expectancy. Similarly, if the United States could decrease its incidence of heart disease to Japanese levels, even greater increases in American life expectancy could be achieved.

If senescence rather than diseases were in fact a major killer, life expectancy at the ***oldest*** ages would ***not*** be showing such great improvement. Reductions in the ***rate*** of aging of cells, as demonstrated in nonhuman clinical and cellular studies, could possibly delay the age of onset of chronic disease as well as significantly increase life expectancy (21). If future technologies reduce the rate of human cellular aging then significant increases in human life expectancy and life span could occur with no corresponding increase in the period of morbidity among the elderly (26).

Some researchers hold that we are on the threshold of major gains in human life expectancy because of prospects for identifying specific genes related to longevity[23] (30). New technologies may yield methods for improving the efficiency of the immune system. One method would control the problem of autoimmunity, in which the body's immune system attacks the "good" cells along with the "bad." Another approach contends that accumulated damage to DNA, the message center of the cell, results in decreased rates of DNA repair as humans age. New methods and technologies for improving the DNA repair rate for longer periods of time may, some researchers suggest, be a major step toward increased longevity. Another possible life span extension method is the nutritional restriction diet. Current studies on mice indicate that the rate of aging can be reduced and life span increased in mice that receive carefully restricted diets. The application of technologies such as antioxidant and membrane stabilization processes, altering neuroendocrine hormone balance by hypophysectomy (surgical alteration or removal of the pituitary gland), or drug therapy have also been hypothesized as life extension methods (3).

Some theorists suggest that combinations of two or more of these proposed technologies can yield 20= to 30-year increases in life span during the next generation. Recent work in these areas of life span extension and changes in rate of aging is provocative, but fails to answer questions about the application of animal study results to humans.

[23]The example in humans is a part of the sixth chromosome that is considered the center of the immune system. It is known as the major histocompatibility complex and is being studied to understand its relationship to rates of cellular aging and immune functioning.

The long-term effects of applying such methods to humans remain unknown. Other questions concern the time period in which such applications or their effects, if any, could occur for human populations.

Recent data indicate that the age of onset and the prevalence of chronic conditions among the elderly have not changed in accord with recent increases in average life expectancy at age 65 (2,17). Because there is as yet no way to prevent (or effectively treat or cure) major chronic diseases such as osteoarthritis and Alzheimer disease, there is little reason to postulate declining incidence of these disabling conditions among elderly cohorts in the near future (see ch. 3). And as the older population ages in ensuing decades, the prevalence of these conditions could also rise.

Contrasting views hold that the data do not accurately account for today's healthier behaviors among portions of the younger population, as suggested by data on one subgroup of young persons that show lower blood pressure, serum cholesterol, and cigarette consumption levels than their parents' generation (4). Proponents of this belief argue that if healthy behaviors were encouraged among all age groups, healthier future cohorts of elderly persons would result (6).

Investigation of the implications of these behaviors for their possible long-term effects on health (e.g., heart conditions or osteoarthritis) and **functional** ability (e.g., Alzheimer disease) is in its infancy (see ch. 4). But if projected gains in life span and/or average life expectancy were to be achieved within onegeneration, these dramatic changes would take place just as the baby boom cohort "comes of age" as the elderly boom of the 2010=25 period. The implications of this possibility are profound in terms of both added productivity among the elderly and increased demands on societal resources.

Implications of chronic disease and disability

These emerging technological and demographic trends have important and varying implications for Federal policies related to the provision of health care, social services, long-term care, and income supports to the elderly. The demand for these types of supports and the resources and capabilities that increased numbers of older persons contribute to society will depend on the nature of the population aging process and the period of morbidity that can be expected Additional impacts from these changes in technology and aging will involve the marital status, living arrangements, extended family size, work and retirement patterns, and other characteristics of future elderly populations characterized by higher life expectancies.

