Sudden Cardiac Death in the United States, 1989 to 1998

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Background—Sudden cardiac death (SCD) is a major clinical and public health problem.

Methods and Results—United States (US) vital statistics mortality data from 1989 to 1998 were analyzed. SCD is defined as deaths occurring out of the hospital or in the emergency room or as “dead on arrival” with an underlying cause of death reported as a cardiac disease (ICD-9 code 390 to 398, 402, or 404 to 429). Death rates were calculated for residents of the US aged ≥35 years and standardized to the 2000 US population. Of 719,456 cardiac deaths among adults aged ≥35 years in 1998, 456,076 (63%) were defined as SCD. Among decedents aged 35 to 44 years, 74% of cardiac deaths were SCD. Of all SCDs in 1998, coronary heart disease (ICD-9 codes 410 to 414) was the underlying cause on 62% of death certificates. Death rates for SCD increased with age and were higher in men than women, although there was no difference at age ≥85 years. The black population had higher death rates for SCD than white, American Indian/Alaska Native, or Asian/Pacific Islander populations. The Hispanic population had lower death rates for SCD than the non-Hispanic population. From 1989 to 1998, SCD, as the proportion of all cardiac deaths, increased 12.4% (56.3% to 63.9%), and age-adjusted SCD rates declined 11.7% in men and 5.8% in women. During the same time, age-specific death rates for SCD increased 21% among women aged 35 to 44 years.

Conclusions—SCD remains an important public health problem in the US. The increase in death rates for SCD among younger women warrants additional investigation. (Circulation. 2001;104:2158-2163.)

Key Words: death, sudden ■ heart diseases ■ mortality ■ epidemiology

Sudden cardiac death (SCD) is the most common lethal manifestation of heart disease, and in many cases it is the descent’s first and only symptom.1–3 The high incidence and sudden, unexpected nature, combining with the low successful rate of resuscitation, make SCD a major unsolved problem in clinical cardiology, emergency medicine, and public health.4–7 Clinical and pathologic findings suggest that patients with conditions such as coronary artery disease, cardiomyopathy, cardiac rhythm disturbances, or hypertensive heart disease are at high risk of SCD.8 In most cases, the mechanism of onset is a ventricular tachycardia that rapidly progresses to ventricular fibrillation and circulatory collapse.5–7,9

Clinically, SCD is the sudden, unexpected natural death from a cardiac cause a short time (generally ≤1 hour) after the onset of symptoms in a person without any previous condition that would seem fatal.5,6 Unfortunately, such a definition is difficult to apply in the public health surveillance, because the death certificate often does not include the time of onset. As an alternative, Gillum and colleagues10–12 have defined SCD as any cardiac death occurring out of the hospital or taking place in the emergency room or dead on arrival in the emergency room. This approach has reasonable validity13,14 and is useful for assessing population trends in SCD. The present study uses a similar approach with some modifications to characterize the epidemiologic features of SCD in residents of the United States (US) aged ≥35 years and to describe the secular trend of SCD from 1989 to 1998.

Methods

US vital statistics mortality data compiled by the National Center for Health Statistics at the Centers for Disease Control and Prevention were used for analyses. Death certificates are processed in state vital statistics offices and then sent to the National Center for Health for entry into a detailed national mortality database file.19 Causes of death on the death certificate are reported by a physician, medical examiner, or coroner. Demographic information such as sex, age, and race is reported by funeral directors, usually from observation or information provided by family members. We defined a cardiac disease death as one for which the underlying cause of death was classified to ICD-9 code 390 to 398, 402, or 404 to 429. SCD was defined as a death that was reported as occurring out of hospital or in the emergency room or as “dead on arrival” with an underlying cause of death reported as cardiac disease.

All analyses were performed using SAS and were limited to US residents aged ≥35 years because of the small number of younger cases (<1%). We also limited our analyses for 1989 and later because of the major change in the coding of place of death in death certificates in 1989. We assessed characteristics and trends in the proportions of cardiac deaths that were SCD, characteristics of persons suffering SCD in 1998, and trends in death rates for SCD.
from 1989 to 1998. Death rates for SCD were calculated for groups defined by calendar year, age (35 to 44, 45 to 54, 55 to 64, 65 to 74, 75 to 84, and ≥85 years), sex, and race (white, black, American Indian/Alaska Native, and Asian/Pacific Islander). Hispanic origin has been reported on death certificates since 1978; since then, an increasing number of states have added this item. Because of large missing data in earlier years, the variable was used in 1998 analyses only. Denominators were the US Bureau of the Census mid-year estimates of the resident population for each group. Age-adjusted death rates were standardized by the direct method to the 2000 projected US population. Relative change in death rates for SCD from 1989 to 1998 was calculated as the 1998 rate minus the 1989 rate, divided by the 1989 rate, and multiplied by 100.

