
Ahmedin Jemal, DVM, PhD
Elizabeth Ward, PhD
Yongping Hao, PhD
Michael Thun, MD, MS

Context  The decrease in overall death rates in the United States may mask changes in death rates from specific conditions.

Objective  To examine temporal trends in the age-standardized death rates and in the number of deaths from the 6 leading causes of death in the United States.


Main Outcome Measure  The age-standardized death rate and number of deaths (coded as underlying cause) from each of the 6 leading causes of death: heart disease, stroke, cancer, chronic obstructive pulmonary disease, accidents (ie, related to transportation [motor vehicle, other land vehicles, and water, air, and space] and not related to transportation [falls, fire, and accidental poisoning]), and diabetes mellitus.

Results  The age-standardized death rate (per 100,000 per year) from all causes combined decreased from 1242 in 1970 to 845 in 2002. The largest percentage decreases were in death rates from stroke (63%), heart disease (52%), and accidents (41%). The largest absolute decreases in death rates were from heart disease (262 deaths per 100,000), stroke (96 deaths per 100,000), and accidents (26 deaths per 100,000). The death rate from all types of cancer combined increased between 1970 and 1990 and then decreased through 2002, yielding a net decline of 2.7%. In contrast, death rates doubled from chronic obstructive pulmonary disease over the entire time interval and increased by 45% for diabetes since 1987. Despite decreases in age-standardized death rates from 4 of the 6 leading causes of death, the absolute number of deaths from these conditions continues to increase, although these deaths occur at older ages.

Conclusions  The absolute number of deaths and age at death continue to increase in the United States. These temporal trends have major implications for health care and health care costs in an aging population.

METHODS

Cause of death statistics in the United States are based on underlying cause of death.1 The underlying cause is defined as the disease or injury that initiated the sequence of events leading directly to death. It is selected from the conditions entered in the cause of death section on the death certificate by the certifying physician, coroner, or medical examiner based on the sequence of morbid events and coding rules specified by the International Classification of Diseases (ICD).2

Effective with data year 1968, computer software has been used by the National Center for Health Statistics to determine the underlying cause of death from information on all causes (multiple causes) listed on the death certificate.1

For mortality statistics in the interval 1970 through 2002, underlying causes of death were classified according to the ICD-8, ICD-9, and ICD-10 coding and selection rules,3-5 with major causes of death grouped consistently across the ICD codes to facilitate evaluation of long-term trends.6 The ICD-10 codes used for the 6 leading causes of death were 100-109, 111, 113, and 120-151 for heart disease; C00-C07 for cancer; I00-I09 for stroke (cerebrovascular disease); E10-E14 for diabetes mellitus; J40-J47 for chronic obstructive pulmonary disease (COPD); and V01-X59 and Y85-Y86 for accidents (ie, related to transportation [motor vehicle, other land vehicles, and water, air, and space] and not related to transportation [falls, fire, and accidental poisoning]). The ICD-8 and the ICD-9 codes were 390-398, 402, 404, and 410-429 for heart disease; 430-438 for stroke; 250 for diabetes mellitus; and 800-994 for accidents. For cancer, the ICD-8 codes were 140-207 and the ICD-9 codes were

©2005 American Medical Association. All rights reserved.
We calculated the age-standardized death rates (directly adjusted to the 2000 US standard population) for all causes and the 6 leading causes of death using SEER*Stat software, developed by the Surveillance, Epidemiology, and End Results program of the National Cancer Institute.7,8 When the 2002 death rate for a particular condition was lower than the 1970 rate, the contribution of this decrease to the overall decrease in all-cause death rates over the same time interval was expressed as a percentage. Trends in age-standardized death rates from 1970 through 2002 for each of these conditions were described using joinpoint regression analysis.9 The joinpoint regression model fits a series of joined straight lines on a log scale to the trends in age-adjusted rates. The terms increase or decrease were used when the slope (coefficient) of the trend was statistically different from zero (2-sided P<.05); otherwise, the terms stable or level were used.

We also examined the leading causes of death in 2002 by age and temporal trends in age-specific death rates and number of deaths from heart disease and cancer for individuals aged 40 years or older by 10-year age intervals from 1970 to 2002.

RESULTS
Between 1970 and 2002, the age-standardized death rate (per 100 000 population) from all causes combined decreased 32% from 1242.2 to 844.6 based on the year 2000 age standard (Table). Among the 6 leading causes of death (Table and Figure 1), the largest percentage decreases during this interval were in the death rates from heart disease (52%), cerebrovascular disease or stroke (63%), and accidents (41%). The absolute decrease was largest for heart disease (262 deaths per 100,000) followed by stroke (96 deaths per 100,000), accidents (26 deaths per 100,000), and cancer (5 deaths per 100,000). The age-standardized death rate from all types of cancers combined first increased from 1970 to 1990, and then decreased through 2002, yielding a net decline of 2.7%. In contrast, death rates doubled since 1970 for COPD and increased by 43% since 1987 for diabetes mellitus (3% net increase from 1970 to 2002).

When examined by joinpoint regression analysis, the decrease in heart disease and cancer death rates continues, whereas the decrease in the mortality rates from stroke and accidents has slowed or stopped since the early 1990s. In 2002, the leading causes of death were heart disease among persons aged 75 years or older, cancer among persons aged 40 to 74 years, and accidents among persons younger than age 40 years (Figure 2).
and cancer shows that the decrease in the mortality rate from heart disease (FIGURE 3, top panel) affects all age groups containing individuals aged 40 years or older throughout the entire time interval, whereas the decrease in age-specific death rates from all types of cancer begins later and becomes smaller in proportionate terms with increasing age (Figure 3, bottom panel).