Given current indications, the following characteristics and consequences of an aging American population and anticipated technological change are likely to dominate Federal aging policy debates for the short-term future to the turn of the century:

- the growing prevalence in the older population of certain chronic physical and mental conditions, and functional impairments resulting from them, especially among the very old;
- in contrast to the predominance of the current acute-care medical model, a growing need to develop appropriate programs to care for persons with chronic conditions, including provisions for needed social as well as medical services;
- developing options and evaluating the relative costs, both public and private, for different modes of long-term care in different settings;
- questions regarding appropriate medications and evaluations of their positive or negative effects on older persons;
- the possible role of healthier behaviors in reducing the incidence or severity of chronic conditions and maximizing the quality and productivity as well as length of life at older ages;

- the role of informal v. formal social, health, and medical supports in responding to current and future long-term care needs of the elderly;
- the need for institutionalization in caring for those severely ill, highly dependent elderly and disabled persons who require the highest levels of 24-hour skilled nursing care;
- continuing pressure to contain the costs of medical, social, and long-term care services while maintaining their quality and accessibility for all persons;
- the increasing interest in and development of information technologies that can help the elderly in self-health care and maintenance of functional ability;
- the ability to respond to the preferences of most older people to live as independently as possible in comfortable, safe, convenient, and familiar residential settings for as long as possible;
- a growing range of housing options and technological choices that can respond to the desires and needs of older persons with various levels of functional impairments to carry on their daily activities; and
- the trends in labor force participation and functional status among the elderly and the potential for workplace technologies to either displace older workers or provide expanded opportunities for new or continued employment.

An important challenge in relation to these issues is the need to recognize the heterogeneity of the older population in terms of the attitudes, preferences, social characteristics, and health status of its members. It will also be important for Federal policy to carefully anticipate the growing numbers and proportions of older persons who will be most ‘(at risk” of chronic disease and related disabilities. These “at risk” individuals will either require institutionalization or need some level of supportive health and social services in the community.

The following section focuses on the relevance of health, functional impairment, and the environment of the elderly to highlight the interdependent aspects of these characteristics and their impact on the lives of older Americans. The other chapters of this report present detailed information on these areas.

Severity of chronic conditions and patterns of institutionalization

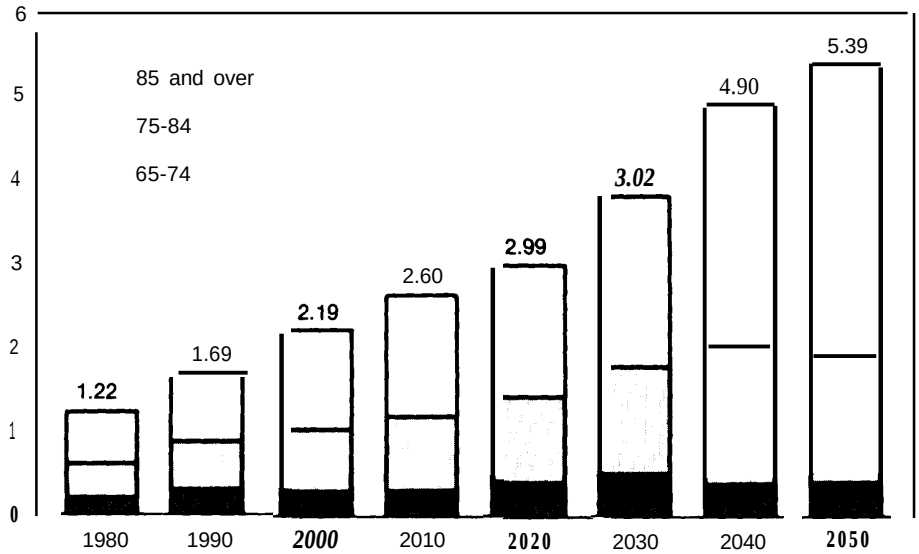
In 1983 there were more than 1.3 million older Americans in nursing homes—5 percent of the over-65 population.[24] This is twice the proportion of elderly persons who lived in nursing homes in 1960. This increase is largely due to the aging of the older population itself and, in particular, to the prevalence of very old women who are widowed. These women are at high risk of institutionalization because they are most likely to live alone, to have no informal support network, and to be poor (i.e., eligible for Medicaid reimbursement for nursing home care; see chs. 7 and 9). If current age-specific trends persist, greater rates of institutionalization among the elderly can be expected as the population continues to age, At any one time, about 10 percent of the over-75 population are institutionalized. More than 1 in 5 (23 percent) of those over 85 are in institutions.

