Original Investigation

Temporal Trends in Mortality in the United States, 1969-2013

Jiemin Ma, PhD, MHS; Elizabeth M. Ward, PhD; Rebecca L. Siegel, MPH; Ahmedin Jemal, DVM, PhD

IMPORTANCE A systematic and comprehensive evaluation of long-term trends in mortality is important for health planning and priority setting and for identifying modifiable factors that may contribute to the trends.

OBJECTIVE To examine temporal trends in deaths in the United States for all causes and for 6 leading causes.

DESIGN, SETTING, AND PARTICIPANTS Joinpoint analysis of US national vital statistics data from 1969 through 2013.

EXPOSURE Causes of death.

MAIN OUTCOMES AND MEASURES Total and annual percent change in age-standardized death rates and years of potential life lost before age 75 years for all causes combined and for heart disease, cancer, chronic obstructive pulmonary disease (COPD), stroke, unintentional injuries, and diabetes mellitus.

RESULTS Between 1969 and 2013, the age-standardized death rate per 100 000 decreased from 1278.8 to 729.8 for all causes (42.9% reduction; 95% CI, 42.8%-43.0%), from 156.8 to 36.0 for stroke (77.0% reduction; 95% CI, 76.9%-77.2%), from 520.4 to 169.1 for heart disease (67.5% reduction; 95% CI, 67.4%-67.6%), from 65.1 to 39.2 for unintentional injuries (39.8% reduction; 95% CI, 39.3%-40.3%), from 198.6 to 163.1 for cancer (17.9% reduction; 95% CI, 17.5%-18.2%), and from 25.3 to 21.1 for diabetes (16.5% reduction; 95% CI, 15.4%-17.5%). In contrast, the rate for COPD increased from 21.0 to 42.2 (100.6% increase; 95% CI, 98.2%-103.1%). However, during the last time segment detected by joinpoint analysis, death rate for COPD in men began to decrease and the declines in rates slowed for heart disease, stroke, and diabetes. For example, the annual decline for heart disease slowed from 3.9% (95% CI, 3.5%-4.2%) during the 2000-2010 period to 1.4% (95% CI, −3.4% to 0.6%) during the 2010-2013 period (P = .02 for slope difference). Between 1969 and 2013, age-standardized years of potential life lost per 1000 decreased from 1.9 to 1.6 for diabetes (14.5% reduction; 95% CI, 12.6%-16.4%), from 21.4 to 12.7 for cancer (40.6%; 95% CI, 40.2%-41.1%), from 19.9 to 10.4 for unintentional injuries (47.5%; 95% CI, 47.0%-48.0%), from 28.8 to 9.1 for heart disease (68.3%; 95% CI, 68.1%-68.5%), and from 6.0 to 1.5 for stroke (74.8%; 95% CI, 74.4%-75.3%). For COPD, the rate for years of potential life lost did not decrease over this time interval.

CONCLUSIONS AND RELEVANCE According to death certificate data between 1969 and 2013, an overall decreasing trend in age-standardized death rate was observed for all causes combined, heart disease, cancer, stroke, unintentional injuries, and diabetes, although the rate of decrease appears to have slowed for heart disease, stroke, and diabetes. The death rate for COPD increased during this period.

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A systematic and comprehensive examination of long-term trends in mortality is important for health planning and priority setting and for identifying modifiable factors that may contribute to the trends. A report in 2005[1] examined temporal trends from 1970 through 2002 for the 6 leading causes of death in the United States and found that age-standardized death rates decreased for all causes and for heart disease, stroke, cancer, and injuries individually, whereas an overall increasing trend was observed for chronic obstructive pulmonary disease (COPD) and diabetes. However, the evolution of US mortality trends since 2002 for these causes is unknown. Therefore, we updated the previous analysis with 11 additional data years (1969-2013) using the same analytic approaches to describe contemporary mortality trends for all causes and 6 leading causes of death. In addition, we examined trends in years of potential life lost due to premature deaths, another important measure of disease burden.

APC *annual percent change*

COPD *chronic obstructive pulmonary disease*

CVD *cardiovascular disease*

NCHS *National Center for Health Statistics*

NVSS *National Vital Statistics System*

Methods

Data Sources

All death data were obtained from the US National Vital Statistics System (NVSS) of the National Center for Health Statistics (NCHS) of the Centers for Disease Control and Prevention, with 1969-2011 data abstracted from SEER*Stat software[2] (1969 is the earliest data year available) and 2012-2013 data abstracted from public-use multiple cause of death files.[3] The NCHS annually compiles information on death certificates from 50 states and the District of Columbia into public-use multiple cause of death files, in which the underlying cause of death is selected according to the coding and selection rules of the *International Classification of Disease* (*ICD*) revision in use at the time of death (*ICD-8* for 1969-1978, *ICD-9* for 1979-1998, and *ICD-10* for 1999-2013).[4] The World Health Organization defines *underlying cause of death* as "the disease or injury which initiated the train of events leading directly to death, or the circumstances of the accident or violence which produced the fatal injury."[5]

