Secular trends in ischemic heart disease mortality: regional variation

Sue Y. S. Kimm, M.D., Steven M. Ornstein, M.D., Elizabeth R. DeLong, Ph.D., and Seymour Grufferman, M.D., Dr. P.H.

ABSTRACT We compared secular trends in ischemic heart disease (IHD) mortality in four southeastern states (North Carolina, Georgia, South Carolina, and Virginia) with those in three selected other states (California, New York, and Utah). Mortality data were obtained from U.S. vital statistics and population information from the U.S. Census Bureau. Age-adjusted IHD mortality increased until 1968 in the southeastern states and then declined and declines were greatest in the nonwhite female population. In contrast, IHD mortality in all groups in California and in the female population in New York and Utah began to decline in the early 1950s, with accelerated declines since 1968. In all states the decline in rates in nonwhite populations have been greatest in the younger age groups. This has not been true in the white populations. Declining IHD mortality correlated moderately well with the decline in death from all cardiovascular disease and from all causes, but not with the declining cerebrovascular disease mortality. Respiratory cancer mortality increased in similar proportions in California and South Carolina, two states with dissimilar IHD trends. These findings suggest that improved control of hypertension and changing patterns of cigarette smoking may not be responsible for the recent decline in IHD mortality.

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THE WELL-PUBLICIZED recent decline in ischemic heart disease (IHD) mortality in this country and in several other western nations1-6 has generated much speculation as to its underlying causes and has rekindled interest in the search for the etiology of IHD. Studies of geographic variations in disease-specific mortality have provided useful epidemiologic clues and might help to elucidate the reasons for the recent decline in IHD mortality.4

International studies of secular IHD mortality trends have shown marked geographicvariability. While mortality has been declining in the United States, Canada, Australia, Finland, Belgium, and Israel, it has been increasing in Sweden, Denmark, Eastern Europe, and the Soviet Union.2, 7-9 Regional studies in the United States have demonstrated dramatic interstate and intercounty differences in IHD mortality, as well as a recent concentration of high rates in the southeastern United States.10-13 However, no study of regional secular trends has been reported. In the last review of this subject, only data from the years up to and including 1971 were analyzed,14 and most of the decline has occurred since that time.1

The first purpose of our study was to examine regional differences in IHD mortality trends in the United States from 1950 to 1976. We also assessed the impact of changing IHD mortality on the rate of death from all cardiovascular disease (CVD) and on the rate of death from all causes. Our second purpose was to investigate some of the hypotheses concerning the reasons for the decline in IHD mortality by studying mortality trends in diseases that share risk factors with IHD. For example, hypertension is known to be a major risk factor for both cerebrovascular disease (CVA) and IHD16, 17 and cigarette smoking is a risk factor for both IHD and respiratory tract cancer.17, 18 We studied trends in CVA and respiratory cancer mortality in an attempt to explore the potential contributions to the decline in IHD mortality made by the decreasing prevalence of uncontrolled hypertension and by changing patterns of cigarette smoking.
Methods

Our study focused on the southeastern states of Georgia, North Carolina, South Carolina, and Virginia. Three other states were selected for comparison: California (because it is a large state with an early decline in IHD mortality),4 Utah (which is known to have low rates of IHD mortality),12 and New York (because it is a representative large northeastern state with a major metropolitan population).

The number of deaths from 1950 to 1976 by race (white and nonwhite), sex, and 5-year age groups for 30 to 74 year olds were obtained from Vital Statistics of the United States.19 We obtained data for all causes of death and for the following specific categories: CVD (coded as Nos. 330-334 and 400-468 in the sixth and seventh revisions of the International Classification of Disease [ICD] and as No. 390-448 in the eighth ICD revision), IHD (sixth, seventh ICD revision, code No. 420; eighth ICD revision, code No. 410-413), and CVA (sixth, seventh ICD revision, code No. 330-334; eighth ICD revision, code No. 430-438). Due to the small nonwhite population in Utah, only the white population in this state was studied. Death statistics were also obtained for respiratory cancer (sixth, seventh ICD revision, code No. 160-164; eighth ICD revision, code No. 160-163) in California and South Carolina, two states with markedly dissimilar IHD mortality patterns.

