Geographic Differences in Mortality From Stroke in North Carolina

1. Analysis of Death Certificates

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SUMMARY Analysis of death certification in North Carolina for a three-year period, 1969 through 1971, showed regional differences in mortality rates from stroke in white men, with the highest rates in the Plains (tobacco growing and farming) area and the lowest rates in the Mountain region. These geographic differences in death rates were observed in all but the youngest age decade and also in the various types of stroke, i.e., hemorrhagic and occlusive cerebrovascular diseases. This regional variation in mortality, however, was not present in white women or blacks. The prevalence at death of heart disease, hypertension and diabetes also was higher in the Plains than in the Mountain region, suggesting that the observed geographic variation of stroke mortality is related to one or more of these major risk factors. It is concluded that the geographic differences in stroke mortality, which had been reported during previous decades, are real and are not due to variations in death certification, errors in diagnosis, or other explanations that might artificially produce inaccuracies in vital statistics.

MORTALITY from cerebrovascular disease in white men has been found to vary significantly from region to region in the United States, with the highest death rates appearing in the South Atlantic and the lowest in the Rocky Mountain areas.1-3 Within the southern states, there are also differences in the frequency of death from stroke, with highest rates in the Plains areas of the Carolinas and Georgia.4-6 The geographic variations in stroke mortality within these states appear to be greater than those observed between regional areas of the country.7 The factors responsible for these geographic differences within or between states are not known, but there is evidence in certain regions of the country to suggest an association between death from stroke and the frequency of hypertension.8-10 The marked differences in mortality rates from stroke observed in North Carolina within a distance of some 200 miles suggest that there may be within this state regional variations in dietary, socioeconomic or environmental determinants which seriously affect the development or outcome of vascular disease.

This study was undertaken to determine whether the regional differences in stroke mortality rates within North Carolina, which had been reported during previous decades, continue to exist and whether they hold for different age groups and for various types of cerebrovascular disease. This investigation also attempts to identify possible regional differences in the risk factors associated with stroke, which could account for the differences in mortality from this illness. The present report describes our analysis of death certification based on North Carolina and national sources of vital statistics. Subsequent reports will present the results of our review of hospital records of deaths occurring in the high and low areas of stroke mortality within North Carolina.

Methods

In order to verify prior reports of geographic variation in stroke mortality in North Carolina, detailed analyses were made of death certificate data provided by the North Carolina State Board of Health and the National Center for Health Statistics (NCHS). The files obtained from the State Board of Health were searched for data regarding deaths from stroke in the calendar years 1969 through 1971 in white men age 35 to 69 who were residents of the state. These deaths consisted only of those in which the underlying cause was coded by the state nosologists as cerebrovascular disease of any type, i.e., rubrics 430 to 438 in the eighth revision of the International Classification of Disease (ICD).

Calculations were made of the age-specific and direct age-adjusted mortality rates for stroke for each of the three years from 1969 through 1971. The appropriate population tables from the 1960 and 1970 U.S. Census of the 100 counties in the state were used for this purpose. A straight-line interpolation was employed to estimate population size for determining death rates in 1969 and 1971. Rates were calculated for each of the four major geographic regions of the state, i.e., the Mountains, Piedmont, Plains and Coastal areas (fig. 1), selected according to their geographic characteristics and to state economic areas as defined by the Bureau of Census.4 These economic areas consist of subdivisions of the state containing groups of contiguous counties which have similar social and economic characteristics.

In addition to the State Board of Health files in which stroke was coded as the underlying cause of death, independent data were obtained from the 1969 NCHS Multiple Cause-Coded death file for North Carolina. (This file was made available to us by Dr. George Meyers, Director of the Duke University Center for Demographic Studies.) From these files, age-specific and age-adjusted mortality rates were calculated for the selected group of white men described above, using all 1969 death certificates in which stroke was listed as being in any way contributory. Mortality rates were calculated for each of the following types of stroke: (1) cerebral hemorrhage (eighth revision ICD 430.0 to 431.9), (2) ischemic, thrombotic and embolic stroke.
(432.0 to 435.9), and (3) vague ill-defined stroke (436.0 to 438.9).