Over the years, NCHS has developed several automated programs to improve coding of underlying cause of death on death certificates.[6] In this study, heart disease was identified by *ICD-8* codes 390-398, 402, 404, and 410-429; *ICD-9* codes 390-398, 402, 404, and 410-429; and *ICD-10* codes I00-I09, I11, I13, and I20-I51. Cancer was identified by *ICD-8* codes 140-207; *ICD-9* codes 140-208 and 238.6; and *ICD-10* codes C00-C97. Stroke was identified by *ICD-8* and *ICD-9* codes 430-438 and *ICD-10* codes I60-I69. Chronic obstructive pulmonary disease was identified by *ICD-8* codes 490-493 and 519.3, *ICD-9* codes 490-496, and *ICD-10* codes J40-J47. Unintentional injuries (including transport crashes [motor vehicle, other land, water, air and space, and other unspecified] and nontransport mishaps [eg, falls, drowning, unintentional discharge of firearms, exposure to smoke, fire and flames, and unintentional poisoning {eg, drug overdose}]) were identified by *ICD-8* and *ICD-9* codes 800-949 and *ICD-10* codes V01-X59 and Y85-Y86. Diabetes mellitus was identified by *ICD-8* and *ICD-9* code 250 and *ICD-10* code E10-E14. Based on the National Human Subjects Protection Advisory Committee's recommendations, this study did not require institutional review board approval because it analyzes government-issued public use data without individual identifiable information.

Statistical Analysis

Death rates for all-cause and for the leading causes of death were calculated by age and sex from 1969 through 2013 based on the corresponding population published by the US Census Bureau.[7] Age-standardized death rates were then calculated according to the 2000 US standard population by 5-year age groups. To understand the burden of premature death, years of potential life lost before age 75 years, were calculated by cause of death. Years of potential life lost for each decedent was calculated by subtracting the age at death in years from 75. The totals for each demographic group were the sum of years of potential life lost for each decedent in the group. Annual age-standardized years of potential life lost per 1000 was adjusted to the 2000 US standard population by single age. We selected 75 years as the reference age because it approximates US life expectancy and is commonly used for such analyses in the scientific literature.[8]

Joinpoint regression was performed to examine temporal trends in age-standardized death rates and years of potential life lost using Joinpoint Regression Program version 4.1.1 (Statistical Research and Applications Branch, National Cancer Institute).[9] A maximum of 5 joinpoints was allowed, and the Bayesian information criterion method was used for model selection. This analysis compared models by starting with no joinpoints and subsequently testing whether 1 or more joinpoints needed to be entered into the model to best fit the data. The most parsimonious models were selected to report the estimated annual percent change (APC) for each time segment detected and the average annual percent change (AAPC) for the full study period, along with their accompanying 95% confidence intervals. The AAPC is a weighted average of the APCs, with the weights equal to the length of the joinpoint segments. The terms increasing or decreasing were used to describe the trend when the APC or AAPC was statistically significantly different from 0; otherwise, stable or level was used. Year categories presented in various results represent year groupings as determined by joinpoint regression. The most recent time period refers to the last joinpoint segment up to 2013.

In addition, we used the Wald test to determine whether a slope change between 2 adjacent slopes was statistically significant. A slowed, leveled, or accelerated increase or decrease refers to adjacent slopes in the joinpoint regression meeting statistical significance for the difference in slopes. All significance tests were 2-sided. Statistical significance was defined as $P < .05$.

Table 1. Joinpoint Analysis of Age-Standardized Death Rate (per 100 000 Population) for All Causes Combined, Stratified by Sex in the United States, 1969-2013[a]

	Deaths (Rate per 100 000)		Average APC (95% CI)	Trend 1		Trend 2		Trend 3	
	1969	2013		Years	APC (95% CI)	Years	APC (95% CI)	Years	APC (95% CI)
Both sexes	1 921 324 (1278.8)	2 596 861 (729.8)	−1.3 (−1.4 to −1.1)[b]	1969-1978	−2.3 (−2.6 to −2.0)[b]	1978-2002	−0.8 (−0.9 to −0.8)[b]	2002-2010	−1.7 (−2.1 to −1.4)[b]
Male	1 080 519 (1610.0)	1 305 939 (865.0)	−1.4 (−1.6 to −1.2)[b]	1969-1973	−1.0 (−2.0 to −0.1)[b]	1973-1977	−2.8 (−4.2 to −1.3)[b]	1977-1988	−0.9 (−1.1 to −0.6)[b]
Female	840 805 (1019.3)	1 290 922 (620.9)	−1.1 (−1.4 to −0.9)[b]	1969-1979	−2.4 (−2.7 to −2.2)[b]	1979-1988	−0.3 (−0.6 to 0.1)	1988 - 1991	−1.7 (−4.8 to 1.5)
				Trend 4		Trend 5		Trend 6	
Both sexes				2010-2013	−0.4 (−1.9 to 1.0)				
Male				1988-2002	−1.4 (−1.5 to −1.2)[b]	2002-2009	−2.0 (−2.4 to −1.6)[b]	2009-2013	−0.9 (−1.7 to −0.1)[b]
Female				1991-2002	−0.2 (−0.4 to 0.1)	2002-2009	−1.8 (−2.3 to −1.3)[b]	2009-2013	−0.6 (−1.5 to 0.3)

Abbreviation: APC, annual percent change.