Population information was obtained from U. S. census reports for the years 1950, 1960, and 1970. Estimates for the intercensal years were made by linear interpolation.20 For North Carolina, population estimates for 1974 to 1976 were provided by the state;21 estimates for 1971 to 1973 were made by linear interpolation.20 For the remaining states, population estimates for 1971 to 1976 were provided by the U. S. Census Bureau.21

Age-adjusted rates were calculated by a direct method, with the 1940 U. S. population as the standard, and changes in these rates over time were expressed as percent increases or decreases. The direct method of adjustment involves the application of age-specific rates from each state to a standard population (the 1940 U. S. population) to derive a summary rate. Due to small numbers, age-specific yearly mortality rates demonstrated greater random variability than did age-adjusted rates. Thus, when examining changes in mortality rates for individual age, race, and sex groups, we first fit a straight line to the rates as a function of time with a least squares model and then calculated percent increases or decreases based on the fitted line.

To determine whether, in states in which there were large decreases in IHD mortality, there were also large decreases in death from CVA, CVD, or all causes, we computed Kendall's tau-b, a nonparametric measure of correlation that does not assume normality or a linear relationship.23 As applied, this rank correlation coefficient and its associated p value give an indication of the strength of the relationship between percent change from 1968 to 1976 in IHD mortality and percent change in mortality from other causes over the seven states in the study.

Results

IHD mortality trends. Age-adjusted IHD mortality trends from 1950 to 1976 for the white male populations in the three selected other states. In contrast to the trends seen in the Southeast, mortality rates declined in California before 1968 and were relatively constant in New York and Utah (figure 2). Since 1968, age-adjusted mortality rates declined in all three states.

The changes in age-adjusted rates between 1950 and 1967, and 1968 and 1976 (before and after the ICD coding change) are presented in table 1 for the four race-sex groups. In the Southeast, mortality increased for all groups from 1950 to 1967, with the greatest increases in the nonwhite male populations. In California, however, rates did not increase during this period and fairly substantial declines were evident in white male and female populations. Likewise, rates did not increase in New York (where there were definite declines in mortality in the female population) or in Utah over this time span. From 1968 to 1976, in all states there were declining mortality rates for each of the race-sex groups. For the southeastern states, this represents reversal of the trend of increasing mortality,

![Figure 1](https://example.com/fig1.png)

**FIGURE 1.** Age-adjusted IHD mortality for the white male populations in four southeastern states in the period from 1950 to 1976.

male populations in the three selected other states.
TABLE 1
Percent change in age-adjusted IHD mortality from 1950 to 1967 and from 1968 to 1976, by race, sex, and state

<table>
<thead>
<tr>
<th>State</th>
<th>1950 to 1967 (6th and 7th ICD revision)</th>
<th>1968 to 1976 (8th ICD revision)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>White men</td>
<td>White women</td>
</tr>
<tr>
<td>Southeastern states</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Georgia</td>
<td>40</td>
<td>15</td>
</tr>
<tr>
<td>North Carolina</td>
<td>35</td>
<td>17</td>
</tr>
<tr>
<td>South Carolina</td>
<td>21</td>
<td>18</td>
</tr>
<tr>
<td>Virginia</td>
<td>26</td>
<td>11</td>
</tr>
<tr>
<td>Selected other states</td>
<td></td>
<td></td>
</tr>
<tr>
<td>California</td>
<td>-16</td>
<td>-18</td>
</tr>
<tr>
<td>New York</td>
<td>0</td>
<td>-17</td>
</tr>
<tr>
<td>Utah</td>
<td>1</td>
<td>-8</td>
</tr>
</tbody>
</table>

The nonwhite population in Utah was not studied due to small numbers.

while for the three other selected states, the already existing trend toward decline appears to have accelerated during this period. In the southeastern states, declines were greater in the nonwhite populations, a pattern that was not seen in the other states.

Since trends for specific age groups can be informative, table 2 demonstrates the declines for the three age groups (40 to 44, 55 to 59, and 70 to 74 years). The 40 to 44 age group was selected for study because it is the youngest age group in which numbers of deaths from IHD adequate for study would be expected. The 70 to 74 age group was selected as representative of the elderly population. We did not study an older age group because cause of death is often not recorded accurately for people over 74 years old. As shown in table 2, in nonwhite populations declines in mortality were greater in the younger age groups and there were smaller declines or slight increases for those in the oldest group. This pattern is not apparent among whites, who demonstrate no consistent relationship between age and the magnitude of the decline in IHD mortality. This was true in all of the states we studied.