Recent projections, using revised 1977 baseline data, show an increase of 83 percent in the elderly nursing home population (to 2.2 million residents) by the year 2000, According to these projections, the very old will become an ever-growing portion of all older persons in nursing homes (see fig. 11). By 2020, when the young-old cohort of the elderly boom is 65 to 74, there could be 3 million elderly persons in nursing homes, more than one-half of whom would be over 85. By 2040, as the elderly boom cohorts reach the very old ages, the numbers of nursing home residents could skyrocket to 6 million or more, threefifths of whom would be the very old. Revised estimates that reflect the most recent aging trends would yield even higher numbers.

The median entry age of nursing home residents has increased steadily since 1960 to the current age of 80. The median age of residents is 83. Although the young-old are largely able to avoid nursing homes, the growth of the old-old and their much higher risk of institutionalization will

[24] Persons over 65 account for approximately 85 percent of all nursing home residents, a figure that has changed little during the last 25 years.

Figure 11 .—Projections of the Nursing Home Population Aged 65 and Over, United States, 1980-2050



SOURCE: U S. Senate, Special Committee on Aging, *Developments in Aging: 1983, Volume 1,* **Washington DC Feb 29.1984 Based on most recent revised estimates of the 1977 population base, U.S. Bureau of the Census Series P-25, 'No. 917-1977, estimated, and Series P-25, No. 922, October 1982. Middles Series Projections; and the National Nursing Home Survey (1977), National Center for Health Statistics.**

be a major Federal concern in future years. unless the incidence of severe mental and physical disabilities related to increased prevalence of chronic diseases among the very old decreases, and assuming that the aging of the older population continues, a greater share of the total older population of the future can be expected to require either 1) full-time skilled nursing care, primarily in institutions or 2) increased custodial and other forms of long-term care in the community. In fact, some estimates show that twice the number of persons now in nursing homes are in need of some type of long-term care in the community (2).

One consideration for Federal policy is the extent to which some proportion of this highly dependent population could be either equally or better cared for in a different residential setting. There is no consensus on the proportion of the institutionalized elderly who could be '(released" from nursing homes. Estimates of those who could receive alternative forms of care or who are considered unnecessarily institutionalized range from none to more than 40 percent (29,32). The difficulties with such estimates lie in the different assumptions that are made regarding the institutional population's characteristics and the relationship of these characteristics to the types of care required. There is little evidence on which to base estimates of the numbers of current nursing home residents who could be cared for in other settings, in part because of a dearth of information on alternative settings and types of formal long-term care (see ch. 7).

Nonetheless, three categories of characteristics are the strongest predictors of nursing home residency: 1) dependency in toileting and eating, 2) dependency in bathing and dressing, and 3) mental disorders (31). These highly interrelated predictors are particularly applicable for the very old and those who live alone. For example, the risk of mental confusion increases notably in the oldest ages and is sometimes the reason that individuals are unable to feed, bathe, or dress themselves. Estimates from national surveys and other sources indicate that, despite the primary diagnosis for admittance, about one-half of all elderly nursing home residents suffer some degree of mental confusion. Other data indicate that the degree of dependency among nursing home residents has increased, along with median age, since 1960.