[a] Standardized to the 2000 US standard population by 5-year age group.

[b] $P < .05$.

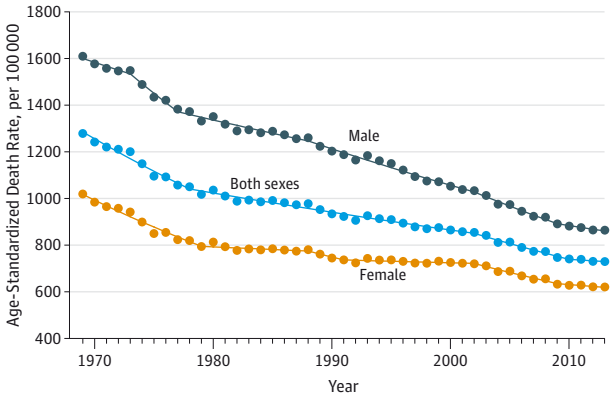
Results

Between 1969 and 2013, the age-standardized death rate for all causes combined decreased from 1278.8 per 100 000 population to 729.8 (42.9% reduction; 95% CI, 42.8% to 43.0%)—an average annual decrease of 1.3% (95% CI, 1.1% to 1.4%) for the entire period (**Table 1** and **Figure 1**). Joinpoint analysis showed that the rate leveled during the 2010-2013 period (APC, −0.4%; 95% CI, −1.9% to 1.0%) after a continuous decrease between 1969 and 2010. However, the APC during the 2010-2013 period was not significantly different ($P = .08$) from the APC during the 2002-2010 period (APC, −1.7%; 95% CI, −2.1% to −1.4%). In males, the death rate decreased continuously from 1969 through 2013. In females, the rate decreased until 2009 and then leveled between 2009 and 2013 (APC, −0.6%; 95% CI, −1.5% to 0.3%).

Five of the 6 leading causes of death (**Table 2** and **Figure 2**) experienced an overall decline in death rates from 1969 through 2013. The rate (per 100 000) decreased from 156.8 to 36.0 for stroke (77.0% reduction; 95% CI, 76.9% to 77.2%), from 520.4 to 169.1 for heart disease (67.5% reduction; 95% CI, 67.4% to 67.6%), from 65.1 to 39.2 for unintentional injuries (39.8% reduction, 95% CI; 39.3 to 40.3%), from 198.6 to 163.1 for cancer (17.9% reduction; 95% CI, 17.5% to 18.2%), and from 25.3 to 21.1 for diabetes (16.5% reduction; 95% CI, 15.4% to17.5%). The death rate for COPD increased during this period, from 21.0 per 100 000 in 1969 to 42.2 per 100 000 in 2013 (100.6% increase; 95% CI, 98.2% to 103.1%).

Joinpoint analysis showed that the death rate for heart disease continued to decrease until 2010 and then stabilized during the 2010-2013 period (APC, −1.4%; 95% CI, −3.4% to 0.6%), reflecting a significant change ($P = .02$) in APC from −3.9% (95% CI, −4.2% to −3.5%) during the 2000-2010 period. Death rates for cancer increased from 1973 through 1990, then decreased after the early 1990s, with rates during the most recent time segment (2001-2013) decreasing by 1.5% per year (95% CI, 1.5% to 1.6%). Death rates for stroke decreased continuously throughout the period. However, the annual decrease slowed from 5.5% (95% CI, 4.6% to 6.3%) during the 2001-2007 period to 3.0% (95% CI, 2.3% to 3.7%) during the 2007-2013 period (test on slope difference, $P = .006$).

Figure 1. Age-Standardized Death Rate From All Causes in the United States, 1969-2013



Data markers represent observed rates; lines are fitted rates based on joinpoint analysis.

Table 2. Joinpoint Analysis of Age-Standardized Death Rate per 100 000 Population by Sex and Cause of Death in the United States, 1969-2013[a]

