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Deaths: Final Data for 2007

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Abstract

Objectives—This report presents final 2007 data on U.S. deaths, death rates, life expectancy, infant and maternal mortality, and trends by selected characteristics such as age, sex, Hispanic origin, race, marital status, educational attainment, injury at work, state of residence, and cause of death.

Methods—Information reported on death certificates, which are completed by funeral directors, attending physicians, medical examiners, and coroners, is presented in descriptive tabulations. The original records are filed in state registration offices. Statistical information is compiled in a national database through the Vital Statistics Cooperative Program of the Centers for Disease Control and Prevention's National Center for Health Statistics. Causes of death are processed in accordance with the *International Classification of Diseases, Tenth Revision* (ICD–10).

Results—In 2007, a total of 2,423,712 deaths were reported in the United States. The age-adjusted death rate was 760.2 deaths per 100,000 standard population, a decrease of 2.1 percent from the 2006 rate and a record low historical figure. Life expectancy at birth rose 0.2 years, from a 2006 value of 77.7 years to a record 77.9 years in 2007. Age-specific death rates decreased for most age groups: 15-24 years, 35-44 years, 45-54 years, 55-64 years, 65-74 years, 75-84 years, and 85 years and over and remained unchanged for age groups: under 1 year, 1-4 years, 5-14 years, and 25-34 years. The 15 leading causes of death in 2007 remained the same as in 2006, with the exception of two causes that exchanged ranks. Alzheimer's disease, the seventh leading cause of death in 2006, became the sixth leading cause in 2007, and Diabetes mellitus, the sixth leading cause in 2006, became the seventh leading cause in 2007. Heart disease and cancer continued to be the leading and second-leading causes of death, together accounting for

almost half of all deaths (48.6 percent). The infant mortality rate in 2007 was 6.75 deaths per 1,000 live births.

Conclusions—Mortality patterns in 2007, such as the decline in the age-adjusted death rate to a record historical low, were generally consistent with long-term trends. Life expectancy reached a record high in 2007, increasing 0.2 year from 2006.

Keywords: mortality • cause of death • life expectancy • vital statistics

Highlights

Mortality experience in 2007

- In 2007, a total of 2,423,712 resident deaths were registered in the United States.
- The age-adjusted death rate, which takes the aging of the population into account, was 760.2 deaths per 100,000 U.S. standard population.
- Life expectancy at birth was 77.9 years.
- The 15 leading causes of death in 2007 were:
    1. Diseases of heart (heart disease)
    2. Malignant neoplasms (cancer)
    3. Cerebrovascular diseases (stroke)
    4. Chronic lower respiratory diseases
    5. Accidents (unintentional injuries)
    6. Alzheimer's disease
    7. Diabetes mellitus (diabetes)
    8. Influenza and pneumonia
    9. Nephritis, nephrotic syndrome and nephrosis (kidney disease)
    10. Septicemia
    11. Intentional self-harm (suicide)
    12. Chronic liver disease and cirrhosis
    13. Essential hypertension and hypertensive renal disease (hypertension)
    14. Parkinson's disease
    15. Assault (homicide)
- In 2007, the infant mortality rate was 6.75 infant deaths per 1,000 live births.

- The 10 leading causes of infant death were:
    1. Congenital malformations, deformations and chromosomal abnormalities (congenital malformations)
    2. Disorders related to short gestation and low birth weight, not elsewhere classified (low birthweight)
    3. Sudden infant death syndrome (SIDS)
    4. Newborn affected by maternal complications of pregnancy (maternal complications)
    5. Accidents (unintentional injuries)
    6. Newborn affected by complications of placenta, cord and membranes (cord and placental complications)
    7. Bacterial sepsis of newborn
    8. Respiratory distress of newborn
    9. Diseases of the circulatory system
    10. Neonatal hemorrhage

Trends

- The age-adjusted death rate in 2007 declined to a record low.
- Life expectancy was 77.9 years, continuing a long-term increasing trend. Life expectancy increased for the total population, as well as for the black and white populations. Black males and females and white males and females experienced an increase in life expectancy in 2007 compared with 2006.
- Age-adjusted death rates decreased significantly in 2007 from 2006 for 5 of the 15 leading causes of death, and increased for 2 of the 15 leading causes. Rates for the top three leading causes—heart disease, cancer, and stroke—continued a long-term decreasing trend. Significant increases occurred for suicide and Chronic liver disease and cirrhosis.
- The differences in mortality between men and women increased slightly in 2007 from 2006. The age-adjusted death rate for men was 40.8 percent greater than that for women, up from 40.6 percent in 2006, while the difference between male and female life expectancy was 5.0 years in 2007, a slight decrease from the 2006 gap of 5.1 years.

- Differences in mortality between the black and white populations persisted. The age-adjusted death rate was 1.3 times greater, infant mortality rate 2.4 times greater, and maternal mortality rate 2.7 times greater for the black population than for the white population. Differences in life expectancy between the black and white population narrowed by 0.2 years from 5.0 years in 2006 to 4.8 years in 2007.
- The postneonatal mortality rate increased 4.0 percent in 2007 from 2006.

Introduction

This report presents detailed 2007 data on deaths and death rates according to a number of social, demographic, and medical characteristics. These data provide information on mortality patterns among residents of the United States by such variables as age, sex, Hispanic origin, race, marital status, educational attainment, injury at work, state of residence, and cause of death. Information on these mortality patterns is key to understanding changes in the health and well-being of the U.S. population (1).

Preliminary data for 2007 were presented in the report ‘‘Deaths: Preliminary Data for 2007’’ using a 91 percent (demographic file) sample of U.S. deaths weighted to independent control totals (2). The findings of this report, based on the final mortality file, are generally consistent with those based on preliminary data; the final mortality file incorporates some modifications to the preliminary file as described in ‘‘Technical Notes.’’ Separate companion reports will present additional details on leading causes of death and life expectancy in the United States (3,4).

Mortality data in this report can be used to monitor and evaluate the health status of the United States in terms of current mortality levels and long-term mortality trends, as well as to identify segments of the U.S. population at greater risk of death from specific diseases and injuries. Differences in death rates among various demographic subpopulations, including race and ethnic groups, may reflect subpopulation differences in factors such as socioeconomic status, access to medical care, and the prevalence of specific risk factors in a particular subpopulation.

Methods

Data in this report are based on information from all resident death certificates filed in the 50 states and the District of Columbia. More than 99 percent of deaths occurring in this country are believed to be registered (5). Tables showing data by state also provide information for Puerto Rico, Virgin Islands, Guam, American Samoa, and the Commonwealth of the Northern Mariana Islands (Northern Marianas). Cause-of-death statistics presented in this report are classified in accordance with the *International Classification of Diseases, Tenth Revision* (ICD–10) (6). A discussion of the cause-of-death classification is provided in ''Technical Notes.''

Mortality data on specific demographic and medical characteristics except educational attainment cover all 50 states and the District of Columbia. Educational attainment data are provided separately for the 22 states and the District of Columbia that used the 2003 version of the standard death certificate, and the 26 states that used the 1989 version of the standard death certificate. Georgia and Rhode Island were excluded because the educational attainment item was not on their death certificate. Details on reporting areas for educational attainment are provided in ''Technical Notes.''

Measures of mortality in this report include the number of deaths; crude, age-specific, and age-adjusted death rates; infant, neonatal, postneonatal, and maternal mortality rates; life expectancy; and rate ratios. Changes in death rates in 2007 compared with 2006, and differences in death rates across demographic groups in 2007, are tested for statistical significance. Unless otherwise specified, reported differences are statistically significant. Additional information on these statistical methods, random variation and relative standard error, the computation of derived statistics and rates, population denominators, and the definition of terms is presented in ''Technical Notes.''

The populations used to calculate death rates for 2000–2007 and the intercensal period 1991–1999 shown in this report were produced under a collaborative arrangement with the U.S. Census Bureau and are consistent with the 2000 census. Reflecting the new guidelines issued in 1997 by the Office of Management and Budget (OMB), the 2000 census included an option for persons to report more than one race as appropriate for themselves and household members (7); see ''Technical Notes.'' The 1997 OMB guidelines also provided for the reporting of Asian persons separately from Native Hawaiian or Other Pacific Islander persons. Under the prior OMB standards issued in 1977, data for Asian or Pacific Islander persons were collected as a single group (8). Most death certificates currently collect only one race for the decedent in the

same categories as specified in the 1977 OMB guidelines; that is, death certificate data do not report Asian persons separately from Native Hawaiian or Other Pacific Islander persons. Death certificate data by race—the source of the numerators for death rates—are thus currently incompatible with the population data collected in the 2000 census and postcensal estimates—the denominators for the rates. To produce death rates by race for 2000–2007, and revised intercensal rates for the 1991–1999 period, the reported population data for multiple-race persons had to be ''bridged'' to single-race categories. In addition, the 2000 census counts were modified to be consistent with the 1977 OMB race categories; that is, to report the data for Asian persons and Native Hawaiian or Other Pacific Islander persons as a combined category, Asian or Pacific Islander, and to reflect age as of the census reference date (9). The procedures used to produce the bridged populations are described in separate publications (10,11). The bridged population data are anticipated to be used over the next few years for computing population-based rates by race. Beginning with deaths occurring in 2003, some states allowed for multiple-race reporting on the death certificate. Multiple-race data for these states are bridged to single-race categories; see ''Technical Notes.'' Once all states are collecting data on race according to the 1997 OMB guidelines, use of the bridged race algorithm is expected to be discontinued.

Readers should keep in mind that the population data used to compile death rates by race in this report are based on special estimation procedures—they are not true counts. This is the case even for the 2000 populations. The estimation procedures used to develop these populations contain some error. Smaller population groups are affected much more than larger population groups (10). Over the next several years, additional information will be incorporated in the estimation procedures, possibly resulting in further revisions of the population estimates; see ''Technical Notes.'' Data presented in this report and other mortality tabulations are available at the National Center for Health Statistics (NCHS) website, http://www.cdc.gov/nchs/deaths.htm. Availability of mortality microdata is described in ''Technical Notes.''

Results and Discussion

Deaths and death rates

In 2007, a total of 2,423,712 resident deaths were registered in the United States, 2,552 fewer deaths than in 2006. The crude death rate for 2007, 803.6 deaths per 100,000 population, was 0.8 percent less than the 2006 rate (810.4) (Tables 1 and A).

The age-adjusted death rate in 2007 was 760.2 deaths per 100,000 U.S. standard population, a record low value that was 2.1 percent lower than the 2006 rate of 776.5 (Tables 1 and A). Age-adjusted death rates are constructs that show what the level of mortality would be if no changes occurred in the age composition of the population from year to year. (For a discussion of age-adjusted death rates, see ''Technical Notes.'') Thus, age-adjusted death rates are better indicators than unadjusted (crude) death rates for examining changes in the risk of death over a period of time when the age distribution of the population is changing. Age-adjusted death rates also are better indicators of relative risk when comparing mortality across geographic areas or between sex or race subgroups of the population that have different age distributions; see ''Technical Notes.'' Since 1980, the age-adjusted death rate has decreased every year except 1983, 1985, 1988, 1993, and 1999. Those years coincided with influenza outbreaks (12–15). The pace of decline for age-adjusted death rates during the last 7 years has been faster than for previous decades. From 1980 through 1989, the decline was 8.5 percent; from 1990 through 1999, 6.7 percent and from 2000 through 2007, 12.5 percent (Figure 1 and Table 1).

Race—In 2007, age-adjusted death rates for the major race groups (Table 1) were:

- White population, 749.4 deaths per 100,000 U.S. standard population
- Black population, 958.0
- American Indian or Alaska Native (AIAN) population, 627.2
- Asian or Pacific Islander (API) population, 415.0

Rates for the AIAN and API populations should be interpreted with caution because of reporting problems regarding correct identification of race on both the death certificate and in population censuses and surveys. The net effect of the reporting problems is for the AIAN rate to be approximately 30 percent understated and the API rate to be approximately 7 percent understated (16).

In 2007, the age-adjusted death rate for the black population was 1.3 times that for the white population (Table B); that is, the average risk of death for the black population was about 30.0 percent higher than for the white population. The ratio (shown to one decimal place) has remained constant since 1997. From 1960 through 1982, rates for the black and white

populations declined by similar percentages—22.6 and 26.5 percent, respectively. From 1982 through 1988, rates diverged (17), increasing 5.2 percent for the black population and decreasing 1.7 percent for the white population. The disparity in age-adjusted death rates between the black and white populations reached its widest point in 1989 (1.4 times greater). Since then, the disparity between the two populations has narrowed as the age-adjusted rate for the black population declined by 24.9 percent and the rate for the white population declined by 18.6 percent. (Table 1 and Figure 2).

In 2007, decreases in age-adjusted death rates were observed for both white and black males and females compared with 2006. In order of relative magnitude of decrease, the reductions from 2006 were 2.6 percent for black males, 2.4 percent for black females, and 2.1 percent for white females and 1.9 percent for white males (Tables A and 1).

In general, age-adjusted death rates have declined between 1980 and 2007 for white males and females, and black males and females. The rate for white males decreased an average of 1.4 percent per year, white females decreased 0.8 percent per year, black males decreased 1.3 percent per year, and black females decreased 1.0 percent per year between 1980 and 2007. However, increases were observed for both white males and white females in 1983, 1985, 1988, and 1993. In addition, the age-adjusted death rate for white females increased in 1995 and 1999. For black males, age-adjusted death rates tended to decrease except for a period of increase from 1983 through 1988. Rates for black females decreased from 1980 through 2007, although with considerable variability in direction of change from year to year (Table 1).

In 2007, the age-adjusted death rate for the AIAN population was 0.8 times that for the white population (Table B); that is, the average risk of death for the AIAN population was about 20 percent lower than for the white population. Despite fluctuations over time and a trend toward convergence in rates from 1988 through 1999, the AIAN-white ratio has been consistently lower than 1.0 since 1980. The AIAN advantage in mortality is due in large part to the underreporting of AIAN mortality on death certificates. From 1980 through 1988, the age-adjusted rate for the AIAN population declined by 17.1 percent (Figure 2 and Table 1). However, the rate fluctuated from 1989 through 1999, peaking at 796.4 deaths per 100,000 U.S. standard population in 1993. Overall, the age-adjusted rate increased by 2.5 percent from 1989 through 1999, and has since trended downward. From 1999 through 2007, it declined by 19.7 percent. In 2007, the age-adjusted rate decreased by 4.0 percent from 2006 for AIAN females. The rate decreased by 2.3

percent from 2006 for both sexes. The observed decrease of 2.3 percent was not statistically significant (Table A). The rate for AIAN males did not change significantly from year to year.