Rates were calculated also for all entries in the death certificates of ischemic and other types of heart disease, hypertension and diabetes — four illnesses considered to be the major precursors of stroke.

Results

Table 1 summarizes the age-adjusted annual mortality rates for all types of stroke (ICD rubrics 430 to 438) in white men ages 35 to 69 for the three years from 1969 through 1971 within each of the four defined regions of North Carolina. These rates are based on data obtained from death certificate records of the North Carolina State Board of Health and include only those deaths in which stroke was coded as the underlying cause. There is a gradient from the western to the eastern parts of the state, with the lowest rates in the Mountain area and the highest rates in the Plains.

The four regions of the state were compared in respect to these rates through the use of a mortality ratio, i.e., the death rate of each region divided by that of the Mountain region. If this ratio is significantly greater than one, the mortality rate in the Mountain region is significantly less than that of the other region. The mortality ratios for Plains versus Mountains ranged from 1.69 in 1971 to 1.75 in 1969. On the bases of these figures indicating a geographic variation in stroke mortality, further analyses were made, using data from the NCHS 1969 Multiple Cause-Coded files to verify and elucidate this phenomenon.

Table 2 shows the age-specific mortality rates in 1969 for all strokes (ICD 430 to 438) entered in the Multiple Cause-Coded files as either the underlying or secondary cause of death. Significant differences in the death rates were again noted among the four regions of the state, with the lowest rates in the western sections and the highest rates in the eastern areas. The mortality rate from stroke (considering all entries) in the Mountain region was 118/100,000; the rates in the Piedmont, Plains and Coastal regions were 140, 200 and 157/100,000, respectively. The mortality ratio was again highest for Plains versus Mountain regions and was calculated to be 1.69 for all entries of stroke. The mortality ratio for these two areas was slightly higher when stroke was certified as the underlying cause of death than when the diagnosis was listed as a secondary cause (1.80 versus 1.52, respectively). Comparison of these figures with those obtained from the North Carolina Board of Health (table 1) leads to the conclusion that the geographic variation in stroke mortality is not an artifact caused by regional differences in the place of entry of stroke diagnoses in death certificates.

As expected, mortality rates in the entire state were highest among the older age groups. Among men 65 to 69 years of age, the death rate from stroke entered as underlying and secondary causes was 660/100,000, a figure considerably higher than those of 269, 83 and 21/100,000 noted in the three younger age decades, respectively. Age-specific rates were generally lowest in the Mountain region and highest in the Plains, except for men in the 35 to 44-year age decade, in whom the number of stroke deaths was too small to provide reliable rates. It is also possible that deaths in this younger age group were caused by a particular type of stroke (e.g., congenital aneurysm or arteriovenous malformation) which would not be influenced by the same regional determinants as for arteriosclerotic or hypertensive cerebrovascular diseases.

Mortality rates were calculated for the three major types of stroke, i.e., cerebral hemorrhage (430 to 431), occlusive disease (432 to 435) and ill-defined disorders (436 to 438), and are shown in table 3 for each of the four regions of the state. The regional differences in death rates for each type of stroke follow the same pattern as those for all strokes combined. The mortality ratio for the Plains versus Mountain regions for hemorrhagic stroke and for occlusive disease listed as underlying causes of death was approximately 1.6, a value lower than that for ill-defined cerebrovascular disorders (2.19). When stroke is entered as a secondary cause of death, the mortality ratio for each type of stroke is again highest in the Plains versus Mountain regions than for any of the other geographic areas.