A different perspective on the temporal trends in mortality from heart disease and cancer is provided by data on the number of deaths that occur from these conditions (FIGURE 4). Because of the aging and growth of the population, the number of deaths attributed to heart disease among persons aged 80 years or older (Figure 4, top panel) increased 60% from 1970 to 2002, even though the age-standardized death rate decreased by 40%

Figure 2. Age-Specific US Death Rates for the 4 Leading Causes of Death by 5-Year Intervals, 2002

Figure 3. Age-Specific Death Rates for Heart Disease and Cancer for Individuals Aged 40 Years or Older by 10-Year Intervals, 1970-2002
in this age group over the same period (Figure 3, top panel). Figure 4 also illustrates the influence of the baby boomer generation (born after World War II) as reflected in the pattern of deaths due to heart disease and cancer in individuals aged 50 to 59 years. A large increase in the number of individuals in this age group began in approximately 1990, resulting in an increase in the number of cancer deaths and flattening rather than decreasing the number of deaths from heart disease.

**COMMENT**

This article provides a concise overview of trends in both age-standardized death rates and numbers of deaths for the 6 leading causes of mortality in the United States from 1970 to 2002, updating a similar analysis from 1950 to 1986. These findings illustrate the substantial and continuing progress in reducing the age-standardized death rate from heart disease, the lack of continuing progress for stroke and accidents, and the increase in the age-standardized rates for COPD and diabetes. The study also illustrates that the reduction in age-standardized death rates, the best measure of progress against diseases, is not synonymous with reducing the number of deaths from these conditions. In fact, the number of deaths continues to increase because of population growth and aging. It is the number of individuals affected by various conditions rather than the age-standardized rate that influence the planning and allocation of preventive and medical services.

Inaccuracies in death certificates and changes in classification of causes of death are potential limitations in the interpretation of mortality trends. However, our analyses are restricted to broad disease categories for which death certificate data are more accurate than for specific diseases. Although 2 revisions of the ICD have been implemented in the United States during the study period (ICD-9 in 1979 and ICD-10 in 1999), there was only 1 significant discontinuity in these broad disease categories. The ICD-8 codes developed by the World Health Organization did not have a code for COPD without mention of asthma, bronchitis, or emphysema. However, in 1970 the National Center for Health Statistics introduced a code (519.3), used in the United States, for this category of diseases, allowing comparability in classification of deaths due to COPD un-

---

**Figure 4.** Number of Deaths From Heart Disease and Cancer for Individuals Aged 40 Years or Older by 10-Year Intervals, 1970-2002

---

JAMA, September 14, 2005—Vol 294, No. 10 (Reprinted)  
©2005 American Medical Association. All rights reserved.
Under ICD-8, ICD-9, and ICD-10. The effect of the changes in ICD rules on the 6 leading causes of death described herein have been studied by calculating the comparability ratio based on the classification of 1 year’s mortality data by both the new ICD codes and the previous ICD codes. All comparability ratios (the total number of deaths due to a specific cause under the new revision divided by the total number of deaths under the previous revision) for the cause of death categories described were between 0.99 and 1.06.

Several important insights are suggested by these temporal trends in the death rates and number of deaths at various ages. First, the decrease in the age-standardized death rate for 4 of the 6 leading causes of death in the United States represents progress toward one of the fundamental goals of disease prevention by extending the number of years of potentially healthy life. This progress has been greater for heart disease and for accidental deaths than for cancer, yet even for cancer the age-standardized death rate has been decreasing by 1.1% per year since 1993. Less favorable developments are the slowing of the decline in age-standardized mortality rates from stroke and accidents since the early 1990s, and the increase in death rates from COPD and diabetes.

Several other countries have reported similar slowdowns in the decrease in stroke mortality; this is striking in the face of a continuing decrease in age-standardized mortality from heart disease. Analyses that differentiate subgroups of stroke mortality suggest that an increase in hemorrhagic (nonthrombotic, nonembolic) stroke may be partly offsetting a continuing decrease in thrombotic stroke. A likely explanation for this is increased use of aspirin and other antithrombotic agents. The reduction in the death rate from accidents from 1970 through the early 1990s coincided with implementation of a 55-mph speed limit during the first energy crisis in the 1970s and mandated use of seat belts in most states beginning in 1984. The recent flattening of the accident mortality rate coincides with the relaxation of the maximum interstate speed limits since 1987.

The bihaplotype in cancer mortality rates reflects both the impact of the tobacco epidemic on tobacco-related cancers through 1990, followed by reduction in cancer mortality through tobacco control and advances in early detection, in treatment, or in both. The increase in COPD death rates results largely from the long-term effects of tobacco smoking in an aging population, whereas the increase in diabetes mortality since the late 1980s reflects dramatic increases in obesity.

A consequence of the large decrease in cardiovascular death rates, combined with the high birth rates that immediately followed World War II, is the growing importance of health and health care needs in an aging population. While improved detection and treatment for chronic diseases has resulted in declining mortality rates, it has also increased the prevalence of “treated disease” and an associated increase in health care expenditures.

**Author Contributions:** Dr Jemal had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Jemal. Acquisition of data: Jemal. Analysis and interpretation of data: Jemal, Ward, Hao, Thun.

**Drafting of the manuscript:** Jemal. Critical revision of the manuscript for important intellectual content: Ward, Hao, Thun. Statistical analysis: Jemal, Hao. Study supervision: Ward, Thun.

**Financial Disclosures:** None reported.

**Funding/Support:** The American Cancer Society funded the analysis, interpretation, compilation of cancer surveillance data.

**Role of the Sponsors:** Staff in the Epidemiology and Surveillance Research Department of the American Cancer Society designed and conducted the study, including analysis, interpretation, and presentation of the manuscript. No staff at the American Cancer Society, other than the study investigators, reviewed or approved the manuscript.

**REFERENCES**