	Deaths (Rate)			Trend 1		Trend 2		Trend 3	
	1969	2013	Average APC (95% CI)	Years	APC (95% CI)	Years	APC (95% CI)	Years	APC (95% CI)
Both sexes									
Heart disease	739 070 (520.4)	611 082 (169.1)	−2.5 (−2.8 to −2.3)[b]	1969-1977	−2.7 (−3.1 to −2.3)[b]	1977-1986	−1.3 (−1.7 to −1.0)[b]	1986-1990	−3.5 (−5.2 to −1.7)[b]
Cancer	321 764 (198.6)	584 872 (163.1)	−0.4 (−0.5 to −0.4)[b]	1969-1973	0.1 (−0.3 to 0.4)	1973-1990	0.5 (0.4 to 0.5)[b]	1990-1994	−0.4 (−0.8 to 0.1)
Stroke	207 123 (156.8)	128 974 (36.0)	−3.3 (−3.5 to −3.1)[b]	1969 - 1973	−2.3 (−3.4 to −1.2)[b]	1973 - 1982	−5.6 (−6.0 to −5.3)[b]	1982-1991	−3.1 (−3.5 to −2.7)[b]
COPD	33 842 (21.0)	149 204 (42.2)	1.6 (1.3 to 1.9)[b]	1969-1979	2.3 (1.5 to 3.1)[b]	1979-1985	4.4 (2.6 to 6.2)[b]	1985-1999	1.8 (1.4 to 2.1)[b]
Unintentional injuries	116 297 (65.1)	130 531 (39.2)	−1.2 (−1.7 to −0.6)[b]	1969-1984	−3.2 (−3.5 to −2.9)[b]	1984 - 1988	0.2 (−3.7 to 4.2)	1988-1992	−3.3 (−7.0 to 0.6)
Diabetes	38 530 (25.3)	75 576 (21.1)	−0.5 (−0.9 to 0.0)	1969-1979	−3.8 (−4.3 to −3.3)[b]	1979-1987	−0.2 (−1.1 to 0.7)	1987-1990	6.0 (−0.1 to 12.5)
Male									
Heart disease	421 729 (668.2)	321 329 (214.4)	−2.6 (−2.8 to −2.3)[b]	1969-1973	−1.4 (−2.5 to −0.3)[b]	1973-1976	−3.6 (−6.9 to −0.1)[b]	1976-1983	−1.3 (−1.9 to −0.7)[b]
Cancer	175 404 (247.6)	307 553 (196.3)	−0.5 (−0.6 to −0.4)[b]	1969-1980	0.8 (0.7 to 0.9)[b]	1980-1990	0.3 (0.2 to 0.4)[b]	1990-1993	−0.5 (−1.5 to 0.6)
Stroke	94 203 (168.4)	53 690 (36.7)	−3.4[b] (−3.7 to −3.2)	1969-1973	−1.8 (−3.0 to −0.6)[b]	1973-1982	−5.9 (−6.4 to −5.5)[b]	1982-1991	−3.2 (−3.7 to −2.6)[b]
COPD	26 857 (39.0)	70 316 (47.7)	0.4 (0.2 to 0.6)[b]	1969-1985	2.2 (1.9 to 2.5)[b]	1985-1999	0.0 (−0.3 to 0.4)	1999-2013	−1.2 (−1.5 to −1.0)[b]
Unintentional injuries	80 639 (93.7)	81 894 (53.0)	−1.3 (−1.9 to −0.7)[b]	1969-1984	−3.0 (−3.3 to −2.7)[b]	1984-1988	−0.4 (−4.3 to 3.7)	1988-1992	−3.4 (−7.3 to 0.6)
Diabetes	15 682 (23.7)	39 839 (25.6)	0.1 (−0.3 to 0.5)	1969-1979	−3.2 (−3.8 to −2.6)[b]	1979-1986	0.1 (−1.3 to 1.5)	1986-1994	4.2 (3.2 to 5.2)[b]
Female									
Heart disease	317 341 (404.4)	289 753 (133.3)	−2.5 (−2.8 to −2.2)[b]	1969-1976	−3.2 (−3.7 to −2.6)[b]	1976-1987	−1.1 (−1.4 to −0.8)[b]	1987-1990	−3.8 (−7.3 to −0.1)[b]
Cancer	146 360 (163.2)	277 319 (139.2)	−0.4 (−0.5 to −0.3)[b]	1969-1975	−0.3 (−0.5 to −0.1)[b]	1975-1990	0.6 (0.5 to 0.6)[b]	1990-1995	−0.2 (−0.5 to 0.1)
Stroke	112 920 (147.9)	75 284 (34.9)	−3.2 (−3.5 to −3.0)[b]	1969-1973	−2.4 (−3.5 to −1.3)[b]	1973-1981	−5.6 (−6.1 to −5.2)[b]	1981-1991	−3.3 (−3.6 to −3.0)[b]
COPD	6985 (7.9)	78 888 (38.5)	3.7[b] (3.3 to 4.1)	1969-1977	4.9[b] (3.2 to 6.7)	1977-1986	8.1[b] (6.9 to 9.4)	1986-1999	3.7[b] (3.2 to 4.1)
Unintentional injuries	35 658 (39.2)	48 637 (26.5)	−0.8 (−1.5 to −0.2)[b]	1969-1983	−3.6 (−4.0 to −3.2)[b]	1983-1989	0.3 (−1.6 to 2.3)	1989-1992	−3.6 (−11.7 to 5.2)
Diabetes	22 848 (26.4)	35 737 (17.6)	−0.9 (−1.4 to −0.5)[b]	1969-1979	−4.2 (−4.7 to −3.7)[b]	1979-1987	−0.5 (−1.4 to 0.4)	1987-1990	5.6 (−0.7 to 12.2)

(continued)

Chronic obstructive pulmonary disease rates increased during the 1969-1999 period and then decreased during the 1999-2013 period (APC,−0.3%; 95% CI, −0.0% to −0.5%). The death rate for unintentional injuries decreased during the 1969-1992 period, leveled during the 1992-2000 period, increased during the 2000-2006 period, and then leveled again during the most recent time segment (APC, −0.5%; 95% CI, −1.3% to 0.4%). Trends in the death rate for diabetes changed continually during the study period (1969-2013). Notably, the rate leveled during 2010-2013 (APC, 0.6%; 95% CI, −1.7% to 2.9%), after decreasing 2.8% (95% CI, 3.4% to 2.2%) per year during 2002-2010 (test on slope difference, $P < .001$).