### Results

In 1998, there were 719,456 cardiac disease deaths among US residents aged ≥35 years, of which 456,076 (63.3%) were defined as SCD. The proportion of SCD among all cardiac deaths in 1998 did not differ substantially between men (62.9%) and women (63.8%). However, women had higher proportion of out-of-hospital cardiac deaths than men, whereas men had higher proportion of death occurring in the emergency room or as “dead on arrival” (Table 1). For younger ages (35 to 74 years), SCD as the proportion of all cardiac death was higher in men (66.6%) than women (57.2%). Overall, SCDs accounted for 74.4% of all cardiac disease deaths for ages 35 to 44 years; 72.7% for 45 to 54 years; 65.6% for 55 to 64 years; 58.0% for 65 to 74 years; 58% for 75 to 84 years; and 68.8% for ≥85 years. In 1998, the proportions of cardiac deaths that occurred in hospital or out of hospital were generally higher for successive age groups; conversely, the proportion that occurred in the emergency room or were dead on arrival generally declined with age (Table 1).

SCD accounted for 63.7% of all cardiac deaths among whites; 62.0% among blacks; 60.5% among American Indians/Alaska Natives; and 55.2% among Asian/Pacific Islanders. The proportion of cardiac deaths that were SCD was higher among non-Hispanics than Hispanics (63.7% versus 54.5%). Whites had a greater proportion of cardiac deaths out of hospital than other groups, whereas blacks had the highest proportion of cardiac deaths occurring in the emergency room or as “dead on arrival” (Table 1).
SCD as the proportion of all cardiac deaths increased 12.4% from 1989 to 1998 (56.3% to 63.9%). The proportion of cardiac deaths that occurred in the emergency room or as “dead on arrival” decreased 9.7%, and the proportion of out-of-hospital SCD increased 23.5% (Table 1).

Of the 456,076 persons suffering SCD in 1998, 51.6% were women and 82.8% were aged $\geq 65$ years. The mean age of SCD victims was 70 years in men and 82.4 years in women. In 1998, coronary heart disease (ICD-9 410 to 414) was listed as the underlying cause on 62.2% of the death certificates. The distribution of underlying causes of death for SCD decedents varied between those aged 35 to 64 years and those aged $\geq 65$ years (Table 2). Acute ischemic heart disease (ICD-9 410 to 411), unspecified cardiovascular disease (ICD-9 429.2), and cardiomyopathy and dysrhythmias (ICD-9 425 to 427) were more common in the younger group. Chronic ischemic heart disease (ICD-9 412 to 414) and heart failure (ICD-9 428) were more frequent in the older group.

As expected, age-specific death rates for SCD in 1998 increased with successive age groups and were higher in men (Table 3), although the gender difference narrowed in older groups and disappeared for ages $\geq 85$ years. The male to female ratio was 2.9 at 35 to 44 years; 3.4 at 45 to 54 years; 2.8 at 55 to 64 years; 2.1 at 65 to 74 years; 1.5 at 75 to 84 years; and 1 at $\geq 85$ years. The overall age-adjusted death rate for SCD was 50% higher in men than women (410.6 versus 274.6 per 100,000) in 1998. The black population had the highest age-adjusted rates, followed by white, American Indians/Alaska

### Table 2. Distribution of Underlying Cause of Death Among SCD Decedents Aged $\geq 35$ Years by Age Group: United States, 1998

<table>
<thead>
<tr>
<th>Type of Cardiac Disease (ICD-9 Code)</th>
<th>35–64 Years (n=78,356)</th>
<th>$\geq 65$ Years (n=377,720)</th>
<th>Total (n=456,076)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acute ischemic heart disease (410–411)</td>
<td>32.9%</td>
<td>25.7%</td>
<td>26.9%</td>
</tr>
<tr>
<td>Chronic ischemic heart disease (412–414)</td>
<td>26.0%</td>
<td>37.2%</td>
<td>35.3%</td>
</tr>
<tr>
<td>Cardiovascular disease, unspecified (429.2)</td>
<td>14.3%</td>
<td>11.7%</td>
<td>12.1%</td>
</tr>
<tr>
<td>Cardiomyopathy and dysrhythmias (425–427)</td>
<td>11.6%</td>
<td>8.8%</td>
<td>9.3%</td>
</tr>
<tr>
<td>Hypertensive heart diseases (402, 404)</td>
<td>7.7%</td>
<td>4.6%</td>
<td>5.1%</td>
</tr>
<tr>
<td>Heart failure (428)</td>
<td>2.0%</td>
<td>7.7%</td>
<td>6.7%</td>
</tr>
<tr>
<td>Carditis and valvular heart disease (420–424, 429.0, 429.1)</td>
<td>1.3%</td>
<td>2.3%</td>
<td>2.2%</td>
</tr>
<tr>
<td>Pulmonary heart disease (415–417)</td>
<td>1.9%</td>
<td>0.8%</td>
<td>1.0%</td>
</tr>
<tr>
<td>All others (390–398, 429.3–429.9)</td>
<td>2.3%</td>
<td>1.2%</td>
<td>1.4%</td>
</tr>
</tbody>
</table>