The age-adjusted death rate for the API population was 0.6 times that for the white population in 2007 (Table B). Some of this advantage is due to the underreporting of API mortality on death certificates. The API-white ratio has been consistently low over time, with a trend toward incremental divergence in rates since 1990 (Table 1 and Figure 2). From 1981 through 1985, the age-adjusted rate for the API population increased by 7.7 percent to reach a peak of 586.5 deaths per 100,000 U.S. standard population. The rate fluctuated from 1985 through 1993 before starting a persistent downward trend. From 1993 through 2007, the age-adjusted rate for the API population decreased by 26.7 percent. In 2007, the rate for the total API population decreased by 3.2 percent from 2006 while the rate for both API males and females decreased by 3.3 percent (Table A).

Hispanic origin—Problems of race and Hispanic-origin reporting affect Hispanic death rates and the comparison of rates for the Hispanic and the non-Hispanic population; see ''Technical Notes.'' Mortality for Hispanics is somewhat understated because of net underreporting of Hispanic origin on the death certificate. Hispanic origin on the death certificate is underreported by an estimated 5 percent (16,18); see ''Technical Notes.'' The age-adjusted death rate for the Hispanic population in 2007 was 546.1, a decrease of 3.2 percent from the rate of 564.0 observed in 2006 (Tables C and 2). The age-adjusted death rate for the total non-Hispanic population decreased by 1.9 percent relative to 2006. In 2007, the age-adjusted rate for the non-Hispanic white population decreased by 1.8 percent from 2006, and that for the non-Hispanic black population declined by 2.3 percent.

Among Hispanic males, the age-adjusted death rate decreased by 3.1 percent in 2007 from 2006. The age-adjusted death rate for non-Hispanic white males and non-Hispanic black males declined 1.7 and 2.4 percent, respectively. Among Hispanic females, the age-adjusted death rate decreased by 3.4 percent. Non-Hispanic white females and non-Hispanic black females experienced declines of 1.9 and 2.2 percent, respectively (Tables C and 2).

In 2007, the age-adjusted death rate (Table 2) was 29.7 percent lower for the Hispanic population than for the non-Hispanic population. Similarly, the age-adjusted death rate for the Hispanic population was 28.5 percent lower than the rate for the non-Hispanic white population, and considerably lower, at 44.2 percent, than that for the non-Hispanic black population. The

large differences in mortality between the Hispanic and non-Hispanic populations are partly a function of the Hispanic population's lower age-specific death rates, particularly at older ages (Table 4). Part of the difference is also attributable to underreporting of Hispanic origin on the death certificates. In addition, various hypotheses have been proposed to explain Hispanics' favorable mortality outcomes. The most prevalent include the healthy migrant effect, which argues that Hispanic immigrants are selected for their good health and robustness, and the ''salmon bias'' effect, which posits that U.S. residents of Hispanic origin may return to their country of origin to die or when ill (19,20).

Within the Hispanic population, the age-adjusted death rate for males was 1.4 times the rate for females (Table 2). The corresponding male-female ratios were 1.4 for the non-Hispanic white population and 1.5 for the non-Hispanic black population. The male-female ratios of age-adjusted death rate within the Hispanic population did not change in 2007 from 2006. Age-adjusted death rates in 2007 for selected Hispanic subgroups (Table 5), in order of relative magnitude, were:

- Puerto Rican population, 636.6 deaths per 100,000 U.S. standard population
- Cuban population, 596.7
- Mexican population, 568.7
- Central and South American population, 325.5

The age-adjusted death rate for the Puerto Rican, and Central and South American population significantly decreased by 11.3 percent and 12.1 percent respectively whereas the rate for the Cuban population increased by 4.7 percent in 2007 from 2006. Among the Hispanic subgroups, the age-adjusted death rate for Central and South American population was significantly lower than the rates for the Mexican, Puerto Rican, and Cuban populations. The differences in age-adjusted death rates among the Mexican, Puerto Rican, and Cuban populations were not statistically significant. Tests of significant differences among the Hispanic subgroups are affected by the large variation in age-specific death rates for some of the subgroups, which reflects their relatively small population sizes.

Death rates by age and sex

No statistically significant increases in age-specific death rates for the major race-sex groups were noted in 2007 (Table A and Figure 3). Age-specific death rates decreased by a

statistically significant margin from 2006 to 2007 for age groups 15–24 years, 35–44 years, 45–54 years, 55–64 years, 65–74 years, 75–84 years, and 85 years and over.

The death rates for males declined in 2007 from 2006 for age groups 15–24 years, 25-34 years, 35–44 years, 45–54 years, 55–64 years, 65–74 years, 75–84 years, and 85 years and over. The observed increase of 2.6 percent for age 1-4 years in 2007 from 2006 was not statistically significant. For females, death rates declined for the age groups 35–44 years, 55–64 years, 65–74 years, 75–84 years, and 85 years and over. The rates for the rest of age groups for females remained unchanged statistically.

Race—Age-specific death rates declined for white males in 2007 for age groups 15–24 years, 35–44 years, 45-54 years, 55–64 years, 65–74 years, 75–84 years, and 85 years and over (Table A). The largest decrease, 3.3 percent, occurred for those aged 15–24 years. No increased rates for males were observed for any age specific groups. For the black male population in 2007, the rates decreased for age groups 25-34 years, 35-44 years, 45–54 years, 65–74 years, and 75–84 years. The largest statistically significant decrease for black males was for those aged 25-34 years, at 5.5 percent. None of the changes in age-specific death rates for AIAN males in 2007 from 2006 were statistically significant. Rates for API males decreased for those aged 55-64 years and 85 years and over—the group with the largest statistically significant decrease at 6.4 percent.

For white females, the death rate decreased in 2007 for those aged 35–44 years, 55–64 years, 65–74 years, 75–84 years, and 85 years and over. The largest decrease, 2.7 percent, was observed for age group 65–74 years. Age-specific rates for black females decreased for age groups under 1 year, 35-44 years, 55–64 years, 75–84 years, and 85 years and over, with the 35-44 years group having the largest decrease at 6.5 percent. For AIAN females, the only statistically significant change was an 8.3 percent decrease for those aged 75-84 years. No rate observed for API females changed statistically in 2007 from 2006.

Hispanic origin—For the Hispanic origin population in 2007 compared with 2006 (Table C), the age-specific death rate decreased for age groups 15-24 years, 35–44 years, 45-54 years, 65–74 years, 75–84 years, and 85 years and over. The largest decrease was for age group 35-44 years, at 5.4 percent; no significant increases in age-specific death rates for Hispanics occurred in 2007 from 2006. Rates for Hispanic males decreased for age groups 15-24 years, 35-44 years, 65–74 years, 75–84 years, and 85 years and over. The largest decrease was for the age group 35-

44 years — 5.8 percent. For Hispanic females, age-specific rates decreased by a statistically significant amount in 2007 from 2006 for those aged 45-54 years, 65–74 years, and 85 years and over. The largest decrease, 5.5 percent, was for the age group 85 years and over.

Expectation of life at birth and at specified ages

Life expectancy at birth represents the average number of years that a group of infants would live if the group was to experience throughout life the age-specific death rates present in the year of birth. **Life table data shown in this report for data years 2000–2007 are based on a newly revised methodology and may differ from figures previously published.** The revised methodology is similar to that developed for the 1999–2001 decennial life tables; see ''Technical Notes.'' Life tables were generated only for the total U.S., black, and white populations.

In 2007, life expectancy at birth for the U.S. population was 77.9 years, an increase of 0.2 year from 77.7 years in 2006 (Tables 6–8). The trend in U.S. life expectancy since 1900 has been one of gradual improvement. In 2007, the life expectancy for females was 80.4 years, a 0.2-year increase from 2006, and the life expectancy for males was 75.4 years, a 0.3-year increase from the previous year. From 1900 through the late 1970s, the sex gap in life expectancy widened (Figure 4; data prior to 1975 not shown), from 2.0 years to 7.8 years. Since its peak in the 1970s, the sex gap has been narrowing (Figure 4). The difference in life expectancy between the sexes was 5.0 years in 2007, a slight decrease from the 5.1-year gap in 2006.

Life expectancy increased 0.4 year for the black population in 2007 to 73.6 years compared with 2006 (73.2). Life expectancy for the white population increased 0.2 year to 78.4 years. The difference in life expectancy between the white and black populations in 2007 was 4.8 years, a 0.2-year decrease from the 2006 gap between the two races and the smallest gap ever recorded. The white-black gap has been narrowing gradually from a peak of 7.1 years in 1989 to the current record low (Figure 4). This continued a long-term decline in the white-black difference in life expectancy that was interrupted from 1982 through 1989 when the gap widened.

Among the major race-sex groups (Tables 7, 8, and Figure 5), white females continued to have the highest life expectancy at birth (80.8 years), followed by black females (76.8 years), white males (75.9 years), and black males (70.0 years). Life expectancies increased by 0.3 year for both the black male and female populations. Life expectancies increased by 0.2 years for both

white males and females. Life expectancy for black males declined every year from 1984 through 1989, then resumed the long-term trend of increase from 1990 through 1992 and 1994 through 2004 and from 2005 through 2007 (Table 8). For white females, life expectancy increased most years from 1970 through 1998. In 1999, life expectancy for white females fell below 1998's record high, and did not increase again until 2003. From 1989 through 1992, during 1994, and from 1995 through 1998, life expectancy for black females increased. In 1999, life expectancy for black females declined as it did for white females, only to begin climbing again in 2000.

Life tables shown in this report may be used to compare life expectancies at selected ages from birth to 100 years. For example, a person who has reached 65 years will live to an older age, on average, than one who has reached 50 years. On the basis of mortality experienced in 2007, a person aged 50 years could expect to live an average of 30.9 more years for a total of 80.9 years. A person aged 65 years could expect to live an average of 18.6 more years for a total of 83.6 years, and a person aged 85 years could expect to live an average of 6.5 more years for a total of 91.5 years (Tables 6 and 7).

Leading causes of death

The 15 leading causes of death in 2007 accounted for 81.4 percent of all deaths in the United States (Table B). Causes of death are ranked according to the number of deaths; for ranking procedures, see ''Technical Notes.'' By rank, the 15 leading causes in 2007 were:

1. Diseases of heart (heart disease)
2. Malignant neoplasms (cancer)
3. Cerebrovascular diseases (stroke)
4. Chronic lower respiratory diseases
5. Accidents (unintentional injuries)
6. Alzheimer's disease
7. Diabetes mellitus (diabetes)
8. Influenza and pneumonia
9. Nephritis, nephrotic syndrome and nephrosis (kidney disease)
10. Septicemia

11. Intentional self-harm (suicide)
12. Chronic liver disease and cirrhosis
13. Essential hypertension and hypertensive renal disease (hypertension)
14. Parkinson's disease
15. Assault (homicide)

The 15 leading causes of death in 2007 retained the same ranking as in 2006 with the exception of Alzheimer's diseases and diabetes which changed position relative to their placement in 2006 as diabetes decreased by 3.4 percent in 2007 from 2006.

The age pattern of mortality can vary greatly by cause of death. As a result, the changing age distribution of a population can significantly influence changes in crude death rates over time. In contrast, the influence of such shifts in the population age structure is eliminated by age-adjusted death rates. Therefore, age-adjusted death rates are better indicators than crude rates for showing changes in mortality over time and among causes of death, and consequently are used in this report to depict trends for leading causes of death (Figure 6).

In 2007, the number of deaths decreased from 2006 by 0.1 percent, or 2,552 fewer deaths. The age-adjusted death rate for all causes decreased by 2.1 percent. This reduction in the risk of dying has been driven mostly by net decreases in the leading causes of death such as heart disease, cancer, stroke, diabetes, and Influenza and pneumonia. The drop in the death rate due to Influenza and pneumonia may be due, in part, to less severe influenza seasons during 2006-2007 and 2007-2008 compared to 2004-2005 and 2005-2006 (14,15).

Among the 15 leading causes of death, the age-adjusted death rate declined significantly for 5 of the leading causes (Table B). Long-term decreasing trends for heart disease, cancer, and stroke—the three leading causes of death—continued in 2007, with decreases of 4.6 percent for heart disease, 1.3 percent for cancer, and 3.2 percent for stroke compared with 2006. Except for a relatively small increase in 1993, mortality from heart disease has steadily declined since 1980 (Figure 6). The age-adjusted death rate for cancer, the second leading cause of death, has shown a gradual but consistent downward trend since 1993 (Figure 6). The rate for stroke has generally declined since 1958, with one exception: an increase of 2.6 percent from 1992 through 1995 (Figure 6).

Additional causes with a significant decrease in the age-adjusted death rate relative to 2006 were: Influenza and pneumonia (9.0 percent) and diabetes (3.4 percent). The increase in

deaths from Alzheimer's disease (0.4 percent) was not statistically significant. The mortality trend for Alzheimer's disease has generally been one of rapid increase (Figure 6). From 1979 through 1998, for example, the rate for Alzheimer's disease increased dramatically due to improvements in diagnosis, awareness of the condition within the medical community, and other unidentified factors (21). The transition from ICD–9 to ICD–10 also brought substantial changes to the coding and selection rules for this condition. This created a major disruption in the time series trend for Alzheimer's disease during 1998–1999 (Figure 6). The large increase in 1999 from 1998 is at least partly due to the ICD transition (22). Evaluating the observed change poses a problem because the comparability ratio (representing the net effect of the new revision on cause-of-death statistics) for Alzheimer's disease may be understated (22–25). Since 1999, the rate has trended upward through 2007.

Significant increases occurred between 2006 and 2007 in the age-adjusted death rate for suicide (3.7 percent) and Chronic liver disease and cirrhosis (3.4 percent). The death rate for suicide has decreased slightly from a high of 13.7 deaths per 100,000 standard population in 1977 to a low of 10.4 in 2000. Since 2000, the age-adjusted death rate for suicide has increased by 8.6 percent. The increase in the age-adjusted death rate for Chronic liver disease and cirrhosis may be largely due to a coding change; see *Quality of reporting and processing cause of death* in the "Technical Notes."