Table 2. Joinpoint Analysis of Age-Standardized Death Rate per 100 000 Population by Sex and Cause of Death in the United States, 1969-2013[a] (continued)

	Deaths (Rate)			Trend 4		Trend 5		Trend 6	
	1969	2013	Average APC (95% CI)	Years	APC (95% CI)	Years	APC (95% CI)	Years	APC (95% CI)
Both sexes									
Heart disease	739 070 (520.4)	611 082 (169.1)	−2.5 (−2.8 to −2.3)[b]	1990-2000	−2.1 (−2.4 to −1.8)[b]	2000-2010	−3.9 (−4.2 to −3.5)[b]	2010-2013	−1.4 (−3.4 to 0.6)
Cancer	321 764 (198.6)	584 872 (163.1)	−0.4 (−0.5 to −0.4)[b]	1994-1998	−1.3 (−1.7 to −0.9)[b]	1998-2001	−0.8 (−1.6 to 0.1)	2001-2013	−1.5 (−1.6 to −1.5)[b]
Stroke	207 123 (156.8)	128 974 (36.0)	−3.3 (−3.5 to −3.1)[b]	1991-2001	−0.6 (−0.9 to −0.2)[b]	2001-2007	−5.5 (−6.3 to −4.6)[b]	2007-2013	−3.0 (−3.7 to −2.3)[b]
COPD	33 842 (21.0)	149 204 (42.2)	1.6 (1.3 to 1.9)[b]	1999-2013	−0.3 (−0.5 to −0.0)[b]				
Unintentional injuries	116 297 (65.1)	130 531 (39.2)	−1.2 (−1.7 to −0.6)[b]	1992-2000	0.1 (−0.9 to 1.2)	2000-2006	1.9 (0.3 to 3.5)[b]	2006-2013	−0.5 (−1.3 to 0.4)
Diabetes	38 530 (25.3)	75 576 (21.1)	−0.5 (−0.9 to 0.0)	1990-2002	2.0 (1.6 to 2.3)[b]	2002-2010	−2.8 (−3.4 to −2.2)[b]	2010-2013	0.6 (−1.7 to 2.9)
Male									
Heart disease	421 729 (668.2)	321 329 (214.4)	−2.6 (−2.8 to −2.3)[b]	1983-2002	−2.7 (−2.8 to −2.6)[b]	2002-2009	−4.1 (−4.7 to −3.5)[b]	2009-2013	−1.6[b] (−2.8 to −0.4)
Cancer	175 404 (247.6)	307 553 (196.3)	−0.5 (−0.6 to −0.4)[b]	1993-2001	−1.5 (−1.6 to −1.4)[b]	2001-2013	−1.8 (−1.9 to −1.7)[b]		
Stroke	94 203 (168.4)	53 690 (36.7)	−3.4 (−3.7 to −3.2)[b]	1991-2000	−0.7 (−1.2 to −0.2)[b]	2000-2009	−5.0 (−5.5 to −4.5)[b]	2009-2013	−2.1 (−3.6 to −0.6)[b]
COPD	26 857 (39.0)	70 316 (47.7)	0.4 (0.2 to 0.6)[b]						
Unintentional injuries	80 639 (93.7)	81 894 (53.0)	−1.3 (−1.9 to −0.7)[b]	1992-2000	−0.2 (−1.3 to 0.9)	2000-2006	1.7 (0.1 to 3.4)[b]	2006-2013	−0.9 (−1.8 to −0.0)[b]
Diabetes	15 682 (23.7)	39 839 (25.6)	0.1 (−0.3 to 0.5)	1994-2003	2.0 (1.4 to 2.7)[b]	2003-2009	−2.7 (−3.8 to −1.5)[b]	2009-2013	0.5 (−1.1 to 2.1)
Female									
Heart disease	317 341 (404.4)	289 753 (133.3)	−2.5 (−2.8 to −2.2)[b]	1990-2001	−1.9 (−2.2 to −1.6)[b]	2001-2010	−4.2 (−4.7 to −3.8)[b]	2010-2013	−1.8 (−3.9 to 0.4)
Cancer	146 360 (163.2)	277 319 (139.2)	−0.4 (−0.5 to −0.3)[b]	1995-1998	−1.2 (−2.1 to −0.3)[b]	1998-2001	−0.4 (−1.2 to 0.5)	2001-2013	−1.4 (−1.5 to −1.4)[b]
Stroke	112 920 (147.9)	75 284 (34.9)	−3.2 (−3.5 to −3.0)[b]	1991-2001	−0.3 (−0.7 to 0.0)	2001-2007	−5.3 (−6.2 to −4.5)[b]	2007-2013	−3.1 (−3.8 to −2.4)[b]
COPD	6985 (7.9)	78 888 (38.5)	3.7 (3.3 to 4.1)[b]	1999-2013	0.3 (0.0 to 0.5)[b]				
Unintentional injuries	35 658 (39.2)	48 637 (26.5)	−0.8 (−1.5 to −0.2)[b]	1992-2013	1.1 (0.9 to 1.3)[b]				
Diabetes	22 848 (26.4)	35 737 (17.6)	−0.9 (−1.4 to −0.5)[b]	1990-2002	1.4 (1.1 to 1.8)[b]	2002-2010	−3.6 (−4.2 to −2.9)[b]	2010-2013	0.2 (−2.4 to 2.8)