### Table 3. Number and Death Rates for SCD and Relative Change Since 1989 Among Adults Aged $\geq 35$ Years by Selected Characteristics: United States, 1998

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age-specific rate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>35–44 y</td>
<td>7533</td>
<td>2584</td>
</tr>
<tr>
<td>45–54 y</td>
<td>19,575</td>
<td>5931</td>
</tr>
<tr>
<td>55–64 y</td>
<td>30,680</td>
<td>12,006</td>
</tr>
<tr>
<td>65–74 y</td>
<td>49,508</td>
<td>28,674</td>
</tr>
<tr>
<td>75–84 y</td>
<td>64,863</td>
<td>66,727</td>
</tr>
<tr>
<td>$\geq 85$ y</td>
<td>48,332</td>
<td>119,416</td>
</tr>
<tr>
<td>Age-adjusted rate†</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>193,174</td>
<td>209,219</td>
</tr>
<tr>
<td>Black</td>
<td>23,780</td>
<td>23,762</td>
</tr>
<tr>
<td>American Indian/Alaska Native</td>
<td>801</td>
<td>600</td>
</tr>
<tr>
<td>Asian/Pacific Islander</td>
<td>2736</td>
<td>1957</td>
</tr>
<tr>
<td>Total US population ($\geq 35$ y)</td>
<td>220,523</td>
<td>235,553</td>
</tr>
<tr>
<td>Hispanic</td>
<td>7160</td>
<td>5943</td>
</tr>
<tr>
<td>Non-Hispanic</td>
<td>212,409</td>
<td>228,770</td>
</tr>
</tbody>
</table>

*Relative change (%) since 1989 is calculated as the 1998 rate minus the 1989 rate, divided by the 1989 rate, and multiplied by 100. Relative change is not available for Hispanic population because death certificate information on Hispanic ethnicity was incomplete in 1989.

†Standardized to the 2000 projected US population.
found an increasing trend in the proportion of out-of-hospital cardiac death in all age groups. Thus, future efforts to reduce the burden of mortality from heart disease must address out-of-hospital deaths, which means better primary prevention, continued improvements in secondary prevention strategies, early recognition of symptoms and signs of heart disease, and more timely access to emergency cardiac care.

We found disturbing trends for women in this report: >50% of their cardiac deaths were out of hospital; their decline in SCD rates was much less than it was for men, and the rate for SCD increased 21% among women aged 35 to 44 years. The reasons for such disturbing trends are not known, and, thus, additional investigation is warranted. A variety of differences in awareness, risk factors, underlying etiology, symptoms and signs, and outcomes of cardiovascular disease may have played some roles. For example, in a recent study, >70% of women reported that they did not talk to their doctors about heart disease, and <10% considered it to be their greatest health concern. Women may receive less aggressive and more delayed treatment for heart disease than men, and they usually have a higher risk of death after heart attack, particularly young women. Furthermore, because the symptoms of heart disease in women are often atypical (eg, neck pain, back pain, jaw pain, or nausea) of chest pain, they may go unrecognized. In addition, reports have indicated that the risk factors for and pathophysiology of SCD may differ in younger versus older women. For example, younger women with SCD were more likely to be smokers, whereas older women had higher prevalence of hypercholesterolemia, hypertension, and diabetes; plaque erosion leading to acute coronary thrombosis is more common in younger women with SCD, whereas plaque rupture or healed myocardial infarction without acute coronary thrombosis was the dominant lesion among older women.