Chronic conditions among the community-dwelling elderly

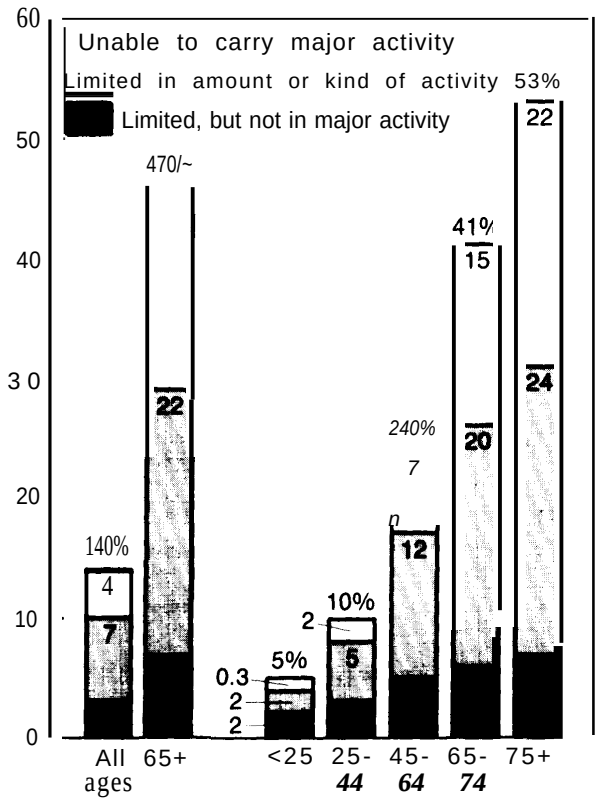
The community dwelling elderly, who comprise 95 percent of Older Americans, have a much lower prevalence of ***severe*** limitations and dependency than the institutionalized older population. In 1981 the most commonly reported chronic conditions for this great majority of the older population were arthritis (46 percent), hypertension (37 percent), hearing impairments (28 percent), and heart conditions (28 percent) (27). Although more than 85 percent of the noninstitutionalized elderly reported one or more chronic conditions in various surveys over the past 20 years, fewer than half of those who had such conditions reported any degree of activity limitation because of them (25). Most older persons thus continue to be independent and active members of the community.

Yet the extent of limitation among the elderly is notable when compared with other segments of the population, as shown in figure 12. Only 14 percent of the total noninstitutionalized population in 1981 reported some form of activity limitation (4 percent were limited in a major activity such as work). Among those 45 to 64, the total proportion whose activities were limited by chronic conditions was 24 percent. Both the prevalence and the severity of chronic conditions and their associated disabilities increase in old age. Fewer than one-third of those who are limited in the **45 to 64** age category are unable to carry on a ***major*** activity, but among those over 65, the proportion rises to almost two-fifths; among those over 75 the proportion exceeds two-fifths (see fig. 12). Beyond age 85, some **60** percent of the community-dwelling elderly report activity limitation from a chronic condition and more than one-half of these persons are unable to carry on a major activity.

Photo credit: *Suzanne L. Murphy*

The great majority of older Americans are active and contributing members in their community.

Figure 12.—Limitation of Activity Due to Chronic Conditions, by Degree of Limitation and Selected Age Groups, 1981



SOURCE: U.S. Senate, Special Committee on Aging, *Developments in Aging 1983*, based on National Center for Health Statistics, 1981 Health Interview Survey, unpublished.

The severity of physical and mental limitations from chronic conditions is thus a critical problem–for the elderly in general and the ***very old*** in particular. The sharp increase in prevalence of dysfunctions among the very old is especially noticeable for osteoarthritis, heart conditions, hearing and vision impairments, and urinary incontinence. Technological applications that can eliminate or mitigate the incidence of either

the underlying chronic conditions or the limitations they present would yield major improve ments in preserving the independence of older persons and their ability to function in the workplace, at home, and in the community.

Assistance for the functionally impaired who need help is provided by formal services, informal care from family and friends, or technologies in the home. Chapters 7 and 9 provide detailed reviews of these subjects, which are briefly discussed in the following section.