Although mortality from Human immunodeficiency virus (HIV) disease has not been on the list of 15 leading causes of death since 1997 (26), it is still of concern. HIV disease continues to be one of the five leading causes of death for specific age groups in females, and the black population. In 2007, a total of 11,295 persons died from HIV disease (Table 10). The age-adjusted death rate (3.7 per 100,000 standard population; Table 16) declined for the 12th consecutive year, decreasing 7.5 percent in 2007 from 2006. The age-adjusted death rate for this cause reached its highest point of 16.3 per 100,000 standard population in 1995 and then declined rapidly through 1998 (decreasing 69.9 percent) (27). The rate of decline for this cause of death has slowed considerably since 1999, decreasing by 30.2 percent from 1999-2007.

Enterocolitis due to *Clostridium difficile* (*C. difficile*), a bacterial inflammation of the intestines, is of growing public health concern because it is often acquired in hospitals or other health-care institutions with long-term patients or residents and accounts for an increasing number of deaths (28–31). In 1999, 793 deaths were due to *C. difficile*; by contrast, in 2007,

6,372 *C. difficile* deaths were recorded, an increase of 147 deaths from the 6,225 reported in 2006. Because of the substantial increase since 1999, beginning in 2006, *C. difficile* is included among the rankable causes of death and is shown appended to the List of 113 Selected Causes of Death in tables in this report; see ‘‘Technical Notes.’’ The age-adjusted death rate for *C. difficile* was 2.0 deaths per 100,000 standard population for both 2006 and 2007. In 2007, this cause was not among the 20 leading causes for the overall population. However, it ranked among the 20 leading causes of death for the population aged 65 years and older. Approximately 92% of deaths due to *C. difficile* occurred in persons aged 65 years and over in 2007.

Changes in mortality levels by age and cause of death have a major effect on changes in life expectancy. Life expectancy at birth increased in 2007 over 2006 by 0.2 year because of decreases in mortality from heart disease, cancer, Influenza and pneumonia, stroke and diabetes. Decreases in mortality from these same causes of death also generated increases in life expectancy among the male and female populations, when analyzed separately. The increase in life expectancy in 2007 from 2006 for the population as a whole could have been greater than 0.2 year were it not for the increase in mortality from Chronic liver disease and cirrhosis and suicide. (For discussion of contributions to the change in life expectancy, see ‘‘Technical Notes.’’)

The relative risk of death in one population group compared with another can be expressed as a ratio. Ratios based on age-adjusted death rates show that males have higher rates than females for 12 of the 15 leading causes of death (Table B), with rates for males being at least two times those for females for five leading causes. The largest ratio, 3.9, was for suicide. Other large ratios were evident for homicide (3.8), Parkinson’s disease and Chronic liver disease and cirrhosis (2.2 each), unintentional injuries (2.1), heart disease (1.5), cancer, diabetes, Influenza and pneumonia, and kidney disease (1.4 each).

The difference in life expectancy between males and females decreased 0.1 year in 2007 over 2006, to 5.0 years (Table 8). The narrowing of the difference between male and female life expectancy was a result of greater improvements in mortality among males than females, particularly with respect to trends for heart disease, unintentional injuries, and HIV disease.

Age-adjusted death rates for the black population were higher than those for the white population for nine of the 15 leading causes of death (Table B). The largest ratio was for homicide, at 5.7. Other causes for which the ratio was high include hypertension (2.5), kidney disease and Septicemia (2.2 each), diabetes (2.1), stroke (1.5), heart disease (1.3), and cancer

(1.2). For six of the leading causes, age-adjusted rates were lower for the black population than for the white population. The smallest black-to-white ratios were for suicide (0.4); that is, the risk of dying from suicide is more than double for the white population than for the black population. Other conditions with a low black-to-white ratio were Parkinson's disease (0.5), Chronic lower respiratory diseases (0.7), Alzheimer's disease and Chronic liver disease and cirrhosis (0.8 each), and unintentional injuries (0.9).

The difference in life expectancy between the black and white populations narrowed from 5.0 years in 2006 to 4.8 years in 2007 (Table 8). The narrowing in the black-white life expectancy gap was due primarily to greater improvements in mortality for the black population than the white population. In particular, the black population gained ground on the white population due to improvements in death rates for unintentional injuries, HIV disease, homicide, and diabetes (data not shown).

Age-adjusted death rates were lower for the AIAN population than the white population for 9 of the 15 leading causes (Table B). The smallest ratios were for Alzheimer's disease and Parkinson's disease (0.5 each), then heart disease, cancer, and stroke, and Chronic lower respiratory diseases (0.7 each). Age-adjusted rates were higher for the AIAN population than the white population for five leading causes. The largest ratio was for Chronic liver disease and cirrhosis (2.6). Other causes for which the ratio was high include homicide, and diabetes (1.8 each), and unintentional injuries (1.3). Rates for the AIAN population are underestimated by about 30 percent due to underreporting on death certificates (16).

For the API population, age-adjusted death rates were lower than those for the white population for 14 of the 15 leading causes (Table B). The largest ratios were for Influenza and pneumonia (0.9), stroke, and diabetes (0.8 each), and kidney disease (0.7). The smallest ratios were for Chronic lower respiratory diseases and Alzheimer's disease (0.3 each), and unintentional injuries and Chronic liver disease and cirrhosis (0.4 each). The risk of dying from Septicemia, suicide or Parkinson's disease for the API population is about half that for the white population. Rates for the API population are underestimated by about 7 percent due to underreporting on death certificates (16).

Age-adjusted death rates were lower for the Hispanic population for 11 of the 15 leading causes of death compared with the non-Hispanic white population (Table B). The smallest ratios were for Chronic lower respiratory diseases and suicide (0.4 each), Other causes for which the

ratio was considerably smaller include cancer, Alzheimer's disease and Parkinson's disease (0.6 each), heart disease and unintentional injuries (0.7 each), and stroke, Influenza and pneumonia, and Septicemia (0.8 each). Age-adjusted death rates for the Hispanic population were greater than for the non-Hispanic white population for three of the 15 leading causes of death. The largest ratio was for homicide (2.5), followed by Chronic liver disease and cirrhosis (1.6) and diabetes (1.5). Rates for the Hispanic population are underestimated by about 5 percent (16).

Leading causes of death for the total population and specific subpopulations are examined in more detail in a separate *National Vital Statistics Report* on leading causes by age, race, Hispanic origin, and sex (4).

Injury mortality by mechanism and intent

In 2007, a total of 182,479 deaths were classified as injury-related (Table 18). Injury data are presented using the external cause-of-injury mortality matrix for ICD–10 as jointly conceived by the International Collaborative Effort (ICE) on Injury Statistics and the Injury Control and Emergency Health Services (ICEHS) section of the American Public Health Association (32,33). The ICD codes for injuries have two essential dimensions: the mechanism of the injury and its manner or intent. The mechanism involves the circumstances of the injury (e.g., fall, motor vehicle accident, poisoning). The manner or intent involves whether the injury was purposefully inflicted (where it can be determined) and, when intentional, whether the injury was self-inflicted (suicide) or inflicted upon another person (assault). In the List of 113 Selected Causes of Death, the focus is on manner or intent, with subcategories showing selected mechanisms. The matrix has two distinct advantages for the analysis of injury mortality data: it contains a comprehensive list of mechanisms, and data can be displayed by mechanism with subcategories of intent (Table 18) or vice versa. Four major mechanisms of injury in 2007— motor-vehicle traffic, poisoning, firearm, and fall—accounted for 74.9 percent of all injury deaths.

Motor-vehicle traffic—In 2007, motor-vehicle traffic-related injuries resulted in 42,031 deaths, accounting for 23.0 percent of all injury deaths (Table 18). The 4.2 percent decrease in the age-adjusted death rate for motor-vehicle traffic-related injuries from 14.4 deaths per 100,000 U.S. standard population in 2006 (34) to 13.8 in 2007 is statistically significant.

Poisoning—In 2007, 40,059 deaths occurred as the result of poisonings, 22.0 percent of all injury deaths (Table 18). The majority of poisoning deaths were either unintentional (74.5

percent) or suicides (15.9 percent). However, 9.4 percent of poisoning deaths were of undetermined intent. The age-adjusted death rate for poisoning increased by 5.6 percent from 12.4 deaths per 100,000 U.S. standard population in 2006 to 13.1 in 2007. Unintentional poisoning death rates in the United States have increased each year from 1999 through 2007 (data prior to 2007 are not shown).

Firearm—In 2007, 31,224 persons died from firearm injuries in the United States (Tables 18–20), accounting for 17.1 percent of all injury deaths that year. Firearm suicide and homicide, the two major component causes, accounted for 55.6 and 40.5 percent, respectively, of all firearm injury deaths in 2007. In 2007, the age-adjusted death rate for firearm suicide and homicide was unchanged statistically from 2006. The age-adjusted rate for all firearm injuries was the same in 2007 as in 2006—10.2 deaths per 100,000 U.S. standard population (Tables 18–20). In 2007, males had a firearm-related, age-adjusted death rate that was 6.7 times that for females. By comparison with the rate for the white population, the rate for the black population was 2.2 times higher; AIAN, 18.0 percent lower; and API, 67.4 percent lower (Table 19). The non-Hispanic white population's rate was 1.2 times that for the Hispanic population, and the rate for the non-Hispanic black population was 2.7 times that for the Hispanic population (Table 20).

Fall—In 2007, 23,443 persons died as the result of falls, 12.8 percent of all injury deaths (Table 18). The overwhelming majority of fall-related deaths (96.5 percent) were unintentional. In 2007, the age-adjusted death rate for falls increased significantly over 2006 (34) by 5.8 percent, from 6.9 deaths per 100,000 U.S. standard population to 7.3.

Drug-induced mortality

In 2007, a total of 38,371 persons died of drug-induced causes in the United States (Tables 21 and 22). This category includes not only deaths from dependent and nondependent use of legal or illegal drugs, but also poisoning from medically prescribed and other drugs. It excludes unintentional injuries, homicides, and other causes indirectly related to drug use, as well as newborn deaths due to the mother's drug use (for a list of drug-induced causes, see ''Technical Notes''). For males in 2007, the age-adjusted death rate for drug-induced causes was 1.7 times the rate for females. The age-adjusted death rate for black females was 28.4 percent lower than the rate for white females, and the rate for black males was 8.9 percent lower than the rate for white males. The age-adjusted death rate for the API population was 85.3 percent lower

than that for the white population (Table 21). Compared with the rate for the Hispanic population, the rate for the non-Hispanic white population was 2.3 times higher, and that for the non-Hispanic black population was 1.8 times higher (Table 22). In 2007, the age-adjusted death rate for drug-induced causes remained unchanged statistically from 2006. Among the major race-sex and race-ethnic-sex groups during the same period, the age-adjusted death rate for drug-induced causes decreased by 3.7 percent for males, 18.5 percent for black males, 22.7 percent for AIAN males, 23.3 percent for API males, 7.8 percent for Hispanic males, and 12.8 percent for Hispanic females (Table 21). The age-adjusted death rate increased significantly by 3.3 percent for all females, 4.1 percent for white females, and 5.6 percent for Non-Hispanic white females.

Alcohol-induced mortality

In 2007, a total of 23,199 persons died of alcohol-induced causes in the United States, 1,126 more deaths than in 2006 (Tables 23 and 24). This category includes not only deaths from dependent and nondependent use of alcohol, but also accidental poisoning by alcohol. It excludes unintentional injuries, homicides, and other causes indirectly related to alcohol use, as well as deaths due to fetal alcohol syndrome (for a list of alcohol-induced causes, see ‘‘Technical Notes’’). In 2007, the age-adjusted death rate for alcohol-induced causes for males was 3.2 times the rate for females. Compared with the rate for the white population, the rate for the black population was 16.0 percent lower; AIAN, 3.5 times higher; and API, 76.0 percent lower. The rate for the Hispanic population was 1.3 times the rate for the non-Hispanic white population and 1.4 times the rate for the non-Hispanic black population (Tables 23 and 24). During 2006–2007, the age-adjusted death rate for alcohol-induced causes for the total population increased by 4.3 percent from 7.0 per 100,000 U.S. standard population in 2006 to 7.3 per 100,000 U.S. standard population in 2007. The age-adjusted death rates increased significantly for non-Hispanic white males (3.8 percent) and non-Hispanic white females (5.6 percent). Increase in age-adjusted death rates for black males and non-Hispanic males was not statistically significant. No statistically significant changes were observed for other major race-sex and race-ethnic-sex groups.

Marital status

For those aged 15 years and over, the number of deaths in 2007 among persons who were married was 917,839; widowed, 879,173; divorced, 313,863; and never married, 260,281 (Table 25); see ‘‘Technical Notes.’’ Those who never married had the highest age-adjusted death rate (1,780.4 per 100,000 U.S. standard population), followed by divorced persons (1,643.8), widowed persons (1,570.7), and married persons (828.3). The never-married group had an age-adjusted death rate 60.5 percent higher than those who were ever married and 2.1 times the rate for the currently married. The age-adjusted death rate for widowed persons was 89.6 percent higher than that for persons who were currently married at the time of death. Divorced persons had a rate 98.5 percent higher than those who were married at the time of death.

For all age groups 15 years and over, age-specific death rates for married persons were much lower than those for never-married persons. For those aged 15–24 years, divorced persons had the highest death rate, whereas for those aged 25–34 years, widowed persons had the highest death rate. Never-married persons had the highest death rate among those aged 35–44 years, 45–54 years, 55–64 years, 65–74 years, and 75 years and over.

For each marital status group in 2007, males had higher age-adjusted death rates than females, ranging from 36.6 percent greater for the never married to 69.6 percent greater for those married at the time of death.

Educational attainment

Age-specific and age-adjusted death rates are shown by educational attainment for age groups in the range of 25–64 years (Table 26). Figures for states that used the 2003 version of the standard death certificate are shown separately from those for states that used the 1989 version of the death certificate (see ‘‘Technical Notes’’). In the District of Columbia and the 22 reporting states that used the 2003 version of the death certificate in 2007, a total of 126,184 decedents aged 25–64 years had received a high school diploma or equivalent, compared with 109,248 who had completed some college or collegiate degree and 60,991 who had achieved less than a high school diploma or equivalent. For the total population, and for males and females separately, mortality is inversely associated with educational attainment; that is, the average risk of death decreases markedly with increasing educational attainment. The age-adjusted death rate

for those with less than a high school diploma or equivalent was 529.5 per 100,000 U.S. standard population—14.1 percent higher than the rate of 463.9 for those with a high school diploma or equivalent and 2.7 times the rate of 196.7 for those with some college or collegiate degree.