Trends in mortality from all CVDs and from all causes.
There were dramatic declines in total CVD mortality in the years from 1950 to 1976 for all race-sex groups. These declines ranged from 16% to 59% and were found in all states studied. This is exemplified by the data for the white male populations, which are listed in table 3. Since 1968, the rate of decline in CVD mortality has accelerated, coincident with the decline in IHD mortality. The percent decline in IHD incidence rates from 1968 to 1976 correlates well with those for CVD.

TABLE 2
Estimated percent decline in age-specific IHD mortality from 1968 to 1976 by race, sex, and state

<table>
<thead>
<tr>
<th>State</th>
<th>40 to 44 year olds</th>
<th>55 to 59 year olds</th>
<th>70 to 74 year olds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>White men</td>
<td>White women</td>
<td>Nonwhite men</td>
</tr>
<tr>
<td>Southeastern states</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Georgia</td>
<td>21</td>
<td>55</td>
<td>48</td>
</tr>
<tr>
<td>North Carolina</td>
<td>12</td>
<td>(-9)</td>
<td>37</td>
</tr>
<tr>
<td>South Carolina</td>
<td>27</td>
<td>9</td>
<td>31</td>
</tr>
<tr>
<td>Virginia</td>
<td>12</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>Selected other states</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>California</td>
<td>31</td>
<td>35</td>
<td>32</td>
</tr>
<tr>
<td>New York</td>
<td>28</td>
<td>25</td>
<td>45</td>
</tr>
<tr>
<td>Utah</td>
<td>26</td>
<td>18</td>
<td>c</td>
</tr>
</tbody>
</table>

The age-specific percentages were obtained from a linear fit of IHD rate by year.

A negative percentage indicates an increased rate.

The nonwhite population in Utah was not studied due to small numbers.
mortality over the seven states for each of the race-sex groups, achieving statistical significance in the nonwhite female populations (table 4).

Mortality from all causes also declined dramatically for all race-sex groups in the years from 1950 to 1976 in all states studied, with declines ranging from 4% to 49%. Since 1968, the rate of decline has accelerated; in fact, for men in the southeastern states, mortality actually increased during the years from 1950 to 1968 and thereafter has declined. The decline in mortality from all causes correlates with the decline in IHD mortality over the seven states (table 4), particularly in the nonwhite populations.

Trends in mortality from CVA and respiratory cancer. There were dramatic declines in CVA mortality in the years from 1950 to 1976 for all race-sex groups in the seven states, with declines ranging from 39% to 73% (table 5). Figure 3 shows an interesting pattern in these various declines. Mortality rates for CVA were widely divergent in 1950 and were divided into two distinct groups (southeastern and other states), the rates in Virginia being the median rates. However, they converged to a more narrow range in 1976, with the southern states retaining their higher rates and with those for Virginia remaining intermediate. The rate of decline in CVA mortality has accelerated since 1968, particularly in nonwhite populations. However, declines in CVA and IHD mortality since 1968 do not appear to be well correlated for any of the race-sex groups (table 4).

Respiratory cancer trends in California and South Carolina from 1950 to 1976 are presented for the white male populations in figure 4. Respiratory cancer mortality increased similarly in both states until around 1968. Thereafter, rates in South Carolina increased rapidly, whereas those in California, the state that showed the earliest decline in incidence of IHD as well as a lower rate, increased only slightly.

### Discussion
Regional variations in IHD mortality have often been used to suggest underlying causal factors for IHD. In 1950, high rates were found for white populations in the New England, Middle Atlantic, South Atlantic, Great Lakes, Mississippi delta, and Western regions of the United States. It was suggested that occupational, geographic, climatic, or geologic factors might be responsible for the observed differences. 

