Public Health Burden of Sudden Cardiac Death in the United States

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Background—Sudden cardiac death (SCD) is a leading cause of death in the United States, but the relative public health burden is unknown. We estimated the burden of premature death from SCD and compared it with other diseases.

Methods and Results—Analyses were based on the following data sources (using most recent sources that provided appropriately stratified data): (1) leading causes of death among men and women from 2009 US death certificate reporting; (2) individual cancer mortality rates from 2008 death certificate reporting from the Centers for Disease Control and Prevention’s National Program of Cancer Registries; (3) county, state, and national population data for 2009 from the US Census Bureau; and (4) SCD rates from the Oregon Sudden Unexpected Death Study (SUDS) population-based surveillance study of SCD between 2002 and 2004. Cases were identified from multiple sources in a prospectively designed surveillance program. Incidence, counts, and years of potential life lost for SCD and other major diseases were compared. The age-adjusted national incidence of SCD was 60 per 100,000 population (95% confidence interval, 54–66 per 100,000). The burden of premature death for men (2.04 million years of potential life lost; 95% uncertainty interval, 1.86–2.23 million) and women (1.29 million years of potential life lost; 95% uncertainty interval, 1.13–1.45 million) was greater for SCD than for all individual cancers and most other leading causes of death.

Conclusions—The societal burden of SCD is high relative to other major causes of death. Accordingly, improved national surveillance with the goal of optimizing and monitoring SCD prevention and treatment should be a high priority. (Circ Arrhythm Electrophysiol. 2014;7:212-217.)

Key Words: cause of death ■ death, sudden, cardiac ■ epidemiology of SCD ■ public policy

Sudden cardiac death (SCD) is characterized by sudden circulatory collapse caused by cardiac arrhythmia. A majority of cases occur in the setting of chronic or acute ischemic heart disease.1 There is little information on the public health burden from SCD around the world, and it was not reported as part of the Global Burden of Disease Study.2 Estimates of annual incidence of SCD in the United States range between 180,000 and 450,000,3 corresponding to between 7% and 18% of all deaths in the United States. The high degree of variability in these estimates is because of limitations in data regarding mode of cardiovascular death. Death certificate reporting provides annual national estimates for many diseases but has proven inaccurate for SCD.4–6 Cohort studies and randomized trials have produced important insights into heart disease. However, inferential on incidence and burden are limited because few studies are designed to prospectively identify SCD and it often takes many years to accrue sufficient numbers of cases for analysis. Detailed knowledge of SCD is critical for targeting SCD-specific prevention and treatment at the population level (designing and evaluating emergency medical response systems and automatic external defibrillator deployments) and patient level (optimizing use of implantable cardioverter-defibrillators and developing new methods targeting arrhythmic death prevention).

Clinical Perspective on p 217

We sought to provide estimates of national SCD incidence and burden of premature death based on data from the Oregon Sudden Unexpected Death Study (SUDS) in Portland, OR, and compare these with other causes of death nationwide. Oregon SUDS is a multisource, population-based study of SCD among all ages in a community of 680,000 people. We estimated the burden of premature death using a well-accepted metric, years of potential life lost (YPLL). YPLL measures the total lost years of life for all individuals with a disease compared with individuals who live to a normal life expectancy.

Methods

Data Sources

Four primary data sources were used for this analysis and were selected from the most recent complete data sets available: (1) SCD rates from the Oregon SUDS population-based surveillance between
for Health Statistics National Vital Statistics System. Individual cancer referred to a cancer originating from a specific anatomic site. Examples include breast cancer and prostate cancer. Base-case estimates referred to national extrapolation of Multnomah County, Oregon, rates of SCD, and sudden cardiac arrest using only age and sex adjustment.

**Multnomah County SCD rates**

Data from 3 years of active surveillance among residents of all ages in Multnomah County were used. Each adjudicated SCD case was assigned to a sex and age category. Eighteen age categories were used: seventeen 5-year categories (0–5 years to 80–85 years) and 1 category of 285 years. The total number of deaths during 3 years for each age–sex category was divided by 3, yielding numerators for each age–sex category. US Census Bureau data for the Multnomah County population at the middle time point of the study period for each age–sex category constituted the denominators for the categories and allowed calculation of the population incidence of SCD for each age–sex category. These category incidences formed the basis for subsequent calculation of YPLL.