For the 26 reporting states that used the 1989 version of the death certificate, a total of 115,327 decedents aged 25–64 years had completed 12 years of education, compared with 81,214 who had completed 13 years or more and 53,458 who had completed less than 12 years. The age-adjusted death rate for those with less than 12 years of education was 664.4 per 100,000 U.S. standard population— 39.3 percent higher than the rate of 477.0 for those with 12 years of education and 3.4 times the rate of 195.4 for those with 13 years of education or more.

Rates are shown only for those aged 25–64 years because persons under age 25 years may not have completed their education. Rates are not shown for older ages because of misreporting of educational attainment on the death certificate; see ‘‘Technical Notes.’’ Data on educational attainment must be interpreted with caution because of misreporting on the death certificate and biases that result from differences between the classification of educational attainment on the death certificate and in census surveys; see ‘‘Technical Notes.’’

Injury at work

For persons aged 15 years and over, a total of 5,025 deaths were reported on death certificates as due to injuries at work (Table 27) in 2007. Rates were lowest for age groups 15–24 years and 65 years and over. The risk of work-related death was much greater for males than for females—the age-adjusted death rate for males was 3.9 deaths per 100,000 U.S. standard population compared with 0.3 for females, resulting in a mortality ratio of about 13 to 1. The age-adjusted rate for the white population, 2.1, was slightly higher than the rate for the black population at 2.0. Male-to-female ratios for the white and black populations were 13.3 and 9.5, respectively.

The number of deaths due to injuries at work decreased by 273 deaths in 2007 over 2006. The age-adjusted death rate from injury at work for the population aged 15 years and over decreased 4.5 percent in 2007 over the year before (Table 28). For specific sex and race groups, the age-adjusted death rate decreased for white males (7.0 percent) and did not change for white females, black males and females.

State of residence

Mortality patterns vary considerably by state (Table 29). The state with the highest age-adjusted death rate in 2007 was West Virginia (951.7 per 100,000 U.S. standard population), with a rate 25.2 percent above the national average (760.2). The state with the lowest age-adjusted death rate was Hawaii (607.4 per 100,000 standard population), with a rate 20.1 percent below the national average. The age-adjusted death rate for West Virginia was 56.7 percent higher than the rate for Hawaii.

Variations in mortality by state are associated with differences in socioeconomic status, race, and ethnic composition as well as differences in risk for specific causes of death (35).

Infant mortality

In 2007, a total of 29,138 deaths occurred in children under 1 year (Table D), 611 more deaths than in 2006. The infant mortality rate was 6.75 per 1,000 live births, the neonatal mortality rate (deaths of infants aged 0–27 days per 1,000 live births) was 4.41, and the postneonatal mortality rate (deaths of infants aged 28 days–1 year per 1,000 live births) was 2.33 in 2007 (Table 30 and Figure 7); see ''Technical Notes'' for information on alternative data sources. The year-to-year change in the infant and neonatal mortality rate during 2006–2007 was not statistically significant; however, the postneonatal mortality rate increased 4.0 percent from 2.24 in 2006 to 2.33 in 2007 for all races combined. Rates also increased significantly for male postneonates (4.0 percent), female postneonates (4.5 percent), and white postneonates (5.4 percent).

The 10 leading causes of infant death in 2007 accounted for 69.0 percent of all infant deaths in the United States (Table E). By rank, the 10 leading causes were:

1. Congenital malformations, deformations and chromosomal abnormalities (congenital malformations)
2. Disorders related to short gestation and low birth weight, not elsewhere classified (low birthweight)
3. Sudden infant death syndrome (SIDS)
4. Newborn affected by maternal complications of pregnancy (maternal complications)

5. Accidents (unintentional injuries)
6. Newborn affected by complications of placenta, cord and membranes (cord and placental complications)
7. Bacterial sepsis of newborn
8. Respiratory distress of newborn
9. Diseases of the circulatory system
10. Neonatal hemorrhage

The 10 leading causes were the same in 2007 as in 2006 (34) with the exception of Respiratory distress of newborn, Bacterial sepsis of newborn, Neonatal hemorrhage, and Diseases of the circulatory system. Respiratory distress of newborn became the 7th leading cause in 2007 rising from 8th in 2006 and Bacterial sepsis of newborn became the 8th leading cause in 2007 dropping from 7th in 2006. Neonatal hemorrhage became the 10th leading cause in 2007 and Diseases of the circulatory system became the 9th leading cause in 2007.

Changes in rates by cause of death among the 10 leading causes were statistically significant for only two conditions. In 2007, unintentional injuries increased by 10.8 percent and Diseases of the circulatory system increased by 14.2 percent from 2006 (Table E).

The ratio of male-to-female and black-to-white infant mortality rates were 1.2 and 2.4, respectively, in 2007—the same as in 2006 (Table 30). Race cited on the death certificate is considered to be relatively accurate for white and black infants (16). For other race groups, however, race may be misreported on the death certificate (36); the reader is directed to a forthcoming report using data from the linked file of live births and infant deaths for better measures of infant mortality by race (37); see ''Technical Notes.''

Hispanic infant mortality—In 2007, the infant mortality rates for Hispanic infants and non-Hispanic white infants were 5.70 and 5.63 deaths per 1,000 live births, respectively (data not shown). Among Hispanic subgroups, the infant mortality rate was 7.99 per 1,000 live births for Puerto Rican, 5.86 for Mexican, 4.59 for Cuban, and 3.24 for Central and South American infants. In 2007 from 2006, mortality rates for Mexican infants decreased by 10.5 percent whereas for Central and South American infants they increased by 14.1 percent. The postneonatal mortality rate for Hispanic population increased by 9.9 percent. No other Hispanic infant mortality rates changed by a statistically significant amount during 2006-2007. Infant mortality rates by specified Hispanic origin and race for non-Hispanic origin are somewhat

understated and better measured using data from the linked file of live births and infant deaths (36); see ‘‘Technical Notes.’’

Maternal mortality

In 2007, a total of 548 women were reported to have died of maternal causes (Tables 33 and 34). As in previous years, the number of maternal deaths does not include all deaths occurring to pregnant women, but only those deaths reported on the death certificate that were assigned to causes related to or aggravated by pregnancy or pregnancy management (ICD–10 codes A34, O00-O95, and O98-O99). Further, the number excludes deaths occurring more than 42 days after the termination of pregnancy and deaths of pregnant women due to external causes (unintentional injuries, homicides, and suicides) (6). An increasing number of states are adopting a separate item on the death certificate indicating pregnancy status of the decedent to improve measurement; see ‘‘Technical Notes.’’ The number of areas with such an item has increased from 16 states in 1996 to 34 states and the District of Columbia in 2007. The maternal mortality rate for 2007 was 12.7 deaths per 100,000 live births. Black women have a substantially higher risk of maternal death than white women. The maternal mortality rate for black women was 26.5, roughly 2.7 times the rate for white women (10.0 deaths per 100,000 live births).

Hispanic maternal mortality—The maternal mortality rate for Hispanic women was 8.9 deaths per 100,000 live births. The non-Hispanic-white maternal mortality rate was 10.5 in 2007. The difference between the Hispanic and non-Hispanic white rates was not statistically significant. As with other statistics involving Hispanic origin, these should be interpreted with caution because of inconsistencies between reporting Hispanic origin on death certificates and on censuses and surveys; see ‘‘Technical Notes.’’

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Technical Notes

Nature and sources of data

Data in this report are based on information from all death certificates filed in the 50 states and the District of Columbia and are processed by the Centers for Disease Control and Prevention's National Center for Health Statistics (NCHS). Data for 2007 are based on records of deaths that occurred during 2007 and were received as of October 28, 2009. Missing from the 2007 data file are approximately 200 deaths that occurred in Allen Parish, Louisiana but were not registered with the Louisiana state office. The registration problem began in 2006 when approximately 150 deaths that occurred in Allen Parish were not registered with the state office for that year.

The U.S. Standard Certificate of Death—which is used as a model by the states—was revised in 2003 (38). Prior to 2003, the Standard Certificate of Death had not been revised since 1989. This report includes data for the 23 states (California, Connecticut, Delaware, Florida, Idaho, Kansas, Michigan, Montana, Nebraska, New Hampshire, New Jersey, New Mexico, New York, Ohio, Oklahoma, Oregon, Rhode Island, South Carolina, South Dakota, Texas, Utah, Washington, and Wyoming) and the District of Columbia that used the 2003 revision of the U.S. Standard Certificate of Death in 2007, and for the remaining 27 states that collected and reported death data in 2007 based on the 1989 revision of the U.S. Standard Certificate of Death. The 1989 and 2003 revisions are described in detail elsewhere (38–41).

Because most of the items presented in this report appear largely comparable despite changes to item wording and format in the 2003 death certificate revision, data from both groups of states are combined unless otherwise stated. Data for Puerto Rico, the Virgin Islands, Guam, American Samoa, and the Northern Marianas are included in tables showing data by state, but are not included in U.S. totals.

Mortality statistics are based on information coded by the states and provided to NCHS through the Vital Statistics Cooperative Program and from copies of original certificates received by NCHS from state registration offices. In 2007, all the states and the District of Columbia participated in this program and submitted part or all of the mortality data for 2007 in electronic data files to NCHS. All areas provided precoded medical (cause-of-death) data to NCHS except Nebraska, New Jersey, and West Virginia. For 2007, all states submitted precoded demographic data for all deaths.

Data for the entire United States refer to events occurring within the United States. Data shown for geographic areas are by place of residence. Beginning with 1970, mortality statistics for the United States exclude deaths of nonresidents of the United States. All data exclude fetal deaths.

Mortality statistics for Puerto Rico, Virgin Islands, American Samoa, and Northern Marianas exclude deaths of nonresidents for each area. For Guam, however, mortality statistics exclude deaths that occurred to a resident of any place other than Guam or the United States.

Cause-of-death classification

The mortality statistics presented in this report were compiled in accordance with World Health Organization (WHO) regulations, which specify that member nations classify and code causes of death in accordance with the current revision of the *International Classification of Diseases* (ICD). The ICD provides the basic guidance used in virtually all countries to code and classify causes of death. Effective with deaths occurring in 1999, the United States began using the Tenth Revision of this classification (ICD–10) (42). In 2004, the second edition of ICD–10 was adopted (6). For earlier years, causes of death were classified according to the revisions then in use— 1979–1998, Ninth Revision; 1968–1978, Eighth Revision, adapted for use in the United States; 1958–1967, Seventh Revision; and 1949–1957, Sixth Revision.

Changes in classification of causes of death due to these revisions may result in discontinuities in cause-of-death trends. Consequently, cause-of-death comparisons among revisions require consideration of comparability ratios and, where available, estimates of their standard errors. Comparability ratios between the Ninth and Tenth revisions, Eighth and Ninth revisions, Seventh and Eighth revisions, and Sixth and Seventh revisions may be found in other NCHS reports and independent tabulations (23–25,43–45).

Rules for coding a cause or causes of death may sometimes require modification when evidence suggests it will improve the quality of cause-of-death data. Prior to 1999, such modifications were made only when a new ICD revision was implemented. A process for updating the ICD was introduced with ICD–10 that allows for midrevision changes. These changes, however, may affect comparability of data between years for select causes of death. Minor changes may be implemented every year, whereas major changes may be implemented every three years (e.g., 2006 data year). In data year 2007, minor changes were implemented; these are discussed in subsequent sections of this report.

The ICD not only details disease classification but also provides definitions, tabulation lists, the format of the death certificate, and the rules for coding cause of death. Cause-of-death data presented in this publication were coded by procedures outlined in annual issues of the *NCHS Instruction Manual* (46,47). The ICD includes rules for selecting the underlying cause of death and regulations on the use of the ICD.

Before data year 1968, mortality medical data were based on manual coding of an underlying cause of death for each certificate in accordance with WHO rules. Effective with data year 1968, NCHS converted to computerized coding of the underlying cause and manual coding of all causes (multiple causes) on the death certificate. In this system, called ‘‘Automated Classification of Medical Entities’’ (ACME) (48), multiple-cause codes are input to computer software that uses WHO rules to select the underlying cause. All cause-of-death data in this report are coded using ACME.

The ACME system is used to select the underlying cause of death for all death certificates in the United States. In addition, NCHS has developed two computer systems as inputs to ACME. Beginning with 1990 data, the Mortality Medical Indexing, Classification, and Retrieval system (MICAR) (49,50) was introduced to automate the coding of multiple causes of death. In addition, MICAR provides more detailed information on the conditions reported on

death certificates than is available through the ICD code structure. Beginning with data year 1993, SuperMICAR, an enhancement of the MICAR system, was introduced, allowing for literal entry of the multiple cause-of-death text as reported by the certifier. This information is then automatically processed by the MICAR and ACME computer systems. Records that cannot be automatically processed by MICAR or SuperMICAR are manually multiple-cause coded and then further processed through ACME. In 2007, SuperMICAR was used to process all of the nation's death records.

In this report, tabulations of cause-of-death statistics are based solely on the underlying cause of death. The underlying cause is defined by WHO 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'' (6). The underlying cause is selected from the conditions entered by the physician in the cause of-death section of the death certificate. When more than one cause or condition is entered by the physician, the underlying cause is determined by the sequence of conditions on the certificate, provisions of the ICD, and associated selection rules and modifications. Generally, more medical information is reported on death certificates than is directly reflected in the underlying cause of death. This is captured in NCHS multiple cause-of-death statistics (51–53).