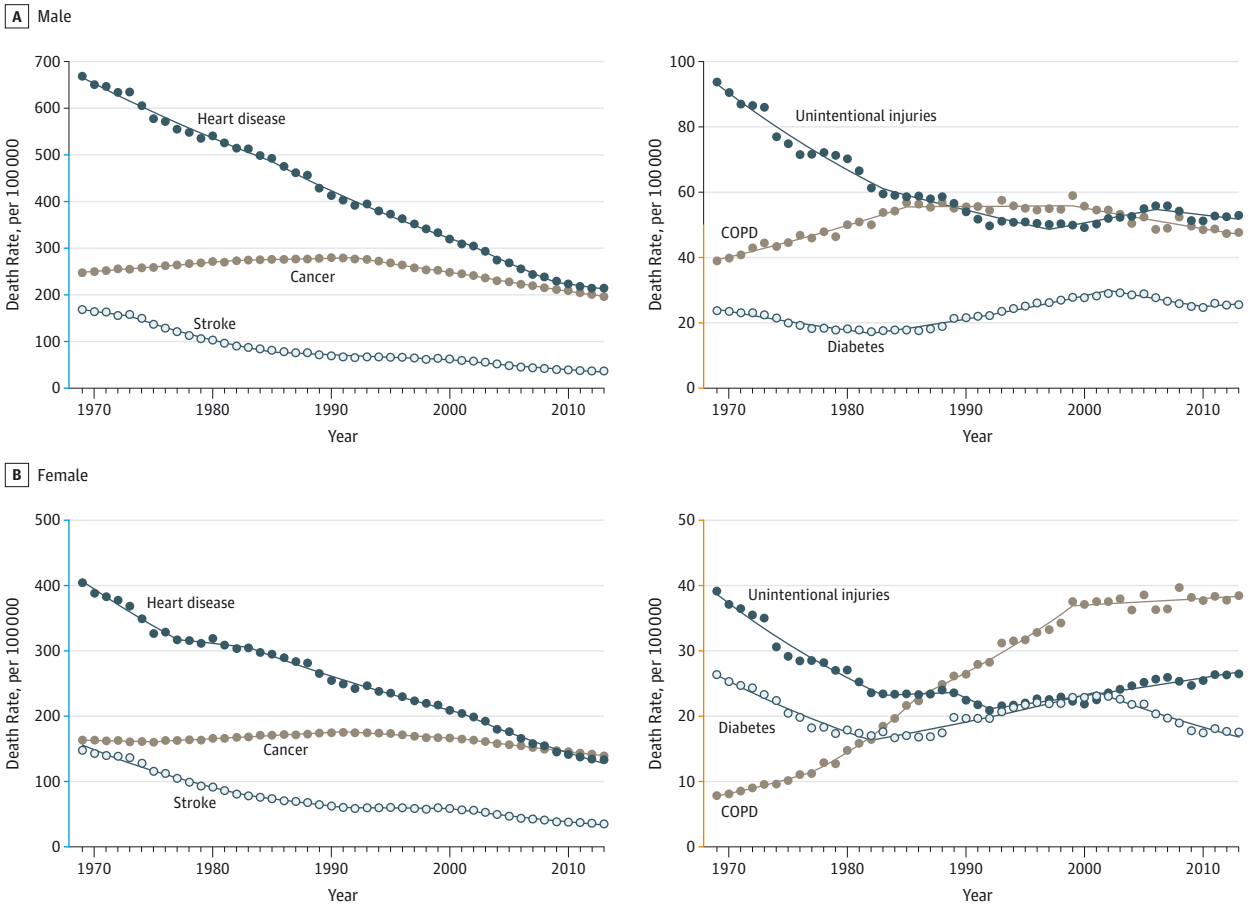
Abbreviations: APC, annual percent change; COPD, chronic obstructive pulmonary disease.

[a] Standardized to the 2000 US standard population by 5-year age group.

[b] $P < .05$

Analysis of age-standardized death rates by sex (Table 2 and Figure 2) showed that males and females experienced similar trends for heart disease, cancer, stroke, and diabetes. For COPD, the death rate for men increased during the 1969-1985 period, leveled during the 1985-1999 period, and then decreased by 1.2% (95% CI, 1.0% to 1.5%) per year dur-

Figure 2. Age-Standardized Death Rate by Sex and Cause of Death in the United States, 1969-2013.



COPD indicates chronic obstructive pulmonary disease.

Data markers represent observed rates; lines are fitted rates based on joinpoint analysis. Left panels, The blue in the y-axes represents the death rate range from 0 to 500 per 100 000 persons. Right panels, The orange in the y-axes represents the death rate range from 0 to 50 per 100 000 persons.

ing the 1999-2013 period; in contrast, the rate for females increased throughout the 1969-2013 period, even though the annual increase during the most recent period (1999-2013) was small (APC, 0.3%; 95% CI, 0.0% to 0.5%).