**National SCD Estimates**

National incidences of SCD were estimated for women, men, and overall using 2 methods. The first adjustment method extrapolated the sex- and age-stratified rates from Oregon SUDS to the nation overall, using conventional age-standardization techniques with the 2009 US population as the reference. National counts of SCD were determined by multiplying the estimated incidences by the national population. Estimates of SCA (combination of SCD and nonlethal arrests meeting criteria above) were calculated in the same manner as SCD and are reported in Table 1 for comparison.

A second national extrapolation technique, cardiac death risk adjustment, was used to adjust for potential regional differences in SCD rates beyond that explained by differences in population age and sex characteristics. For this extrapolation technique, we assumed that the ratio of SCD rates between each state and Multnomah County varied to the same degree as the ratio of overall heart disease mortality between each state and Multnomah County. The Multnomah County population-based SCD rate for each age–sex category was multiplied by the population of the corresponding age–sex category in each of the 50 states plus District of Columbia to yield an estimated state SCD event count. Each state count (stratified by sex) was multiplied by the ratio of overall heart disease mortality between that state and Multnomah County, resulting in an adjusted SCD count. The sum of the adjusted counts yielded the adjusted national totals for SCD. The totals were divided by the national population to create an estimate of national SCD rates adjusted for differences by age, sex, and state. Implicit to this technique were 2 assumptions: (1) regional differences in SCD rates mirror the differences in overall cardiac death risk, and (2) differences in cardiac death risk between regions are constant across sex and age categories.

### Table 1. Comparison of National Sudden Death Estimates Using Different Definitions and Analysis Methods*

<table>
<thead>
<tr>
<th>Sudden cardiac death</th>
<th>Incidence in Women</th>
<th>Incidence in Men</th>
<th>Total Incidence</th>
<th>Total Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base case</td>
<td>45 (37–53)</td>
<td>76 (66–87)</td>
<td>60 (54–66)</td>
<td>183001 (164218–203205)</td>
</tr>
<tr>
<td>Cardiac death risk adjustment</td>
<td>52</td>
<td>88</td>
<td>69</td>
<td>212910</td>
</tr>
<tr>
<td>Sudden cardiac arrest</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Base case</td>
<td>49 (42–58)</td>
<td>83 (73–95)</td>
<td>66 (59–73)</td>
<td>201286 (181417–222594)</td>
</tr>
<tr>
<td>Cardiac death risk adjustment</td>
<td>57</td>
<td>96</td>
<td>76</td>
<td>234085</td>
</tr>
</tbody>
</table>

*95% uncertainty intervals are shown in parentheses and were calculated using the gamma distribution method. Incidence rates are expressed per 100,000 national population and were extrapolated from Multnomah County data (with and without adjustment for state-specific differences in overall cardiac death risk, as described in the Methods section). Sudden cardiac death refers to patients who died within 1 hour of symptom onset if witnessed or within 24 hours of last being seen alive in normal state if unwitnessed. Sudden cardiac arrest refers to all patients with sudden cardiac death as well as those who survived until hospital discharge after resuscitation for a primary arrhythmia.
National Rates of Death From Non-SCD Causes

Death counts from common diseases were identified from national death certificate summary reports that were stratified by the same age–sex categories as the Multnomah County data. Total counts for each sex were divided by the national population of that sex during the year of measurement (2008 for cancers and 2009 for all other causes of death) and multiplied by 100,000 to yield a national population-based rate. Counts within each age–sex category were used for YPLL comparisons.

Years of Potential Life Lost

YPLL was calculated based on the 2.5th and 97.5th percentile distributions from the gamma distribution with

\[ \alpha = 164 \]

and

\[ \beta = 203 \]

where \( R \) is the age-adjusted rates, \( m \) is the number of age groups, \( d_i \) is the number of deaths in age group \( i \), \( P_i \) is the population in age group \( i \), and \( s_i \) is the proportion of the standard population in age group \( i \). Variance is given by

\[ \sigma^2 = \sum_{i=1}^{m} d_i \left( \frac{s_i}{P_i} \right)^2 \]

as suggested for age-adjusted rates as follows:

\[ R = \sum_{i=1}^{m} s_i \left( \frac{d_i}{P_i} \right) \]