Tabulation lists and cause-of-death ranking

Tabulation lists for ICD–10 are published in the *NCHS Instruction Manual*, Part 9, ''ICD–10 Cause-of-Death Lists for Tabulating Mortality Statistics'' (Updated October 2007 to include WHO updates to ICD-10 for data year 2007) (54). For this report, two tabulation lists are used: the List of 113 Selected Causes of Death, used for deaths of all ages, and the List of 130 Selected Causes of Infant Death, used for infants. These lists are also used to rank leading causes of death for the two population groups. For the List of 113 Selected Causes of Death, the group titles of Major cardiovascular diseases (ICD–10 codes I00–I78), and Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (ICD–10 codes R00–R99), are not ranked. In addition, category titles that begin with the words ''other'' and ''all other'' are not ranked to determine the leading causes of death. When one of the titles that represents a subtotal is ranked—for example, Tuberculosis (ICD–10 codes A16–A19)—its component parts

are not ranked—in this case, Respiratory tuberculosis (ICD–10 code A16) and Other tuberculosis (ICD–10 codes A17–A19). For the List of 130 Selected Causes of Infant Death, the same ranking procedures are used except that the category of major cardiovascular diseases is not on the list. More detail regarding ranking procedures can be found in ‘‘Deaths: Leading Causes for 2007’’ (3).

Leading cause-of-death trends discussed in this report are based on cause-of-death data according to ICD–10 for 1999–2007 and ICD–9 for the most comparable cause-of-death titles for 1979–1998. Tables showing ICD–9 categories that are comparable to ICD–10 titles in the List of 113 Selected Causes of Death may be found in ‘‘Comparability of Cause of Death Between ICD–9 and ICD–10: Preliminary Estimates’’ (25) and ‘‘Deaths: Final Data for 1999’’ (22). Although in some cases categories from the List of 113 Selected Causes of Death are identical to those in the earlier List of 72 Selected Causes of Death used with ICD–9, caution must be used because many of these categories are not comparable even though the cause-of-death titles may be the same.

Trend data for 1979–1998 that are classified by ICD–9 but sorted into the List of 113 Selected Causes of Death developed for ICD–10 can be found on the mortality website at http://www.cdc.gov/nchs/data/statab/hist001r.pdf.

Revision of the ICD and resulting changes in classification and rules for selecting the underlying cause of death have important implications for the analysis of mortality trends by cause of death. For some causes of death, the discontinuity in trend can be substantial (24,25). Therefore, considerable caution should be used in analyzing cause-of-death trends for periods of time that extend across more than one revision of the ICD.

Codes added and deleted in 2007

Effective with data year 2007, four new ICD–10 codes were added as valid, underlying cause-of-death codes. These are J09, Influenza due to identified avian influenza virus; U04.9, Severe acute respiratory syndrome [SARS], unspecified; X59.0, Exposure to unspecified factor causing fracture; X59.9, Exposure to unspecified factor causing other and unspecified injury.

In 2007, no deaths were assigned to ICD–10 codes J09 or U04.9. New ICD–10 codes X59.0 and X59.9 provide more detail for ICD-10 code X59, Exposure to unspecified factor.

Beginning in 2007, ICD–10 code X59 represents the subtotal of ICD–10 codes X59.0 and X59.9, but is no longer selected as a three digit underlying cause-of-death code. Deleted from the list of valid underlying cause-of-death codes in 2007 was ICD-10 code F10.0, Mental and behavioral disorders due to use of alcohol, acute intoxication.

In 2007, several changes were made to the 113 causes of death list to reflect the addition of the new codes. With the addition of new ICD-10 code J09, Influenza due to identified avian influenza virus, ICD-10 codes were changed from J10-J18 to J09-J18 for "Influenza and pneumonia, and from J10-J11 to J09-J11 for "Influenza." With the addition of new ICD-10 code U04.9, Severe acute respiratory syndrome [SARS], ICD-10 codes were changed from J20-J22 to J20-J22,U04 for "Other acute lower respiratory infections". Also, category title "Unspecified acute lower respiratory infection" was changed to "Other and unspecified acute lower respiratory infections" and the codes for this cause were changed from J22 to J22,U04 (54).

Changes in 2007 were also made to the list of 130 causes of infant death to reflect the addition of the new codes. With the addition of new ICD-10 code U04.9, ICD-10 codes were changed from J00-J98 to J00-J98,U04 for "Diseases of the respiratory system", and U04 was added to the ICD-10 codes for "Other and unspecified diseases of respiratory system." With the addition of new ICD-10 code J09, Influenza due to identified avian influenza virus, ICD-10 codes were changed from J10-J18 to J09-J18 for "Influenza and pneumonia, and from J10-J11 to J09-J11 for "Influenza" (54).

Codes for terrorism

Beginning with data for 2001, NCHS introduced categories *U01–*U03 for classifying and coding deaths due to acts of terrorism. The asterisks before the category codes indicate that they are not part of the ICD–10. Deaths classified to the terrorism categories are included in the 113 causes of death list in the categories for Assault (homicide) and Intentional self-harm (suicide), and in the 130 causes of death list for infants in the category for Assault (homicide). Additional information on these new categories can be found at

http://www.cdc.gov/nchs/icd/terrorism_code.htm. No deaths were assigned to the terrorism categories in 2007.

Enterocolitis due to Clostridium difficile

The number of deaths from Enterocolitis due to *Clostridium difficile* (*C. difficile*) (ICD–10 code A04.7) has increased dramatically in recent years, from 793 deaths in 1999 to 6,372 deaths in 2007. Data for *C. difficile* are included in tables showing data for 113 selected causes of death in ‘‘Certain other intestinal infections (A04, A07–A09),’’ but were previously not identified separately. Because of the increasing importance of this cause of death, beginning with data year 2006, data for *C. difficile* are shown separately at the bottom of tables showing 113 selected causes, and *C. difficile* has been added to the list of rankable causes.

Quality of reporting and processing cause of death

One index of the quality of reporting causes of death is the proportion of death certificates coded to Chapter XVIII—Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (ICD–10 codes R00–R99). Although deaths occur for which underlying causes are impossible to determine, the proportion coded to R00–R99 indicates the consideration given to the cause-of-death statement by the medical certifier. This proportion also may be used as a rough measure of specificity of medical diagnoses made by the certifier in various areas. In 2007, the percentage of all reported deaths in the United States assigned to Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified, was 1.38 percent, up slightly from 1.31 percent in 2006. Since 2000, the percentage has ranged from 1.23 to 1.38, higher than the percentages in the 1990s which ranged from 1.08 to 1.18 percent.

Rules for coding a cause or causes of death may sometimes require modification when evidence suggests it will improve the quality of cause-of-death data. These changes, however, may affect comparability of data between years for selected causes of death. The implementation of changes in coding rules in 2007 had an impact on several mortality causes—and the comparison of 2007 and 2006 data for these causes—in the following ways:

- The increase in deaths from Anemias (ICD-10 codes D50-D64) between 2006 and 2007 may largely be due to a coding change in 2007. Specifically, more deaths which would have previously been assigned to Congestive heart failure (ICD-10 code I50.0) were instead assigned to Anemia, unspecified (ICD-10 code D64.9).
- The large increase in deaths from Chronic glomerulonephritis, nephritis and nephropathy not specified as acute or chronic, and renal sclerosis unspecified (ICD-10 codes N02-N03,N05-N07,N26) between 2006 and 2007 may mostly be due to a coding change in 2007 that resulted in fewer deaths being assigned to Chronic renal failure, unspecified (ICD-10 code N18.9).
- The increase in Chronic liver disease and cirrhosis (ICD-10 codes K70,K73-K74) between 2006 and 2007 may largely be due to coding change that resulted in more deaths being assigned to Alcoholic liver disease (ICD-10 code K70).
- In 2007, deaths previously assigned to Mental and behavioral disorders due to use of alcohol, acute intoxication.(ICD-10 code F10.0) were instead assigned to Accidental poisoning by and exposure to alcohol (ICD-10 code X45); Intentional self-poisoning (suicide) by and exposure to alcohol (ICD-10 code X65); and Poisoning by and exposure to alcohol, undetermined intent (ICD-10 code Y15).

Rare causes of death

Selected causes of death considered to be of public health concern are routinely confirmed by states according to agreed-upon procedures between state vital statistics programs and the National Center for Health Statistics. These causes, termed infrequent and rare causes of death, are listed in the *NCHS Instruction Manual*, Parts 2a, 11, and 20 (47,55,56).

For data year 2007, complete confirmation of deaths from infrequent and rare causes was not provided by 12 states: Connecticut, Florida, Indiana, Kentucky, Maryland, North Carolina, Oklahoma, Pennsylvania, Rhode Island, South Carolina, Washington, and West Virginia.

Injury mortality by mechanism and intent

Injury mortality data are presented using the external cause of injury mortality matrix for ICD–10 (Table 18). In this framework, cause-of-injury deaths are organized principally by mechanism (e.g., firearm or poisoning), and secondarily by manner or intent of death (e.g., unintentional, suicide, homicide, etc.).

The number of deaths for selected causes in this framework may differ from those shown in tables that use the standard mortality tabulation lists. Following WHO conventions, standard mortality tabulations (Table 10) present external causes of death (ICD–10 codes *U01–*U03 and V01–Y89); in contrast, the matrix (Table 18) excludes deaths classified to Complications of medical and surgical care (ICD–10 codes Y40–Y84 and Y88). For additional information on injury data presented in this framework, see ‘‘Deaths: Injuries, 2002’’ (57) at http://www.cdc.gov/nchs/products/nvsr.htm#vol54. Data for later years are available through CDC’s Wonder system at http://wonder.cdc.gov/ or through CDC’s Web-based Injury Statistics Query and Reporting System (WISQARS) at http://www.cdc.gov/injury/wisqars/index.html. Implementation of changes to ICD-10 may affect the matrix, requiring modification of codes in select categories. For information on the latest ICD–10 external cause-of-injury codes included in the matrix, see http://www.cdc.gov/nchs/injury/injury_tools.htm.

Codes for firearm deaths

Causes of death attributable to firearm mortality include ICD–10 codes *U01.4, Terrorism involving firearms (homicide); W32–W34, Accidental discharge of firearms; X72–X74, Intentional self-harm (suicide) by discharge of firearms; X93–X95, Assault (homicide) by discharge of firearms; Y22–Y24, Discharge of firearms, undetermined intent; and Y35.0, Legal intervention involving firearm discharge. Deaths from injury by firearms exclude deaths due to explosives and other causes indirectly related to firearms.

Codes for drug-induced deaths

Causes of death attributable to drug-induced mortality include ICD–10 codes: D52.1, Drug-induced folate deficiency anemia; D59.0, Drug-induced hemolytic anemia; D59.2, Drug-induced nonautoimmune hemolytic anemia; D61.1, Drug-induced aplastic anemia; D64.2, Secondary sideroblastic anemia due to drugs and toxins; E06.4, Drug-induced thyroiditis; E16.0, Drug-induced hypoglycemia without coma; E23.1, Drug-induced hypopituitarism; E24.2, Drug-induced Cushing's syndrome; E27.3, Drug-induced adrenocortical insufficiency; E66.1, Drug-induced obesity; selected codes from the ICD–10 title of mental and behavioral disorders due to psychoactive substance use, specifically, F11.0–F11.5, F11.7–F11.9, F12.0–F12.5, F12.7–F12.9, F13.0–F13.5, F13.7–F13.9, F14.0–F14.5, F14.7–F14.9, F15.0–F15.5, F15.7–F15.9, F16.0–F16.5, F16.7–F16.9, F17.0, F17.3–F17.5, F17.7–F17.9, F18.0–F18.5, F18.7–F18.9, F19.0–F19.5, F19.7–F19.9; G21.1, Other drug-induced secondary parkinsonism; G24.0, Drug-induced dystonia; G25.1, Drug-induced tremor; G25.4, Drug-induced chorea; G25.6, Drug-induced tics and other tics of organic origin; G44.4, Drug-induced headache, not elsewhere classified; G62.0, Drug-induced polyneuropathy; G72.0, Drug-induced myopathy; I95.2, Hypotension due to drugs; J70.2, Acute drug-induced interstitial lung disorders; J70.3, Chronic drug-induced interstitial lung disorders; J70.4, Drug-induced interstitial lung disorder, unspecified; K85.3, Drug-induced acute pancreatitis; L10.5, Drug-induced pemphigus; L27.0, Generalized skin eruption due to drugs and medicaments; L27.1, Localized skin eruption due to drugs and medicaments; M10.2, Drug-induced gout; M32.0, Drug-induced systemic lupus erythematosus; M80.4, Drug-induced osteoporosis with pathological fracture; M81.4, Drug-induced osteoporosis; M83.5, Other drug-induced osteomalacia in adults; M87.1, Osteonecrosis due to drugs; R50.2, Drug-induced fever; R78.1, Finding of opiate drug in blood; R78.2, Finding of cocaine in blood; R78.3, Finding of hallucinogen in blood; R78.4, Finding of other drugs of addictive potential in blood; R78.5, Finding of psychotropic drug in blood; X40–X44, Accidental poisoning by and exposure to drugs, medicaments and biological substances; X60–X64, Intentional self-poisoning (suicide) by and exposure to drugs, medicaments and biological substances; X85, Assault (homicide) by drugs, medicaments and biological substances; and Y10–Y14, Poisoning by and exposure to drugs, medicaments and biological substances, undetermined intent. Drug-induced causes exclude accidents, homicides, and other causes indirectly related to drug use, as well as newborn deaths associated with the mother's drug use.

Codes for alcohol-induced deaths

Causes of death attributable to alcohol-induced mortality include ICD–10 codes: E24.4, Alcohol-induced pseudo-Cushing's syndrome; F10, Mental and behavioral disorders due to alcohol use; G31.2, Degeneration of nervous system due to alcohol; G62.1, Alcoholic polyneuropathy; G72.1, Alcoholic myopathy; I42.6, Alcoholic cardiomyopathy; K29.2, Alcoholic gastritis; K70, Alcoholic liver disease; K85.2, Alcohol-induced acute pancreatitis; K86.0, Alcohol-induced chronic pancreatitis; R78.0, Finding of alcohol in blood; X45, Accidental poisoning by and exposure to alcohol; X65, Intentional self-poisoning by and exposure to alcohol; and Y15, Poisoning by and exposure to alcohol, undetermined intent. Alcohol-induced causes exclude accidents, homicides, and other causes indirectly related to alcohol use, as well as newborn deaths associated with maternal alcohol use.

Race and Hispanic origin

The 2003 revision of the U.S. Standard Certificate of Death allows the reporting of more than one race (multiple races) (38). This change was implemented to reflect the increasing diversity of the population of the United States and to be consistent with the decennial census. The race and ethnicity items on the revised certificate are compliant with the 1997 ''Revision of the Race and Ethnic Standards for Federal Statistics and Administrative Reporting,'' issued by the Office of Management and Budget (OMB). This revision replaced standards that were issued in 1977 (8). The new standards mandate the collection of more than one race where applicable for federal data (7). In addition, the new certificate is compliant with the OMB-mandated minimum set of five races to be reported for federal data. Multiple race includes any combination of white, black or African American, American Indian or Alaska Native (AIAN), Asian, and Native Hawaiian or Other Pacific Islander (NHOPI). If two or more specific subgroups such as Korean and Chinese are reported, these count as a single race of Asian rather than as multiple races.