### TABLE 4
Correlation of percent decline in age-adjusted IHD mortality with percent decline in age-adjusted mortality from CVA, CVD, and from all causes in seven selected states in the period from 1968 to 1976

<table>
<thead>
<tr>
<th>Group</th>
<th>CVA</th>
<th>CVD</th>
<th>All causes</th>
</tr>
</thead>
<tbody>
<tr>
<td>White men</td>
<td>.33</td>
<td>.52</td>
<td>.33</td>
</tr>
<tr>
<td>White women</td>
<td>-.05</td>
<td>.43</td>
<td>.24</td>
</tr>
<tr>
<td>Nonwhite men</td>
<td>-.07</td>
<td>.47</td>
<td>.60</td>
</tr>
<tr>
<td>Nonwhite women</td>
<td>.47</td>
<td>.73</td>
<td>.47</td>
</tr>
</tbody>
</table>

*By Kendall tau-b test (n = 7 for white men and white women, n = 6 for nonwhite men and nonwhite women).*
By the period from 1968 to 1971, IHD mortality in the white male population was highest in the southeastern states; rates for white women were highest in the Northeast. Higher rates were correlated with eastern longitude, northern latitude, and lower altitude.  
We compared secular trends in a region marked by recently high IHD rates with those in three selected other states. Long-term study of mortality trends is complicated by periodic changes in the ICD coding for specific causes of death. The change in 1968 from the seventh to eighth ICD revision caused sharp breaks in IHD mortality curves, and increased the age-adjusted rate for the total U. S. population by 1%. Unfortunately, there are no age-, race-, and sex-specific ratios for comparisons between the seventh and eighth ICD revisions; thus rates before and after 1968 cannot be directly compared. We have therefore focused our analyses on IHD mortality after 1968, the period during which the decline has been most dramatic.

Declines in IHD mortality since 1968 were greater for all nonwhite populations in the southeastern states and for younger nonwhite populations in the three other states studied. The greater decline in rates in nonwhites may be an artifact of the 1968 ICD coding change. Declines for each race and sex were similar in the southeastern and selected other states. However, mortality declined earlier than 1968 in the latter and the overall decline for the period studied (1950 to 1976) was greater in these states.

We found little discernible correlation between CVA and IHD mortality trends. While CVA mortality declined in both the southeastern and other states throughout the period from 1950 to 1976, IHD mortality in the southeastern states continued to increase until after 1968. Despite the overall decline in mortality from both diseases, there was little correlation between the magnitudes of decline in CVA and IHD mortality for any of the race-sex groups. We have no evidence, therefore, to conclude that a declining prevalence of...
hypertension, at least as indexed by CVA mortality, is a major contributing factor to the decline in the incidence of IHD mortality. It is also known that control of hypertension is associated with a reduction in stroke mortality, but not necessarily in IHD mortality.24

Respiratory tract cancer mortality increased similarly in California (a state in which there has been declining IHD mortality since the early 1950s) and South Carolina (in which there was increasing IHD mortality until after 1968). Cigarette smoking is a major risk factor for both diseases,17 yet we observed no abatement in the rise in respiratory cancer mortality at a time when IHD mortality was declining. This suggests either that changes in tobacco use do not play a major role in the decline in IHD mortality or that a decline in cigarette consumption might be reflected in an IHD decline before being reflected in a downturn in respiratory cancer mortality. It is also known that smoking confers different degrees of risk for lung cancer and IHD; the relative risk for lung cancer among smokers as compared with nonsmokers is 13 whereas that for IHD is 2.4.17,18

In summary, we have found that two diseases that share risk factors with IHD have “behaved” quite differently from IHD during the period from 1950 to 1976. It may be that the IHD decline is totally independent of any fundamental changes in the prevalence of hypertension or cigarette smoking. It is also possible that mortality outcomes of diseases with common risk factors are too crude a measure for comparison of the etiologic mechanisms or that the same risk factor has a variable latency period between exposure and outcome.

We have found different secular IHD mortality trends in the southeastern states and other states, both in terms of the time and magnitude of the decline. These differences have important epidemiologic implications because they suggest that the declines in mortality may not be due to revolutionary changes, either in lifestyle or in medical care, that occurred at one time, but are rather due to a series of changes that took place at various times in different regions. These findings also have important public health implications because the more substantial declines in IHD mortality in the three other selected states contributed to greater declines in both overall CVD mortality and rates of death from all causes. IHD remains the leading cause of death in this country, and among the seven states studied, those with higher IHD rates have a higher death rates from all causes. Therefore, any change in IHD mortality rates would have an impact on the overall mortality in the U. S. population.

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