Previous studies have reported considerable geographic variation of stroke mortality rates in the United States. While the quality of diagnoses on death certificates is questionable, especially for studies of individuals, certification studies have suggested that large differences in stroke mortality between high- and low-rate areas are real and reflect differences in the same direction in incidence and, possibly, case fatality.

It is well known that there have been rapid declines in mortality from stroke over the last few decades. We present changes in the geographic distribution of stroke during this period of decline for white men and white women aged 35–74 years at the level of state economic areas (SEAs).

**Subjects and Methods**

We used annual mortality data from the National Center for Health Statistics (NCHS) and population data from the Census Bureau to generate annual 5-year-age–specific stroke mortality rates (deaths per 100,000) for whites by sex for each of the 507 SEAs (single counties or groups of counties with similar social and economic characteristics) in the continental U.S. We focused on whites due to the large geographic variation in the composition and size of nonwhite populations. International Classification of Disease codes for the seventh (330–334, 1962–1967), eighth (430–438, 1968–1978), and ninth (430–438, 1979–1982) revisions have comparability ratios close to unity. We did not include data for New Jersey for 1962 and 1963 because the state did not code race on death certificates in those years. We obtained data for 1972 from a tape of all deaths prepared for the Environmental Protection Agency and the National Cancer Institute because NCHS coded only 50% of the 1972 deaths. We adjusted annual age-specific rates for whites between 35–39 and 70–74 years old for age using the direct method and the 1970 total US population distribution as a standard. We computed rates for combined years and regions as weighted averages of SEA rates using the white population aged 35–74 years in each SEA as weights, and these rates may differ slightly from directly age-adjusted rates for longer times and larger regions due to the proportional hazards assumption involved in using this method.

We present separate maps for white men and white women for three 7-year periods: 1962–1968, 1969–1975, and 1976–1982. Annual data were grouped into three periods to divide the 21 years equally and to increase the stability of the stroke mortality rate estimates for individual SEAs. Each map includes a graph of the frequency distribution of stroke mortality rates and a shaded bar showing

the rates by deciles; the lowest decile is in white, the second decile in light gray, the middle six deciles in medium gray, the ninth decile in dark gray, and the tenth decile in black.

Results

Figure 1 shows that SEA stroke mortality rates for white men aged 35–74 years in 1962–1968 varied from a low of 61.1 to a high of 243.5 per 100,000. The weighted mean of all SEA rates in this period was 119.7 per 100,000 (Table 1). A striking cluster of SEA rates in the tenth decile can be observed in the Southeast (Mississippi, Alabama, Georgia, North Carolina, and South Carolina). Most SEAs with rates in the ninth and tenth deciles are in the South. Lowest rates occurred in the western half of the country, particularly in the Plains and Rocky Mountain states.

Despite the decline of national stroke mortality rates for white men between 1962–1968 and 1969–1975 (from 119.7 to 110.1 deaths per 100,000 [Table 1]), the range of SEA rates remained virtually unchanged in the period of 1969–1975 (Figure 2). Although declining rates clearly predominated (as indicated by lower rates at the 10th, 20th, 80th, and 90th percentiles of the distribution), there were some SEAs for which stroke mortality rates either increased or did not change. While the gross geographic pattern observed in 1962–1968 is evident in 1969–1975, there was some break-up of the concentration of SEAs with the highest rates in the Southeast and an increased concentration of SEAs with rates in the ninth and tenth deciles along the southern Mississippi River and the Ohio River valley.

In 1976–1982, there was a marked reduction in the range (Figure 3) as well as the mean (Table 1) of SEA stroke mortality rates for white men. The distribution of rates was relatively less compact. While the broad east–west gradient was maintained, there was continued break-up of the cluster of SEAs with rates in the ninth and tenth deciles in the Southeast and a continuing emergence of a cluster of SEAs with highest rates along the Mississippi River and in the Ohio River valley.

The range and mean (Table 1) of stroke mortality rates were lower for white women than for white men. The weights used in Table 1 were based on the 1970 US total population.

TABLE 1. Weighted Mean Stroke Mortality Rates for White Men and White Women Aged 35–74 Years in Continental United States

<table>
<thead>
<tr>
<th>Period</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>1962–1968</td>
<td>119.7</td>
<td>87.9</td>
</tr>
<tr>
<td>1969–1975</td>
<td>110.1</td>
<td>79.2</td>
</tr>
<tr>
<td>1976–1982</td>
<td>75.8</td>
<td>57.0</td>
</tr>
<tr>
<td>% change</td>
<td>-36.7</td>
<td>-35.1</td>
</tr>
</tbody>
</table>

Mortality rate, deaths per 100,000 age-adjusted to 1970 US total population.
FIGURE 2. Stroke mortality map, age-adjusted stroke death rates per 100,000 white men aged 35–74 years, 1969–1975, continental United States.

men. Rates for white women in 1962-1968 showed the same broad east–west gradient observed for white men but with a relatively more Northeast and North Central distribution of SEAs with the highest rates and a more Central, rather than Western, distribution of SEAs with the lowest rates (Figure 4). Compared with white men, white women show fewer high-rate SEAs along the lower Mississippi River but more high-rate SEAs along the upper Ohio River valley. SEAs with high rates in the Southeast are more clearly confined to the coastal plain for white women than for white men.