Surveillance reports using death certificate data have several limitations. First, the cause of death is not validated by a medical record or autopsy verification. The reliability and accuracy of cause of death depends on the correctness of the diagnosis and accuracy with which the death certificate is completed by the physician, medical examiner, or coroner. A previous study indicated that coronary heart disease may be substantially over-represented as a cause of death on death certificates, with the consequence that national mortality statistics may have overestimated the frequency of coronary heart disease by up to 24%. Second, the consensus clinical definition of SCD in the US includes death within 1 hour of onset of symptoms as a major criterion, although other criteria, such as death within 6 hours and 24 hours, were also used in other studies. Unfortunately, time of onset of disease symptoms and time of death are often not recorded on death certificates. However, studies involving retrospective physician review have reported that the validity of the underlying cause of death on the death certificate for out-of-hospital coronary heart disease deaths and SCD is high. Although other data sources presently available to assess population and national trends in SCD provided that the false-positive rate remains relatively constant over time. Ultimately, an im-

Discussion

Despite major advances in the prevention and medical treatment of cardiac diseases and improvements in emergency transport systems, we found that >60% of cardiac disease deaths continue to remain sudden. These 400 000 to 450 000 sudden cardiac deaths per year from 1989 to 1998 represent cardiac disease deaths that occur out of hospital, in the emergency room, or as “dead on arrival.” The present surveillance data demonstrate a 10-year decline in the proportion of cardiac deaths that occurred in the hospital or in the emergency room or were dead on arrival at the emergency room but an alarming increase in the proportion that never made it to the hospital. This trend probably reflects aging of the US population and the later onset of sudden, fatal cardiac events in the elderly, who experience 83% of SCDs. Still, we

![Figure 1. Age-adjusted death rates (per 100 000 US population) for sudden cardiac death among men aged 35 years and older by race in the US from 1989 to 1990.](http://circ.ahajournals.org/DownloadedFrom/hrc-ahajournals.org)

![Figure 2. Age-adjusted death rates (per 100 000 US population) for sudden cardiac death among women aged 35 years and older by race in the US from 1989 to 1990.](http://circ.ahajournals.org/DownloadedFrom/hrc-ahajournals.org)
proved national surveillance system or a national registry on SCD will be essential in providing better information on incidence, management, and outcomes and will help determine the success of clinical and public health interventions against cardiovascular disease in the population.

The validity of the reporting of race and Hispanic ethnicity on death certificates is another concern. To our knowledge, few studies have examined SCD in American Indian/Alaskan Native, Asian/Pacific Islander, or Hispanic populations in the US. In this report, we found that adults in these racial and ethnic groups had lower SCD death rates than white or black adults. Underreporting of American Indian/Alaska Native or Asian/Pacific Islander race or of Hispanic ethnicity on death certificates and census population counts may lead to underestimates of SCD in these groups and overestimates among white and black populations. In addition, another limitation of surveillance report based on death certificate data is that we are unable to ascertain predisposing risk factors for SCDs other than age, race, ethnicity, and sex.

These limitations notwithstanding, this surveillance report is valuable for its provision of the most recently available statistics for SCD for the entire US adult population. Unlike case-control studies and hospital registries, the US death certificate data has sufficient numbers to allow comparisons of secular trends, sex, age, and race or ethnicity. In addition, this study differs from the previous reports that focused on sudden death attributable to coronary heart disease only by including all cardiac disease, which may yield a more in-depth understanding of the etiology of sudden cardiac death in the US population.

The encouraging declines in the proportion of cardiac deaths occurring in the hospital or the emergency room or as “dead on arrival” may reflect the improvements in emergency services and more timely and appropriate treatment. However, the increased trend in SCD outside of the hospital indicates a need for public health initiatives to improve the early recognition of heart attack symptoms and signs. Educational and media efforts should specifically target women and younger adults, who may dismiss cardiac arrest as a problem of men and the elderly. According to the Rapid Early Action for Coronary Treatment Trial, although knowledge of chest pain as an important heart attack symptom is relatively high in the US, there are racial and gender variations in identifying correct symptoms and signs of heart disease. National efforts are needed to increase the proportion of the general public who recognize signs and symptoms of a heart attack and who are willing to participate in the “chain of survival,” which includes dialing 911, attempting cardiac resuscitation, and using automated external defibrillators until emergency personnel arrive. Finally, the primary prevention of coronary heart disease should remain a major focus of public health. Physicians and other health care providers should never miss the opportunity during routine physical examinations to counsel patients, including apparently healthy young adults and women of all ages, about the importance of controlling high blood pressure and high cholesterol levels, smoking avoidance or cessation, weight management, regular physical activity, and a diet low in saturated fats and cholesterol and rich in fruits and vegetables.

In conclusion, SCD remains an important clinical and public health problem in the US. Increased death rates for SCD among younger women warrant additional investigation of their potential risk factors. Public health education and media efforts should target increased awareness of the symptoms and signs of cardiac arrest and should attempt to increase the numbers of bystanders trained and willing to initiate the “chain of survival.”

References