Socioeconomic characteristics and sources of assistance

Coinciding with the growth of the old-old and very old segments of the elderly population is the growth in numbers of older Americans who live alone. This trend is almost entirely attributable to the increase in the number of very old surviving women. In 1982 one-half of all older women were widowed, compared with only 12 percent of all older men. These proportions rise significantly among those over 75—to 69 percent for women and 22 percent for men (see ch. 9). Conversely, among all women over 75, only 22 percent were married and living with their spouse in 1982; for men, the corresponding figure was 70 percent.

A consequence of these differences is that women over 75 are far more likely to be living alone than men—45 percent of women as opposed to 19 percent of men. These differences in marital status and living arrangements, coupled with older women's greater life expectancy, mean that very old women are far more likely to live alone and, therefore, are less likely to have informal assistance from a spouse or other person in the home. By 1995 more than 55 percent of all elderly households are expected to consist of persons living alone or with nonrelatives; four-fifths of this population will be older women.

These trends indicate that the elderly are likely to require a greater variety of housing types and living environments than exist today. Higher proportions of single-person households, especially among the very old, are likely to increase the demand for congregate types of housing, residential-care complexes, and life-care communities. The functional status of the growing older population and their need for assistance will influence this demand for more supportive types of living arrangements. The ability of some elderly subgroups to pay for such environments and support services may be limited by low incomes. This is particularly relevant for the short-term future as increasing proportions of the elderly reach the oldest ages with little more than Social Security for their monthly incomes.

older women are clearly at greatest risk of poverty. Low rates of labor force participation among women 45 to 64 in previous decades, compounded by low average income levels of those women who were in the labor force, indicate that greater numbers of old-old and very old women are likely to have incomes below the Federal poverty level for the next two decades. In 1982, 14,6 percent of all older persons were living below the poverty level. Twice as many older women who lived alone (28.7 percent) were in this category. Black women are especially vulnerable in this regard. Almost one-half of all black women over 72 had incomes below the poverty level, a rate ***five times*** that of their white male counterparts.[25] Almost 70 percent of black women who live alone have incomes below the poverty level (28). These differences are expected to persist for the remainder of this century.

Certain older Americans in fact face "quadruple jeopardy" in terms of higher risks of chronic disease, functional impairment, poverty, and living alone—those who are: 1) very old, 2) women, 3) widowed, and 4) black. Thus, the burdens of old age are far greater among the very old, especially among women and minorities. Although these elderly individuals are most likely to suffer impairments from chronic conditions, they are least likely to have informal supports or the resources to pay for formal care at home, And very old women who are widowed are a growing propor-

[25]Older women in general have Social Security retirement incomes that are considerably lower than those of older men. Women's tradi - tionally lower wages provide a much lower earnings base for calculation of Social Security retirement income benefits. Very old black persons, particular} women, are highly likely to receive only the minimum benefits.

tion of the older population. If these trends con= tinue, during the rest of this century a growing proportion of the older population in need of care is likely to rely on publicly subsidized sources of assistance, whether in long-term care institutions or in their own homes and the corn= munity.

The following chapters review the range of age-related issues that can be addressed by various types of technologies. Cost+effective technologies that improve the health and functional status of the elderly may help reduce the anticipated increases in per capita public and private health expenditures. Delaying the onset of major chronic diseases and improving their treatment or prevention will greatly enhance the functional independence of the elderly, making their lives more productive and meaningful. Technological adaptations of the living environment can assist older persons in adjusting to environmental demands, thereby promoting their independence and safety in the home and in the community. Longer years of life and new technologies for the workplace could provide opportunities for some older persons to fulfill their desires for a longer worklife or for second and third careers. Others may choose to expand their leisure and recreational activities in retirement.

In combination, these technological changes can enhance the well-being of older persons and maximize their ability to remain independent and active members of society. The U.S. Congress and Federal Government could directly and indirectly assist in this effort. The issues and options at the end of each ensuing chapter set forth some of the considerations for congressional review.

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