Statistical Analysis

Calculations were performed using Microsoft Excel version 14.0 and SAS version 9.4. The statistical level of uncertainty surrounding national SCD incidence rates was calculated using 95% confidence intervals (CIs) according to the gamma distribution method.

\[ CIs = \left( \frac{v}{2} X_i^2, \frac{v}{2} \right) \]

Comparisons of National Rates of SCD With Other Leading Causes of Death

Among women, overall heart disease and cancer were the leading causes of death, with rates of 188 per 100,000 and 174 per 100,000, respectively (Table 2). Rates of cerebrovascular disease (49 per 100,000), chronic lower respiratory disease (46 per 100,000), lung cancer (45 per 100,000), and SCD (45 per 100,000; 95% CI, 37–53 per 100,000) were all in a similar range. Among men, heart disease and cancer death rates were 205 per 100,000 and 197 per 100,000, respectively (Table 3). Deaths from SCD (76 per 100,000; 95% CI, 66–87 per 100,000) exceeded all other individual causes of death, including lung cancer, accident, chronic lower respiratory disease, cerebrovascular disease, diabetes mellitus, prostate cancer, and colorectal cancer.

Comparisons of Burden of Premature Death From SCD With Other Leading Causes of Death

Table 2. Female Mortality for Sudden Cardiac Death, Common Diseases, and Individual Cancers*
Among women, total YPLL for SCD (1.29 million; 95% uncertainty interval, 1.13–1.45 million) was greater than that of other cancers for each sex (Figure 1). For men, there was a similar early peak of YPLL from accidental death, although of smaller magnitude. Heart disease and SCD premature death burdens began to increase more slowly, with lower peaks relative to overall cancer. Unlike heart disease in men and unlike cancer in both sexes, YPLL from heart disease in women continued to climb in old age.

SCD was responsible for a greater burden of premature death than all cancers other than heart disease. The estimated annual national incidence of SCD using standard age and sex adjustment was 183,000 (95% uncertainty interval=164,000–203,000). The point estimate for national SCD incidence after adding cardiac death risk adjustment increased to 213,000. This study not only adds to previous reports of SCD incidence but also places the problem of SCD in a broader societal perspective by comparing it with other causes of death. Because of lower population-based rates of SCD in Oregon, the actual national burden of premature death from SCD is likely even greater than what we have reported in our base-case estimate. Adjusting for regional differences in SCD rates resulted in a 15% higher burden of YPLL from SCD for both men and women.

To our knowledge, this is the first study to estimate national rates of SCD using prospective surveillance systems with rigorously adjudicated cause-of-death information on patients of all ages. This allows for the comparison of premature death between SCD and other causes. The societal burden of premature death is an important factor that should help to guide relative allocation of resources for studying, preventing, and treating diseases. The high burden of SCD stands in contrast to the limited scientific knowledge regarding its incidence, origin, and risk factors. This may be a manifestation of the modest epidemiological surveillance efforts dedicated to heart disease overall. Heart disease deaths are tracked nationally only by use of death certificates as part of the CDC’s National Vital Statistics System. This is of limited use for detailed epidemiological research, and it has been repeatedly shown to inaccurately reflect the mode of cardiovascular death compared with detailed clinical review of cases. Incidence and recurrent event data for heart disease, reported annually in the American Heart Association's Heart Disease and Stroke Statistics updates, are not available for SCD.