For unintentional injuries, the death rate for men decreased by 0.9% (95% CI, 0.0% to 1.8%) per year during the most recent period (2006-2013), preceded by an increasing trend during the 2000-2006 period and a stable trend during the 1992-2000 period; in contrast, the rate continuously increased during the 1992-2013 period for women.

Trends in premature deaths, expressed as age-standardized years of potential life lost per 1000, are presented in **Table 3**, eTable 1, eFigure 1, and eFigure 2 in the Supplement. Between 1969 and 2013, the years-of-potential-life-lost rate for all causes decreased from 134.7 to 64.1 (52.4% reduction; 95% CI, 52.2% to 52.6%)—an annual average decrease of 1.7% (95% CI, 1.5% to 2.0%). Premature deaths decreased for all major causes of death except for COPD, which remained constant. Specifically, the years-of-potential-life-lost rate decreased from 1.9 to 1.6 for diabetes (14.5% reduction; 95% CI, 12.6% to 16.4%), from 21.4 to 12.7 for cancer (40.6% reduction; 95% CI, 40.2% to 41.1%), from 19.9 to 10.4 for unintentional injuries (47.5% reduction; 95% CI, 47.0% to 48.0%), from 28.8 to 9.1 for heart disease (68.3% reduction; 95% CI, 68.1% to 68.5%), and from 6.0 to 1.5 for stroke (74.8% reduction; 95% CI, 74.4% to 75.3%).

Similar to the findings in death rates, the decrease in years-of-potential-life-lost rate slowed for heart disease and leveled for diabetes after 2010. Specifically, APC changed from −2.7% (95% CI, −2.8% to −2.6%) during the years 1993 through 2010 to −0.6% (95% CI, −2.4% to 1.2%) during the years 2010 through 2013 (test on slope difference, $P = .03$) for heart disease and for diabetes, changed from −2.0% (95% CI, −2.9% to −1.1%) during the years 2003 through 2010, to 1.8% (95% CI, −0.8% to 4.5%) during the years 2010 through 2013 (test on slope difference, $P = .01$). For cancer, in contrast to the increase and decrease in death rates, premature deaths decreased continuously over the entire study period.

Table 3. Joinpoint Analysis of Age-Standardized Years of Potential Life Lost by Cause of Death in the United States, 1969-2013[a]

	Years of Potential Life Lost (1/1000)			Trend 1		Trend 2		Trend 3	
	1969	2013	Average APC (95% CI)	Years	APC (95% CI)	Years	APC (95% CI)	Years	APC (95% CI)
All causes	134.7	64.1	−1.7 (−2.0 to −1.5)[b]	1969-1983	−2.7 (−2.8 to −2.6)[b]	1983-1988	−0.4 (−1.3 to 0.6)	1988-1995	−1.1 (−1.6 to −0.6)[b]
Heart disease	28.8	9.1	−2.6 (−2.9 to −2.3)[b]	1969-1977	−3.1 (−3.4 to −2.8)[b]	1977-1987	−2.4 (−2.6 to −2.1)[b]	1987-1990	−5.1 (−8.0 to −2.0)[b]
Cancer	21.4	12.7	−1.2 (−1.2 to −1.1)[b]	1969-1981	−0.5 (−0.6 to −0.4)[b]	1981-1985	−0.1 (−0.7 to 0.5)	1985-1992	−0.8 (−1.0 to −0.6)[b]
Stroke	6.0	1.5	−3.1 (−3.4 to −2.8)[b]	1969-1973	−2.9 (−3.6 to −2.1)[b]	1973-1979	−6.8 (−7.4 to −6.2)[b]	1979-1983	−4.1 (−5.6 to −2.6)[b]
COPD	1.7	1.6	−0.1 (−0.4 to 0.2)	1969-1979	−1.2 (−1.7 to −0.6)[b]	1979-1986	2.0 (1.0 to 3.1)[b]	1986-1999	0.1 (−0.2 to 0.5)
Unintentional injuries	19.9	10.4	−1.6 (−2.4 to −0.7)[b]	1969-1976	−3.4 (−4.5 to −2.4)[b]	1976-1979	0.7 (−7.4 to 9.6)	1979-1982	−5.8 (−13.5 to 2.6)
Diabetes	1.9	1.6	−0.4 (−0.8 to −0.1)[b]	1969-1977	−4.7 (−5.4 to −4.0)[b]	1977-1984	−1.3 (−2.6 to −0.1)[b]	1984-1994	3.2 (2.6 to 3.9)[b]
				Trend 4		Trend 5		Trend 6	
All causes				1995-1998	−4.0 (−6.9 to −0.9)[b]	1998-2003	−0.4 (−1.4 to 0.6)	2003-2013	−1.4 (−1.7 to −1.2)[b]
Heart disease				1990-1993	−1.2 (−4.3 to 2.1)	1993-2010	−2.7 (−2.8 to −2.6)[b]	2010-2013	−0.6 (−2.4 to 1.2)
Cancer				1992-2008	−2.0 (−2.0 to −1.9)[b]	2008-2013	−1.6 (−1.9 to −1.4)[b]		
Stroke				1983-1992	−2.6 (−3.0 to −2.3)[b]	1992-1995	0.4 (−2.9 to 3.9)	1995-2013	−2.5 (−2.6 to −2.4)[b]
COPD				1999-2006	−1.3 (−2.2 to −0.5)[b]	2006-2013	0.0 (−0.6 to 0.7)		
Unintentional injuries				1982-1998	−1.8 (−2.2 to −1.4)[b]	1998-2006	1.6 (0.4 to 2.8)[b]	2006-2013	−1.7 (−2.9 to −0.6)[b]
Diabetes				1994-2003	0.7 (0.1 to 1.3)[b]	2003-2010	−2.0 (−2.9 to −1.1)[b]	2010-2013	1.8 (−0.8 to 4.5)

Abbreviations: APC, annual percent change; COPD, chronic obstructive pulmonary disease.