The number of states reporting multiple race has increased, from 7 states in 2003 to 27 states and the District of Columbia in 2007:

- In 2003, multiple race was reported on the revised death certificates of California, Idaho, Montana, and New York, as well as on the unrevised certificates of Hawaii, Maine, and Wisconsin.
- In 2004, multiple race was reported for the entire year on the revised death certificates of California, Idaho, Michigan, Montana, New Jersey, New York, Oklahoma, South Dakota, Washington, and Wyoming, as well as on the unrevised certificates of Hawaii, Maine, Minnesota, and Wisconsin. New Hampshire began reporting multiple race in mid-April 2004 upon implementing the revised certificate.
- In 2005, multiple race was reported for the entire year on the revised death certificates of California, Connecticut, Florida, Idaho, Kansas, Michigan, Montana, Nebraska, New Hampshire, New Jersey, New York, Oklahoma, South Carolina, South Dakota, Utah, Washington, and Wyoming as well as on the unrevised certificates of Hawaii, Maine, Minnesota, and Wisconsin. The District of Columbia began reporting multiple race in March 2005 upon implementing the revised certificate.
- In 2006, multiple race was reported on the revised death certificates of California, Connecticut, the District of Columbia, Florida, Idaho, Kansas, Michigan, Montana, Nebraska, New Hampshire, New Jersey, New Mexico, New York, Oklahoma, Oregon, Rhode Island, South Carolina, South Dakota, Texas, Utah, Washington, and Wyoming as well as on the unrevised certificates of Hawaii, Maine, Minnesota, and Wisconsin.
- In 2007, multiple race was reported on the revised death certificates of California, Connecticut, Delaware, the District of Columbia, Florida, Idaho, Kansas, Michigan, Montana, Nebraska, New Hampshire, New Jersey, New Mexico, New York, Ohio, Oklahoma, Oregon, Rhode Island, South Carolina, South Dakota, Texas, Utah, Washington, and Wyoming as well as on the unrevised certificates of Hawaii, Maine, Minnesota, and Wisconsin.

In 2007, more than one race was reported for 0.4 percent of the records in the 27 multiple-race reporting states and the District of Columbia (Table I). Although still uncommon, multiple races were reported more often for younger decedents than for older decedents (2.3

percent of decedents under age 25 years compared with 0.6 percent of decedents aged 25–64 years and 0.2 percent of decedents aged 65 years and over). No decedent was reported as having more than four races. Of those records where more than one race was reported, the NHOPI category was reported in combination with another race (46.3 percent) more often than the other categories (white, 0.4 percent; black, 0.7 percent; Asian, 5.2 percent; and AIAN, 20.0 percent).

Data from the vital records of the 23 states based on the 1989 revision of the U.S. Standard Certificate of Death follow the 1977 OMB standard, allowing only a single race to be reported (8,41). In addition, these states report a minimum set of four races as stipulated in the 1977 standard. These are white, black or African American, American Indian or Alaska Native, and Asian or Pacific Islander (API).

In order to provide uniformity and comparability of data during the transition period, before all or most of the data becomes available in the new multiple-race format, it is necessary to ‘‘bridge’’ the responses of those for whom more than one race was reported (multiple race) to a single race. The bridging procedure is similar to that used to bridge multiracial population estimates (10,11). Multiracial decedents are imputed to a single race (white, black, AIAN, or API) according to their combination of races, Hispanic origin, sex, and age indicated on the death certificate. The imputation procedure is described in detail at http://www.cdc.gov/nchs/data/dvs/Multiple_race_documentation_5-10-04.pdf. Similarly, when calculating infant and maternal mortality rates, multiracial infants are bridged into a single race. The bridging procedure for multiple-race mothers and fathers is based on the procedure used to bridge the multiple-race population estimates (37) (See “*Infant and maternal mortality rates”*).

Race and Hispanic origin are reported separately on the death certificate. Therefore, data shown by race include persons of Hispanic and non-Hispanic origin, and data for Hispanic origin include persons of any race. In this report, unless otherwise specified, deaths of persons of Hispanic origin are included in the totals for each race group—white, black, AIAN, and API—according to the decedent’s race as reported on the death certificate. Data shown for Hispanic persons include all persons of Hispanic origin of any race.

Mortality data for the Hispanic-origin population are based on deaths of residents of all 50 states and the District of Columbia. Data year 1997 was the first year in which mortality data for the Hispanic population were available for the entire United States.

Quality of race and Hispanic origin data—Death rates for Hispanic, AIAN, and API persons should be interpreted with caution because of inconsistencies in reporting Hispanic origin or race on the death certificate as compared with censuses, surveys, and birth certificates. Studies have shown underreporting on death certificates of AIAN, API, and Hispanic decedents, as well as undercounts of these groups in censuses (16,18,58,59).

A number of studies have been conducted on the reliability of race reported on the death certificate by comparing it with race reported on another data collection instrument, such as the census or a survey (16,18,58,59). Inconsistencies may arise because of differences in who provides race information on the compared records. Race information on the death certificate is reported by a funeral director as provided by an informant or, in the absence of an informant, on the basis of observation. In contrast, race on the census or the Current Population Survey (CPS) is obtained while the individual is alive; in these cases, race is self-reported or reported by another member of the household familiar with the individual and, therefore, may be considered more valid. A high level of agreement between the death certificate and the census or survey report is essential to assure unbiased death rates by race.

Studies (16,18,58,59) show that a person self-reported as AIAN or API on census or survey records was sometimes reported as white on the death certificate. The net effect of misclassification is an underestimation of deaths and death rates for races other than white and black. In addition, undercoverage of minority groups in the census and resultant population estimates introduces biases into death rates by race (16,18,58–61). Unlike the 1990 census, coverage error in the 2000 census was found to be statistically significant only for the non-Hispanic white population (overcounted by approximately 1.13 percent) and non-Hispanic black population (undercounted by approximately 1.84 percent) (60).

Using the National Longitudinal Mortality Study, Arias et al. examined the reliability of race and Hispanic origin reported on about 250,000 death certificates compared with that reported on a total of 26 Current Population Surveys conducted by the U.S. Bureau of the Census for 1979–1998 (16,18). Agreement between the two sources was found to be excellent for the white and black populations, both exhibiting CPS to death certificate ratios of 1.00. On the other hand, substantial differences were found for other race groups. The ratio of CPS to death certificates was found to be 1.30 for the AIAN population and 1.07 for the API population, indicating net underreporting on death certificates of 30 percent for AIAN and 7 percent for API.

The ratio of deaths for CPS to death certificates for Hispanics was found to be 1.05, indicating a net underreporting on death certificates for the Hispanic population of 5 percent.

Data on the Central and South American and Other Hispanic origin populations are affected by whether a state submits literal text to NCHS, thereby making it possible to identify decedents as being of Central and South American origin.

Other races and race not stated—Beginning in 1992, all records coded as ''other races'' (0.36 percent of total deaths in 2007) were assigned to the specified race of the previous record. Records for which race was unknown, not stated, or not classifiable (0.17 percent) were assigned the racial designation of the previous record.

Infant and maternal mortality rates—For 1989–2007, as in previous years, infant and maternal deaths continue to be tabulated by the race of the decedent. However, beginning with the 1989 data year, the method of tabulating live births by race was changed from race of parents to race of mother, as stated on the birth certificate. This change affects infant and maternal mortality rates because live births are the denominators of these rates (40,62). To improve continuity and ease of interpretation, trend data by race in this report have been retabulated by race of mother for all years beginning with the 1980 data year.

Quantitatively, the change in the basis for tabulating live births by race of mother results in more white births and fewer black births and births of other races. Consequently, infant and maternal mortality rates under the new tabulating procedure tend to be about 2 percent lower for white infants and about 5 percent higher for black infants than when they are computed by the previous method of tabulating live births by race of parents. Rates for most other minority races also are higher when computed by race of mother (63,64).

In 2007, multiple race was reported on the revised birth certificates of California, Colorado, Delaware, Florida, Georgia (for births occurring after January 1 only), Idaho, Indiana, Iowa, Kansas, Kentucky, Michigan (for births at most facilities), Nebraska, New Hampshire, New York state (excluding New York City), North Dakota, Ohio, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Vermont, Washington, and Wyoming, and on the unrevised birth certificates of Hawaii, Minnesota, and Utah (65).

Infant mortality rates for the Hispanic-origin population are based on numbers of resident infant deaths reported to be of Hispanic origin and numbers of resident live births by Hispanic origin of mother for the United States. In computing infant mortality rates, deaths and live births

of unknown origin are not distributed among the specified Hispanic and non-Hispanic groups. In the United States in 2007, the percentage of infant deaths of unknown origin was 0.6 percent and the percentage of live births to mothers of unknown origin was 0.7 percent.

Small numbers of infant deaths for specific Hispanic-origin groups result in infant mortality rates subject to relatively large random variation (see ‘‘Random variation’’). Infant mortality rates by Hispanic origin are less subject to reporting error when based on linked files of infant deaths and live births (36,37).

Infant mortality rates calculated from the general mortality file for specified race and Hispanic origin contain errors because of reporting problems that affect the classification of race and Hispanic origin on the birth and death certificates for the same infant. Infant mortality rates by specified race and Hispanic origin are more accurate when based on the linked file of infant deaths and live births (36,37). The linked file computes infant mortality rates using the race and Hispanic origin of the mother from the birth certificate in both the numerator and denominator of the rate. In addition, the mother’s race and Hispanic origin from the birth certificate is considered to be more accurately reported than the infant’s race and Hispanic origin from the death certificate—on the birth certificate, race is generally reported by the mother at the time of delivery, whereas on the death certificate, the infant’s race and Hispanic origin is reported by an informant, usually the mother but sometimes the funeral director. Estimates of reporting errors have been made by comparing rates based on the linked files with those in which the infant’s race is based on information from the death certificate (36,58).

Life tables

The life table provides a comprehensive measure of the effect of mortality on life expectancy. It is composed of sets of values showing the mortality experience of a hypothetical group of infants born at the same time and subject throughout their lifetime to the age-specific death rates of a particular time period, usually a given year. Prior to data year 1997, U.S. life tables were abridged and constructed by reference to a standard table (63). In addition, the age range for these life tables was limited to 5-year age groups ending with the age group 85 years and over. Beginning with final data reported for 1997, the life table methodology was changed

from previous annual reports, with a revised methodology used for 1997–1999 data and a newly revised methodology for 2000–2007 data.

For data years 1997–1999, complete life tables were constructed by single years of age extending to age 100 years (66) using a revised methodology similar to that of the 1989–1991 decennial life tables (67). The revised methodology offers comparability with decennial life table methodology, greater accuracy, and greater age detail. A comparison of the two methods shows small differences in resulting values for life expectancy (66). Although the revised method produces complete life tables (by single years of age), the life table data shown in this report are summarized in 5-year age groupings. To calculate the probability of dying at each age, the revised methodology used vital statistics death rates for ages under 85 years, and mortality data from the Medicare program for ages 85 years and over. The Medicare data are shown to be significantly more reliable than vital statistics data when modeling the probability of dying at the oldest ages (68).

Life table data shown in this report for data years 2000–2007 are based on the newly revised methodology and may differ from figures previously published. Complete life tables by single years of age extending to age 100 years were constructed using a methodology similar to that developed for the 1999–2001 decennial life tables (69). To calculate the probability of dying at each age, the newly revised methodology used vital statistics death rates for ages under 66 years, and modeled probabilities of death for ages 66 to 100 years based on blended vital statistics and Medicare probabilities of dying (69). The newly revised methodology, along with a more comprehensive description of the methodology, was published in United States Life Tables, 2005 NVSR Volume 58, Number 10. See http://www.cdc.gov/nchs/data/nvsr/nvsr58/nvsr58_10.pdf for additional information.

Causes of death contributing to changes in life expectancy

A life table partitioning technique was used to estimate causes of death contributing to changes in life expectancy in this report. The method partitions changes into component additive parts and identifies the causes of death having the greatest influence, positive or negative, on changes in life expectancy (17,70,71).

Marital status

Age-specific and age-adjusted death rates by marital status are shown by sex in Table 25. Mortality data by marital status are generally of high quality. A study of death certificate data using the 1986 National Mortality Followback Survey showed a high level of consistency in reporting marital status (61). Age-adjusted death rates by marital status were computed based on age-specific rates and the standard population for those aged 25 years and over. Although age-specific death rates by marital status are shown for the age group 15–24 years, they are not included in the computation of the age-adjusted rate because of their high variability, particularly for the widowed population. Furthermore, the age groups 75–84 years and 85 years and over are combined because of high variability in death rates among those aged 85 years and over, particularly for the never-married population.

Educational attainment

Beginning in 2003, some registration areas adopted the new Standard Certificate of Death, which includes a revised educational attainment item, replacing the 1989 version which had focused on highest school grade completed. Neither the new nor old item captures vocational training. The change establishes consistency with Census Bureau data to improve the ability to identify specific degrees and persons who had completed 12 years of education but did not hold either a high school diploma or General Educational Development (GED) high school equivalency diploma. The previous item also had been used inappropriately and inaccurately to infer degree status. Based on testing by the U.S. Census Bureau, the new item identifies about 2 percent more persons with less than a high school diploma or equivalent, 13 percent fewer persons with a high school diploma, and 8 percent more persons with at least some college (72). In 2007, the District of Columbia and 22 states used the revised item: California, Connecticut, Delaware, Florida, Idaho, Kansas, Michigan, Montana, Nebraska, New Hampshire, New Jersey, New Mexico, New York, Ohio, Oklahoma, Oregon, South Carolina, South Dakota, Texas, Utah, Washington, and Wyoming. The unrevised education item continued to be used by 26 states: Alabama, Alaska, Arizona, Arkansas, Colorado, Hawaii, Illinois, Indiana, Iowa, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Minnesota, Mississippi, Missouri, Nevada, North

Carolina, North Dakota, Pennsylvania, Tennessee, Vermont, Virginia, West Virginia, and Wisconsin.