### Discussion

This study demonstrates the large public health burden of SCD, which is responsible for 40% to 50% of YPLL from heart disease. The incidence and premature death burden from SCD exceeded that of any individual cancer in both men and women. Among women, SCD exceeded all noncardiac causes of premature death except overall cancer. Among men, SCD exceeded all except overall cancer and accidents. The estimated annual national incidence of SCD using standard age and sex adjustment was 183,000 (95% uncertainty interval=164,000–203,000). The point estimate for national SCD incidence after adding cardiac death risk adjustment increased to 213,000. This study not only adds to previous reports of SCD incidence but also places the problem of SCD in a broader societal perspective by comparing it with other causes of death. Because of lower population-based rates of SCD in Oregon, the actual national burden of premature death from SCD is likely even greater than what we have reported in our base-case estimate. Adjusting for regional differences in SCD rates resulted in a 15% higher burden of YPLL from SCD for both men and women.
The US approach to cancer epidemiology serves as a contrast and potential model for cardiovascular epidemiology. The Surveillance, Epidemiology, and End Result (SEER) registry, established in 1973 as part of the National Cancer Institute, collects detailed information about patient characteristics, tumor characteristics, clinical treatments, and patient outcomes for cancer cases in 20 geographic areas.18 It encompasses 28% of the US population, and the registry’s demographics are representative of the nation as a whole. The director of the Division of Cancer Prevention at the National Cancer Institute has stated that “SEER is a mainstay of the National Cancer Program…rational leadership of National Cancer Institute would not be possible without SEER.”19 The magnitude of SCD illustrated in the present study and its inherent limitations (see below) argue for an improved epidemiological surveillance system for cardiovascular death that is akin to SEER. With better knowledge of the nature of SCD, more effective investigation into mechanisms, prevention, and treatment can be undertaken. For a disorder such as SCD with myriad etiologic pathways, such research is particularly important.

Because no nationally representative epidemiological studies of SCD currently exist, our estimates based on the Oregon SUDS study provide the most accurate available comparison of the burden of premature death from SCD relative to other diseases. The most important limitation is the use of a single metropolitan area. In lieu of a national cardiovascular epidemiological registry system, a majority of inferences about incidence and trends of cardiovascular disease have been derived from cohorts much smaller than Multnomah County’s population.20 At this point, Multnomah County is the only source of all of the requisite attributes for this analysis. In particular, cause-of-death and mode-of-death adjudication must be robust to prevent inclusion of cardiac arrests that are not primarily arrhythmic (eg, primary respiratory failure) or occur in the setting of a known terminal illness (eg, metastatic cancer) from leading to an overestimation of SCD rates. For example, despite other strengths of the ROC Epistry–Cardiac Arrest study, it seems to have overestimated the rate of SCD in the Portland metropolitan area (60 per 100,000 in Oregon SUDS with detailed clinical mode-of-death adjudication; 71 per 100,000 in ROC Epistry–Cardiac Arrest).20 Another important limitation is that the death certificate data used for non-SCD death are prone to disease miscategorization (although likely to a lesser degree than death certificate–based SCD data). Nonetheless, these data sources are preferred by CDC for nationwide comparisons, and alternative sources are not available. Finally, YPLL estimates in the present study are generally less than those from the US portion of the Global Burden of Diseases Study.21 This is likely because of the use of US-specific life expectancy estimates in the present study, whereas the Global Burden of Diseases Study used the lowest death rate across countries for each age group to estimate US life expectancies.

Conclusions

The societal burden of SCD as measured by YPLL is highly relative to other major noncardiac conditions. Creation of a nationwide surveillance system for cardiovascular disease has been recognized as a priority.22,23 As the present study illustrates, the high societal burden of SCD alone could justify such a project. In areas where research collaborations between cardiology and emergency medicine systems are feasible, a network of nationally representative community-based studies of SCD could be developed to measure rates and modes of cardiovascular death and track them over time. Such an effort would facilitate a better understanding of SCD causes and a more accurate and timely assessment of the effectiveness of SCD prevention and treatment efforts.

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Disclosures

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Sudden Cardiac Death Burden

CLINICAL PERSPECTIVE
Sudden cardiac death (SCD) is widely recognized as an important cause of death, but national estimates of its magnitude have proven unreliable. Investigators of the Oregon Sudden Unexpected Death Study (SUDS) have engaged in multiple-source, population-based research that minimizes the inaccuracies that often limit SCD surveillance. Using data from Oregon SUDS, the Centers for Disease Control and Prevention, and the US Census Bureau, they estimated the national incidence and burden of premature death (measured as years of potential life lost) because of SCD and compared it with other major causes of death. The total annual number of SCD cases in the United States was between 183,000 and 213,000 using different estimation methods. The burden of premature death was 2.0 million years of potential life lost for men and 1.3 million years of potential life lost for women, more than any individual cancer and most other leading causes of death. The authors conclude that the magnitude of premature death from SCD makes prevention of this condition a major public health priority. The creation of a national surveillance network for SCD will be a vital step toward discovering new methods of prevention and monitoring their effectiveness.

References
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