In 1969–1975, the range of stroke mortality rates for white women was reduced due to a lower maximum rate, the distribution was shifted to the left, and the minimum rate remained about the same (Figure 5). The high rates in the Southeast and the low rates in the Plains states were still evident, while the high-rate SEAs in Indiana and Ohio were more pronounced.

As for white men, stroke mortality rates for white women dropped dramatically between 1969–1975 and 1976–1982 (Table 1, Figure 6). Maps for white men (Figure 3) and white women (Figure 6) show their greatest similarity in this period, with three bands of high-rate SEAs running in generally southwest-to-northeast directions along the Mississippi River and Ohio River valley, the southern Appalachian Mountains from Alabama through West Virginia, and the Southeast coastal plain. This pattern is clearer for white men than for white women.

The magnitude of the decline in stroke mortality rates can be observed by comparing the extreme deciles of the distributions in the first and third periods. For both white men and white women, some values that in 1962–1968 occurred in the first decile (white) would be in the tenth decile (black) by 1976–1982. The distributions of rates in the first and third periods show little overlap despite their temporal separation by only 7 years. Between 1962–1968 and 1976–1982, the US mean stroke mortality rate fell 36.7% for white men and 35.1% for white women (Table 1).

Discussion

Maps of age-adjusted stroke mortality rates for white men and white women aged 35–74 years in three periods show considerable geographic variation. In comparing our maps it is important to note that the shading reflects the rank order of death rates separately for each sex and period. Thus, our maps focus on the relative geographic variation of mortality. In broad terms, there is evidence of a similar pattern of higher stroke mortality rates in the eastern U.S. and lower rates in the western U.S. for both white men and white women in all three periods. This east–west gradient is similar to
FIGURE 5. Stroke mortality map, age-adjusted stroke death rates per 100,000 white women aged 35–74 years, 1969–1975, continental United States.

the broad geographic distribution of heart disease mortality rates. 7

Within this broad pattern, however, a number of consistent smaller aggregations of SEAs with high stroke mortality rates can be observed. Perhaps the best known is the region of very high rates in the Southeast coastal plain known as the "stroke belt." 8 Despite the large declines in stroke mortality rates between the early 1960s and the early 1980s, and the presence in our latter two map periods of an increasing number of lower-rate SEAs in the rest of the South, the coastal plain SEAs of the Southeast remain in the ninth and tenth deciles of national rates for both white men and white women.

Other high-rate SEAs in the eastern U.S. occurred in the southern Appalachian Mountains and along the Mississippi River and in the Ohio River valley. The Mississippi-Ohio River concentration became more pronounced for both white men and white women over the 2 decades. By 1976–1982, both Indiana and Ohio contained a number of SEAs with stroke mortality rates in the ninth and tenth deciles for both white men and white women. Pennsylvania contained several SEAs with rates in the ninth and tenth deciles for white women in both 1962–1968 and 1969–1975.

SEAs with stroke mortality rates in the first and second deciles were most consistently found in the Plains, Mountain, and Pacific states for both white men and white women, though some low-rate SEAs, especially for white women, occurred in the eastern U.S. Of the eastern states, only Florida consistently contained SEAs with rates in the first and second deciles for both white men and white women.

In the past, stroke mortality rate maps have been presented for states, 2 SEAs, 3 and counties. 4 Our SEA maps show considerable variation within states that would not be apparent from state maps. On the other hand, due to the instability of mortality rates in small populations, 5 county maps can produce less clear spatial patterns and have in the past led some authors to conclude that there is little geographic variation in stroke mortality rates. 6

Unlike geographic studies of the association between mortality rates and other geographic attributes that use summary measures such as rate ratios or regression coefficients, maps assign a value to each area, usually based on information from only that area. Areas with small populations have unstable rates and are more likely to be found in the extreme quantiles of the rate distribution while areas with large populations are more likely to be found in the central quantiles (W.B. Davis, W. Gesler, and S. Wing, unpublished data). Due to white women's lower rates, this problem is somewhat greater for them than for white men. While this phenomenon creates some random scatter in maps, stroke mortality rates for whites aged 35–74 years and for 7 calendar years still give sufficient stability to observe striking interstate and intrastate patterns that persist and develop over time.

The geographic patterns we present must be viewed with some caution due to geographic differences in the certification of cause of death. While studies have revealed important problems in certification, 4 they also suggest that major differences between high- and low-rate areas are real and reflect differences in the same direction in incidence and case fatality. 6 No comparable data on trends in certification over time in high- and low-rate areas are available. While certification issues are of concern, we restricted our analysis to whites aged <75 years to reduce the problem of deaths with multiple chronic conditions where the difficulty of choosing one underlying cause is greatest.

The decline of the stroke mortality rate is popularly viewed as being largely a function of the declining incidence of severe hypertension and the increasing treatment of hypertension. In this regard, it is noteworthy that socioeconomic status (SES) and living conditions have improved in the United States during the period of the decline. SES is negatively associated with the prevalence of hypertension 10 and with stroke mortality. 11 These associations are consistent with the concentration of high stroke rates in the South, an area economically underdeveloped in relation to the rest of the nation. 12 Furthermore, the partial break-up of the Southern "stroke belt" is consistent with the emergence of an economically more developed "New South." 13 While our rates and maps cannot directly address these hypotheses, they provide descriptive information that may be useful in evaluating proposed determinants of the secular decline of mortality from stroke in the United States.

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