Table 26 shows mortality data by educational attainment for states using the 2003 version of the standard death certificate and, separately, for states using the 1989 version. Data were approximately 80 percent or more complete on a state-of-occurrence basis. Data for Georgia and Rhode Island were excluded because the educational attainment item was not on their certificates. Age-adjusted death rates by educational attainment were computed based on the age-specific rates and the standard population for those aged 25–64 years. Data for those aged 65 years and over are not shown because reporting quality is poorer at older ages (73).

Rates by educational attainment for states using the unrevised certificate are affected by differences between measurement of education for the numerator, which is based on the number of years of education completed as reported on the 1989 revision of the death certificate, and the denominator, which is based on highest degree completed as reported on the 2000 Census and the Current Population Surveys (72,74).

Table II shows a 2002 to 2007 comparison of the percent distribution of deaths by measures of educational attainment for areas using the revised certificate in 2007. However, South Dakota is excluded from this table because that state first began reporting education in 2004 and has no comparison data for 2002.

Injury at work

Information on deaths attributed to injuries at work is derived from a separate item on the death certificate that asks the medical certifier whether the death resulted from an injury sustained at work. This item is on the death certificate of all states. Number of deaths, age-specific death rates, and age-adjusted death rates for injury at work are shown in Tables 27 and 28. Deaths, crude death rates, and age-adjusted death rates for injury at work are shown for those aged 15 years and over. Age-adjusted death rates for injury at work were computed using age-specific death rates and the 2000 U.S. standard population for those aged 15 years and over; see ‘‘Computing rates.’’

Infant mortality

Infant mortality rates are the most commonly used index for measuring the risk of dying during the first year of life. The rates presented in this report are calculated by dividing the number of infant deaths in a calendar year by the number of live births registered for the same period, and are presented as rates per 1,000 or per 100,000 live births. For final birth figures used in the denominator for infant mortality rates, see ‘‘Births: Final Data for 2007’’ (65). In contrast to infant mortality rates based on live births, infant death rates are based on the estimated population under 1 year of age. Infant death rates that appear in tabulations of age-specific death rates in this report are calculated by dividing the number of infant deaths by the July 1, 2007, population estimate of persons under 1 year of age, based on 2000 census populations. These rates are presented per 100,000 population in this age group. Because of differences in the denominators, infant death rates may differ from infant mortality rates.

Another data source is available for infant mortality—the linked file of live births and infant deaths. Data from this source differs from the infant mortality data presented in this report because the linked file includes only events in which both the birth and the death occur in the United States, and late-filed births. Processing of the linked file allows for further exclusion of infant records due to duplicates and records with additional information that raise questions about an infant’s age. Although the differences are usually minuscule, infant mortality rates based on the linked file tend to be somewhat smaller than those based on data from the general mortality file as presented in this report. The linked file is the preferred source for infant mortality by race because it uses the mother’s self-reported race from the child’s birth certificate (36,37), which is more reliable than the infant’s race listed on the death certificate, and because the numerator and denominator are referring to the same person’s race.

Maternal mortality

Maternal mortality rates are computed on the basis of the number of live births. The maternal mortality rate indicates the likelihood of a pregnant woman dying of maternal causes. The rates are calculated by dividing the number of maternal deaths in a calendar year by the number of live births registered for the same period and are presented as rates per 100,000 live

births. The number of live births used in the denominator is an approximation of the population of pregnant women who are at risk of a maternal death.

Maternal deaths are defined by WHO as ‘‘the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the duration and the site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management, but not from accidental or incidental causes’’ (6). Included in these deaths are ICD–10 codes A34, O00–O95, and O98–O99.

If a state death certificate includes a separate question regarding pregnancy status, a positive response to the question is interpreted as if ‘‘pregnant’’ were reported in Part II of the cause-of-death section of the death certificate. If a specified length of time is not provided by the medical certifier, the pregnancy is assumed to have terminated 42 days or less prior to death. Furthermore, if only indirect maternal causes of death (i.e., a previously existing disease or a disease that developed during pregnancy not due to direct obstetric causes but aggravated by physiological effects of pregnancy) are reported in Part I and pregnancy is reported in either Part I or Part II, the death is classified as a maternal death.

An evaluation study for the 1995–1997 period found that 35 percent more maternal deaths were identified through surveillance efforts than by solely using the death certificate. A number of explanations accounted for the lower ascertainment from death certificates, including lack of information reported in the cause-of-death section, use of fewer sources, and some differences in identification (75). This differential is due, in part, to decreasing changes in the coding of indirect maternal causes under ICD–10 that accounted for a nearly 13 percent increase in maternal deaths compared with ICD–9, and the increasing use of a pregnancy status checkbox on death certificates.

The 2003 revision of the U.S. Standard Certificate of Death introduced a standard question format with categories to take advantage of additional codes available in ICD–10 for deaths with a connection to pregnancy, childbirth, and the puerperium. As states revise their certificates, most are expected to introduce the standard item or replace pre-existing questions with it, allowing for wider adoption of a pregnancy status item nationwide and greater standardization of the particular item used. As of 2007, 34 states and the District of Columbia have a separate question related to pregnancy status of female decedents around the time of their death, and 2 states have a prompt encouraging certifiers to report recent pregnancies on the death

certificate. However, at least six different questions were used in the 34 states, reflecting the mix of states using the 2003 standard format and states with pre-existing questions.

The number of maternal deaths has increased most years since 2003 as a result of direct and indirect effects of inclusion of a pregnancy status item on the 2003 version of the standard death certificate (76). For states that already had a separate question, additional guidance was provided in 2003 for identifying maternal deaths, resulting in more deaths being identified. For states that adopt the standard item, additional information is available for use in identifying maternal deaths.

Population bases for computing rates

Populations used for computing death rates and life tables shown in this report represent the population residing in the United States, enumerated as of April 1 for census years and estimated as of July 1 for all other years. Population estimates used to compute death rates for the United States for 2007 are shown by race for 5-year age groups in Table III and are available by single years of age at http://www.cdc.gov/nchs/nvss/mortality_tables.htm (77).

Population estimates in Table IV for Mexican, Puerto Rican, Cuban, and Other Hispanic populations, and population estimates by marital status in Table V, are based on the Current Population Survey adjusted to resident population control totals for the United States (78) and, as such, are subject to sampling variation; see ‘‘Random variation.’’ The control totals used are 2000-based population estimates for the United States for July 1, 2007 (77).

Population estimates by educational attainment, shown in Table VI, are also based on the Current Population Survey adjusted to resident population control totals (78), and similarly subject to sampling variation (see ‘‘Random variation’’). The control totals used are 2000 based population estimates for July 1, 2007, for the 22 states and District of Columbia that reported mortality data by educational attainment using the 2003 version of the U.S. Standard Certificate of Death, and for the 26 states that reported it using the 1989 version (77).

Population estimates for each state, shown in Table VII, were estimated from state-level postcensal population estimates based on the 2000 census, estimated as of July 1, 2007 (77). Population estimates for Puerto Rico, Virgin Islands, Guam, American Samoa, and Northern Marianas, also shown in Table VII, are based on the 2000 census, estimated as of July 1, 2007

(79). Population estimates for each state and territory are not subject to sampling variation because the sources used in demographic analysis are complete counts.

Death rates shown in this report for 1991–2007 are based on populations consistent with the 2000 census levels (77–87). These estimates were produced under a collaborative arrangement with the U.S. Census Bureau and are based on the 2000 census counts by age, race, and sex, modified for consistency with U.S. Office of Management and Budget race categories as of 1977 and historical categories for death data (8). The modification procedures are described in detail elsewhere (10,11).

Computing rates

Except for infant and maternal mortality rates, rates are on an annual basis per 100,000 estimated population residing in the specified area. Infant and maternal mortality rates are per 1,000 or per 100,000 live births. Comparisons made in the text among rates, unless otherwise specified, are statistically significant at the 0.05 level of significance. Lack of comment in the text about any two rates does not mean that the difference was tested and found not to be significant at this level.

Age-adjusted rates (R') are used to compare relative mortality risks among groups and over time. However, they should be viewed as relative indexes rather than as actual measures of mortality risk. They were computed by the direct method—that is, by applying age-specific death rates (R_i) to the U.S. standard population age distribution (Table VIII):

$$R' = \sum_i \frac{P_{si}}{P_s} R_i$$

where P_{si} is the standard population for age group i and P_s is the total U.S. standard population (all ages combined).

Beginning with the 1999 data year, a new population standard was adopted by NCHS for use in age-adjusting death rates. Based on the projected year 2000 population of the United States, the new standard replaces the 1940 standard population that had been used for over 50 years. The new population standard affects levels of mortality and, to some extent, trends and group comparisons. Of particular note are the effects on race mortality comparisons. For detailed

discussion, see *Age Standardization of Death Rates: Implementation of the Year 2000 Standard* (88). Beginning with 2003 data, the traditional standard million population along with corresponding standard weights to six decimal places were replaced by the projected year 2000 population age distribution (see Table VIII). The effect of the change is negligible and does not significantly affect comparability with age-adjusted rates calculated using the previous method.

All age-adjusted rates shown in this report are based on the 2000 U.S. standard population. The 2000 standard population used for computing age-adjusted rates and standard errors, excluding those by marital status, education, injury at work, and the U.S. territories, is shown in Table VIII.

Age-adjusted rates by marital status were computed by applying the age-specific death rates to the U.S. standard population for those aged 25 years and over. Although age-specific death rates by marital status are shown for the age group 15–24 years, they are not included in the calculation of age-adjusted rates because of their high variability, particularly for the widowed population. Age groups 75–84 and 85 years and over are combined because of high variability in death rates in the 85 years and over age group, particularly for the never-married population. The 2000 standard population used for computing age-adjusted rates and standard errors by marital status is shown in Table IX.

Age-adjusted rates by educational attainment were computed by applying the age-specific death rates to the U.S. standard population for those aged 25–64 years. Data for those aged 65 years and over are not shown because reporting quality is poorer for older ages (74). The year 2000 standard population used for computing age-adjusted rates and standard errors by education is shown in Table X.

Age-adjusted rates for injury at work were computed by applying the age-specific death rates to the U.S. standard population for those aged 15 years and over. The 2000 standard population used for computing age-adjusted rates and standard errors for injury at work is shown in Table XI.

Age-adjusted rates for Puerto Rico, Virgin Islands, Guam, American Samoa, and Northern Marianas were computed by applying the age-specific death rates to the U.S. standard population. Age groups for 75 years and over were combined because population counts were unavailable by age group over 75 years. The 2000 standard population used for computing age-adjusted rates and standard errors for the territories is shown in Table XII.

Using the same standard population, death rates for the total population and for each race-sex group were adjusted separately. The age-adjusted rates were based on 10-year age groups. Age-adjusted death rates are not comparable with crude rates.

Death rates for the Hispanic population are based only on events to persons reported as Hispanic. Rates for non-Hispanic white persons are based on the sum of all events to white decedents reported as non-Hispanic and white decedents with origin not stated. Hispanic origin is not imputed if it is not reported.

Random variation

The mortality data presented in this report, with the exception of data for 1972, are not subject to sampling error. In 1972, mortality data were based on a 50 percent sample of deaths because of resource constraints. Mortality data, even based on complete counts, may be affected by random variation—that is, the number of deaths that actually occurred may be considered as one of a large series of possible results that could have arisen under the same circumstances (89,90). When the number of deaths is small, perhaps fewer than 100, random variation tends to be relatively large. Therefore, considerable caution must be observed in interpreting statistics based on small numbers of deaths.

Measuring random variability—To quantify the random variation associated with mortality statistics, one must make an assumption regarding the appropriate underlying distribution. Deaths, as infrequent events, can be viewed as deriving from a Poisson probability distribution. The Poisson distribution is simple conceptually and computationally, and provides reasonable, conservative variance estimates for mortality statistics when the probability of dying is relatively low (89). Using the properties of the Poisson distribution, the standard error (SE) associated with the number of deaths (D) is:

1. $$SE(D) = \sqrt{\text{var}(D)} = \sqrt{D}$$

where var(D) denotes the variance of D.

The standard error associated with crude and age-specific death rates (R) assumes that the population denominator (P) is a constant and is:

2. $$SE(R) = \sqrt{\text{var}\left(\frac{D}{P}\right)} = \sqrt{\frac{1}{P^2}\text{var}(D)} = \sqrt{\frac{D}{P^2}} = \frac{R}{\sqrt{D}}$$

The coefficient of variation or relative standard error (RSE) is a useful measure of relative variation. The RSE is calculated by dividing the statistic (e.g., number of deaths, death rate) into its standard error and multiplying by 100. For the number of deaths:

$$RSE(D) = 100\frac{SE(D)}{D} = 100\frac{\sqrt{D}}{D} = 100\sqrt{\frac{1}{D}}$$

For crude and age-specific death rates:

$$RSE(R) = 100\frac{SE(R)}{R} = 100\frac{R/\sqrt{D}}{R} = 100\sqrt{\frac{1}{D}}$$

Thus:

3. $$RSE(D) = RSE(R) = 100\sqrt{\frac{1}{D}}$$

The standard error of the age-adjusted death rate (R') is:

4. $$SE(R') = \sqrt{\sum_i \left(\frac{P_{si}}{P_s}\right)^2 \text{var}(R_i)} = \sqrt{\sum_i \left\{\left(\frac{P_{si}}{P_s}\right)^2 \left(\frac{R_i^2}{D_i}\right)\right\}}$$

where:

- R_i is the age-specific rate for the ith age group
- P_{si} is the age-specific standard population for the ith age group from the U.S. standard population age distribution (see Table VIII and age-adjusted death rate under ‘‘Definition of terms’’)
- P_s is the total U.S. standard population (all ages combined)
- D_i is the number of deaths for the ith age group

The RSE for the age-adjusted rate, $RSE(R')$, is calculated by dividing $SE(R')$ from Formula 4 by the age-adjusted death rate, R', and multiplying by 100:

$$RSE(R') = 100\frac{SE(R')}{R'}$$

For tables showing infant and maternal mortality rates based on live births (B) in the denominator, calculation of the standard error assumes random variability in both the numerator and denominator. The standard error for the infant mortality rate (IMR) is:

5. $$SE(IMR) = \sqrt{\frac{\text{var}(D) + IMR * \text{var}(B)}{E(B)^2}} = \sqrt{\frac{D}{B^2} + \frac{D^2}{B^3}}$$

where the number of births, B, is also assumed to be distributed according to a Poisson distribution and $E(B)$ is the expectation of B.