[a] Standardized to the 2000 US standard population by single age.

[b] $P < .05$.

Discussion

This temporal analysis of deaths in the United States found an overall decreasing trend in the age-standardized death rate between 1969 and 2013 for all causes combined, and for diabetes, heart disease, cancer, stroke, unintentional injuries, and diabetes. However, the rate of decrease appears to have slowed for heart disease, stroke, and diabetes. In contrast, the rate for COPD doubled over this period, while a decreasing trend was observed in men after 1999.

The decrease in the overall death rate, largely due to long-term declines for heart disease, stroke, and cancer, has been reported in several previous studies in the United States[10] and in other developed countries.[11] The progress against heart disease and stroke is attributed to improvements in control of hypertension and hyperlipidemia, smoking cessation, and medical treatment.[12-14] The reduction in cancer deaths since the early 1990s is also an outcome of tobacco control efforts, as well as advances in early detection and treatment.[15,16] Notably, the years-of-potential-life-lost rate (<75 years) from cancer has been decreasing since 1969, preceding the decline in cancer death rates by about 20 years. This may reflect the importance of smoking cessation in substantially reducing premature mortality.

The overall decrease in the death rate for unintentional injuries has been largely attributed to continuous declines in motor vehicle–related deaths.[17] The decline in death rates for unintentional injuries in men beginning in 2006, after an increase during the years 2000 through 2006, was a

result of the combination of the slowing of the increase in death rates from drug poisoning since 2006[18] and the recent acceleration of decreases in motor vehicle-related deaths.[19] The continued increase in death rates for COPD in women largely reflects the lagged effects of smoking prevalence.[20]

Our observed recent attenuation in declining death rates for obesity-related diseases (eg, heart disease, stroke, and diabetes) may reflect the lagged consequences of increased obesity prevalence since the 1980s.[21,22] A similar leveling off of declines in death rates for coronary heart disease among young adults has been observed in Wales and England[23] and Australia.[24] In addition to obesity, explanations for these patterns include ceiling on life expectancy,[25] although the slowdown was also observed in premature deaths (measured by years of potential life lost), and slowing of the rate of discovery and dissemination of public health and clinical interventions that have driven declines in morality in recent decades.

Further disease-specific studies are needed to investigate these trends. Regardless of the changes in death rates, the increasing numbers of old persons in the United States and growth of the US population will pose a considerable challenge for health care delivery in the coming decades, in view of the shortage of primary care physicians[26] and geriatricians,[27] increasing cost of health care,[28] and the lag between healthy life and life expectancies.[29]

Limitations

This study has some limitations. First, inaccuracy of death certificates may influence the interpretation of our findings on disease-specific trends. Validation studies showed that cause-of-death information on death certificates was generally accurate for cancer[30] and injuries,[31] whereas deaths from COPD,[32] stroke,[33] and diabetes[34] tend to be underreported and deaths from heart disease tend to be overreported.[35] There is no evidence that temporal changes in coding of cardiovascular disease (CVD) on death certificates have affected the assessment of CVD's secular trends.[36,37] However, the improvements in diabetes reporting may partly explain the increasing trends in death rates for diabetes in recent years.[34]

Second, the coding of the underlying cause of death changed during the study period, from *ICD-8* to *ICD-9* in 1979 and to *ICD-10* in 1999. However, the causes of death examined in this study were affected little by these changes, with the comparability ratios of *ICD-9* vs *ICD-8* and of *ICD-10* vs *ICD-9*, ranging from 0.99 to 1.06.[38,39] Moreover, this would not affect our findings for all-cause mortality, which is immune to changes in disease classification. Third, the slowdown in decreasing death rates during the most recent time segment should be interpreted with caution. A short-term trend (2010-2013 for heart disease and diabetes) is prone to random variations, and its predictive value is subject to uncertainties.

Conclusions

According to death certificate data between 1969 and 2013, an overall decreasing trend in age-standardized death rate was observed for all causes combined, heart disease, cancer, stroke, unintentional injuries, and diabetes, although the rate of decrease appears to have slowed for heart disease, stroke, and diabetes. The death rate for COPD increased during this period.

ARTICLE INFORMATION

Author Contributions: Dr Ma 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: Ma, Jemal.
Acquisition, analysis, or interpretation of data: All authors.
Drafting of the manuscript: Ma, Jemal.
Critical revision of the manuscript for important intellectual content: All authors.
Statistical analysis: Ma.
Study supervision: Jemal.

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