The RSE for the IMR is:

6. $$RSE(IMR) = 100\frac{SE(IMR)}{IMR} = 100\sqrt{\frac{1}{D} + \frac{1}{B}}$$

For maternal mortality rates, Formulas 5 and 6 may be used, substituting the maternal mortality rate for the IMR.

Formulas 1–6 may be used for all tables presented in this report except for death rates and age-adjusted death rates shown in Tables 5, 25, and 26, which are calculated using population figures that are subject to sampling error.

Tables 5, 25, and 26—Death rates for Mexican, Puerto Rican, Cuban, and Other Hispanic populations in Table 5, by marital status in Table 25, and by educational attainment in Table 26 are based on population estimates derived from the Current Population Survey for 2007, and adjusted to resident population control totals. As a result, the rates are subject to sampling variability in the denominator as well as random variability in the numerator.

For crude and age-specific death rates (R), the standard error is calculated as:

7. $$SE(R) = R\sqrt{\frac{1}{D} + 0.67\left(a + \frac{b}{P}\right)}$$

For age-adjusted death rates (R'):

8. $$SE(R') = \sqrt{\sum_i \left\{\left(\frac{P_{si}}{P_s}\right)^2 R_i^2 \left[\frac{1}{D_i} + 0.67\left(a + \frac{b}{P_i}\right)\right]\right\}}$$

where a and b in Formulas 7 and 8 represent parameters presented in Table XIII, which are derived from the CPS data for 2007 and 2008 and vary depending on the subgroup of interest (91,92).

Suppression of unreliable rates—Beginning with 1989 data, an asterisk is shown in place of a crude or age-specific death rate based on fewer than 20 deaths, the equivalent of an RSE of 23 percent or more. The limit of 20 deaths is a convenient, if somewhat arbitrary, benchmark, below which rates are considered to be too statistically unreliable for presentation. For infant and maternal mortality rates, the same threshold of fewer than 20 deaths is used to determine whether an asterisk is presented in place of the rate. For age-adjusted death rates, the suppression criterion is based on the sum of age-specific deaths; i.e., if the sum of the age-specific deaths is less than 20, an asterisk replaces the rate. These procedures are used throughout this report except for death rates shown in Tables 5, 25, and 26.

In Tables 5, 25, and 26, sampling variability in the population denominator has a substantial impact on the overall variability in the death rate. Therefore, the number of deaths in the numerator is not used as the sole suppression factor. RSEs for rates shown in Tables 5, 25, and 26 are derived from Formulas 7 and 8 by dividing the result of Formula 7 by the crude/age-specific rate, and the result of Formula 8 by the age-adjusted rate, and then multiplying by 100. Rates are replaced by asterisks if the calculated RSE is 23 percent or more. In some cases, for smaller population subgroups, the estimated sample population from the CPS may be zero, even though deaths are presented for the subgroups. In these cases, the death rate is incalculable and automatically replaced with an asterisk.

Confidence intervals and statistical tests based on 100 deaths or more—When the number of deaths is large, a normal approximation may be used in calculating confidence intervals and statistical tests. How large, in terms of number of deaths, is to some extent subjective. In general, for crude and age-specific death rates and for infant and maternal mortality rates, the normal approximation performs well when the number of deaths is 100 or greater. For age-adjusted rates, the criterion for use of the normal approximation is somewhat more complicated (63,88,93). Formula 9 is used to calculate 95 percent confidence limits for the death rate when the normal approximation is appropriate:

9. $$L(R) = R - 1.96(SE(R)) \text{ and } U(R) = R + 1.96(SE(R))$$

where $L(R)$ and $U(R)$ are the lower and upper limits of the confidence interval, respectively. The resulting 95 percent confidence interval can be interpreted to mean that the chances are 95 in 100 that the ‘‘true’’ death rate falls between $L(R)$ and $U(R)$. For example, suppose that the crude

death rate for Malignant neoplasms is 186.6 per 100,000 population based on 562,875 deaths. Lower and upper 95 percent confidence limits using Formula 9 are calculated as:

$L(186.6) = 186.6 - 1.96(.25) = 186.1$ and
$U(186.6) = 186.6 + 1.96(.25) = 187.1$

Thus, the chances are 95 in 100 that the true death rate for malignant neoplasms is between 186.2 and 187.0. Formula 9 can also be used to calculate 95 percent confidence intervals for the number of deaths, age-adjusted death rates, infant mortality rates, and other mortality statistics when the normal approximation is appropriate by replacing R with D, R', IMR,etc.

When testing the difference between two rates, R_1 and R_2 (each based on 100 or more deaths), the normal approximation may be used to calculate a test statistic, z, such that:

10. $$z = \frac{R_1 - R_2}{\sqrt{SE(R_1)^2 + SE(R_2)^2}}$$

If $|z| \geq 1.96$, then the difference between the rates is statistically significant at the 0.05 level. If $|z| < 1.96$, then the difference is not statistically significant. Formula 10 can also be used to perform tests for other mortality statistics when the normal approximation is appropriate (when both statistics being compared meet the normal criteria) by replacing R_1 and R_2 with D_1 and D_2, R'_1 and R'_2, etc. For example, suppose that the male age-adjusted death rate for Malignant neoplasms of trachea, bronchus, and lung (lung cancer) is 67.0 per 100,000 U.S. standard population in 2006 (R_1) and 65.1 per 100,000 U.S. standard population in 2007 (R_2). The standard error for each of these figures, SE(R_1) and SE(R_2), is calculated using Formula 4. A test using Formula 10 can determine if the decrease in the age-adjusted rate is statistically significant:

$$z = \frac{67.0 - 65.1}{\sqrt{(0.202)^2 + (0.200)^2}} = 6.68$$

Because $z = 6.68 > 1.96$, the decrease from 2006 to 2007 in the male age-adjusted death rate for lung cancer is statistically significant.

Confidence intervals and statistical tests based on fewer than 100 deaths—When the number of deaths is not large (fewer than 100), the Poisson distribution cannot be approximated by the normal distribution. The normal distribution is symmetrical, with a range from $-\infty$ to $+\infty$. As a result, confidence intervals based on the normal distribution also have this range. The number of deaths or the death rate, however, cannot be less than zero. When the number of deaths is very small, approximating confidence intervals for deaths and death rates using the normal distribution will sometimes produce lower confidence limits that are negative. The Poisson distribution, in contrast, is an asymmetric distribution with zero as a lower bound—confidence limits based on this distribution will never be less than zero. A simple method based on the more general family of gamma distributions, of which the Poisson is a member, can be used to approximate confidence intervals for deaths and death rates when the number of deaths is small (87,92). For more information regarding how the gamma method is derived, see *Derivation of the gamma method* at the end of this section.

Calculations using the gamma method can be made using commonly available spreadsheet programs or statistical software (e.g., Excel, SAS) that include an inverse gamma function. In Excel, the function "gammainv (probability, alpha, beta)" returns values associated with the inverse gamma function for a given probability between 0 and 1. For 95 percent confidence limits, the probability associated with the lower limit is .05/2 = .025 and with the upper limit, 1-(.05/2) = .975. Alpha and beta are parameters associated with the gamma distribution. For the number of deaths and crude and age-specific death rates, alpha = D (the number of deaths) and beta = 1. In Excel, the following formulas can be used to calculate lower and upper 95 percent confidence limits for the number of deaths and crude and age-specific death rates:

$L(D)$ = GAMMAINV(.025, D, 1) and $U(D)$ = GAMMAINV(.975, D+1, 1)

Confidence limits for the death rate are then calculated by dividing $L(D)$ and $U(D)$ by the population (P) at risk of dying (see Formula 17).

Alternatively, 95 percent confidence limits can be estimated using the lower and upper confidence limit factors shown in Table XIV. For the number of deaths, D, and the death rate, R,

11. $L(D) = L \times D$ and $U(D) = U \times D$

12. $L(R) = L \times R$ and $U(R) = U \times R$

where L and U in both formulas are the lower and upper confidence limit factors that correspond to the appropriate number of deaths, D, in Table XIV. For example, suppose that the death rate for AIAN females aged 1–4 years is 46.0 per 100,000 and based on 40 deaths. Applying Formula 12, values for L and U from Table XIV for 40 deaths are multiplied by the death rate, 46.0, such that:

$L(R) = L(46.0) = 0.714415 \times 46.0 = 32.9$ and
$U(R) = U(50.5) = 1.361716 \times 46.0 = 62.6$

These confidence limits indicate that the chances are 95 out of 100 that the actual death rate for AIAN females aged 1–4 years is between 32.9 and 62.6 per 100,000.

Although the calculations are similar, confidence intervals based on small numbers for age-adjusted death rates, infant and maternal mortality rates, and rates that are subject to sampling variability in the denominator are somewhat more complicated (63,88). Refer to the most recent version of the Mortality Technical Appendix for more details at http://www.cdc.gov/nchs/datawh/statab/pubd/ta.htm.

When comparing the difference between two rates (R_1 and R_2), where one or both of the rates are based on fewer than 100 deaths, a comparison of 95 percent confidence intervals may be used as a statistical test. If the 95 percent confidence intervals do not overlap, then the difference can be said to be statistically significant at the 0.05 level. A simple rule of thumb is: If $R_1 > R_2$, then test if $L(R_1) > U(R_2)$, or if $R_2 > R_1$, then test if $L(R_2) > U(R_1)$. Positive tests denote statistical significance at the 0.05 level. For example, suppose that AIAN females aged 1–4 years have a death rate (R_1) of 46.0 based on 40 deaths and API females aged 1–4 years have a death rate (R_2) of 17.9 per 100,000 based on 73 deaths. The 95 percent confidence limits for R_1 and R_2 calculated using Formula 12 would be:

$L(R_1) = L(46.0) = 0.714415 \times 46.0 = 32.9$ and
$U(R_1) = U_1(46.0) = 1.361716 \times 46.0 = 62.6$

$L(R_2)= L(17.9) = 0.783840 \times 17.9 = 14.0$ and

$U(R_2)= U(17.9) = 1.257350 \times 17.9 = 22.5$

Because $R_1 > R_2$ and $L(R_1) > U(R_2)$, it can be concluded that the difference between the death rates for AIAN females aged 1–4 years and API females of the same age is statistically significant at the 0.05 level. That is, taking into account random variability, API females aged 1–4 years have a death rate significantly lower than that for AIAN females of the same age.

This test may also be used to perform tests for other statistics when the normal approximation is not appropriate for one or both of the statistics being compared, by replacing R_1 and R_2 with D_1 and D_2, R'_1 and R'_2, etc.

Users of the method of comparing confidence intervals should be aware that this method is a conservative test for statistical significance—the difference between two rates may, in fact, be statistically significant even though confidence intervals for the two rates overlap (94). Caution should be observed when interpreting a nonsignificant difference between two rates, especially when the lower and upper limits being compared overlap only slightly.

Derivation of the gamma method—For a random variable X that follows a gamma distribution $\Gamma(y,z)$, where y and z are the parameters that determine the shape of the distribution (95), $E(X)= yz$ and $Var(X)= yz^2$. For the number of deaths, D, $E(D) = D$ and $Var(D) = D$. It follows that $y = D$ and $z = 1$, and thus:

13. $D \sim \Gamma(D,1)$

From Equation 13, it is clear that the shape of the distribution of deaths depends only on the number of deaths.

For the death rate, R, $E(R) = R$ and $Var(R) = D/P^2$. It follows, in this case, that $y = D$ and $z = P^{-1}$, and thus:

14. $R \sim \Gamma(D,P^{-1})$

A useful property of the gamma distribution is that for $X \sim \Gamma(y,z)$, X can be divided by z such that $X/z \sim \Gamma(y,1)$. This converts the gamma distribution into a simplified, standard form, dependent only on parameter y. Expressing Equation 14 in its simplified form gives:

15. $R/P^{-1} = D \sim \Gamma(D,1)$

From Equation 15, it is clear that the shape of the distribution of the death rate is also dependent solely on the number of deaths.

Using the results of Equations 13 and 15, the inverse gamma distribution can be used to calculate upper and lower confidence limits. Lower and upper 100(1–α) percent confidence limits for the number of deaths, *L(D)* and *U(D)*, are estimated as:

16. $L(D) = \Gamma^{-1}_{(D,1)}(\alpha / 2)$ and $U(D) = \Gamma^{-1}_{(D+1,1)}(1-\alpha /2)$

where Γ^{-1} represents the inverse of the gamma distribution and D+1 in the formula for *U(D)* reflects a continuity correction, which is necessary because *D* is a discrete random variable and the gamma distribution is a continuous distribution. For a 95 percent confidence interval, $\alpha = .05$. For the death rate, it can be shown that:

17. $L(R) = L(D)/P$ and $U(R) = U(D)/P$

For more detail regarding the derivation of the gamma method and its application to age-adjusted death rates and other mortality statistics, see "References" (63,87,92).

Availability of mortality data

Mortality data are available in publications, unpublished tables, and electronic products as described on the NCHS mortality website at http://www.cdc.gov/nchs/deaths.htm. More detailed analysis than this report provides can be derived from the mortality public-use data set issued each data year. Since 1968, the data set has been available through NCHS in ASCII format and can now be downloaded from

http://www.cdc.gov/nchs/data_access/Vitalstatsonline.htm. Additional resources available from NCHS include *Vital Statistics of the United States*, Mortality; *Vital and Health Statistics*, Series 20 reports; and *National Vital Statistics Reports*.

Definition of terms

Infant deaths—Deaths of infants aged under 1 year.

Neonatal deaths—Deaths of infants aged 0–27 days.

Postneonatal deaths—Deaths of infants aged 28 days–1 year.

Crude death rate—Total deaths per 100,000 population for a specified period. This rate represents the average chance of dying during a specified period for persons in the entire population.

Age-specific death rate—Deaths per 100,000 population in a specified age group, such as 1–4 years or 5–9 years, for a specified period.

Age-adjusted death rate—The death rate used to make comparisons of relative mortality risks across groups and over time. This rate should be viewed as a construct or an index rather than a direct or actual measure of mortality risk. Statistically, it is a weighted average of age-specific death rates, where the weights represent the fixed population proportions by age.

Contents

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