The regional differences in stroke mortality observed in white men are not as clearly defined in white women or in blacks (fig. 2). In each region of the state, the mortality from stroke among white women was somewhat less than that for white men, but no significant geographic differences in mortality were noted. Although stroke mortality among blacks

![Figure 1](http://stroke.ahajournals.org/)

**Figure 1** State economic areas (1 to 11) of North Carolina based on 1960 report of U.S. Bureau of the Census. Letters A to F indicate standard metropolitan areas. The heavy black lines separate the four major geographic regions of the state.

![Figure 2](http://stroke.ahajournals.org/)

**Figure 2** Age-adjusted mortality rates (per 100,000) for stroke (ICD 430 to 438) in North Carolina in 1969 according to region of state and sex-race groups (all entries). The numbers within each bar indicate the number of stroke deaths for that region.
is considerably higher than among white men or white women, no regional differences in rates are seen. There are, however, relatively few blacks living in the Mountain region of the state.

Table 4 shows the prevalence at death in the various regions in North Carolina of four illnesses considered to be important precursors or risk factors for stroke, i.e., hypertension, diabetes, ischemic heart disease and other types of heart disease. The rates for each of these disorders were generally lowest in the Mountain region and invariably highest in the Plains area of the state. These differences were present regardless of whether the deaths were certified as related in any way to stroke or caused by other illnesses. The ratios for hypertension and diabetes in the Plains versus Mountain area among stroke-related deaths were 1.23 and 1.54, respectively. The comparable ratios for ischemic heart disease and other heart disease were slightly higher, i.e., 1.73 and 2.23, respectively. The fact that these four risk factors are higher in the Plains than in other sections of the state suggest that the excess of stroke deaths in the Plains area may be related to one or more of these illnesses.

**Discussion**

These analyses of the 1969 to 1971 vital statistics in North Carolina suggest that mortality from stroke in white men is different in the four major geographic-economic regions of the state. In each of these three years, death rates from this illness were highest in the Plains and lowest in the Mountain region. A west-to-east gradient for mortality from this disease was also observed, with the death rates in the Piedmont
TABLE 3  Age-Adjusted Mortality Rates (per 100,000) From Stroke in 1969 According to Entry on Death Certificate, Region of State and Mortality Ratio Between Regions (White Men Age 35 to 69)

<table>
<thead>
<tr>
<th>Stroke Entered as Underlying Cause</th>
<th>Entire state</th>
<th>Mountains</th>
<th>Piedmont</th>
<th>Plains</th>
<th>Coastal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemorrhagic disease (ICD 430-431)</td>
<td>222</td>
<td>33.8</td>
<td>8.0</td>
<td>25.0</td>
<td>31.0</td>
</tr>
<tr>
<td>Ratio*</td>
<td>1.00</td>
<td>1.12</td>
<td>1.61</td>
<td>1.11</td>
<td></td>
</tr>
<tr>
<td>Occlusive disease (ICD 432-435)</td>
<td>171</td>
<td>26.0</td>
<td>24.0</td>
<td>20.2</td>
<td></td>
</tr>
<tr>
<td>Ratio*</td>
<td>1.00</td>
<td>1.17</td>
<td>1.65</td>
<td>1.60</td>
<td></td>
</tr>
<tr>
<td>Ill-defined disease (ICD 436-438)</td>
<td>239</td>
<td>36.4</td>
<td>27.0</td>
<td>22.6</td>
<td></td>
</tr>
<tr>
<td>Ratio*</td>
<td>1.00</td>
<td>1.13</td>
<td>1.56</td>
<td>1.33</td>
<td></td>
</tr>
<tr>
<td>All stroke (ICD 430-438)</td>
<td>632</td>
<td>96.2</td>
<td>82.0</td>
<td>70.9</td>
<td>103.8</td>
</tr>
<tr>
<td>Ratio*</td>
<td>1.00</td>
<td>1.26</td>
<td>1.80</td>
<td>1.46</td>
<td></td>
</tr>
</tbody>
</table>

*Ratio = rate for each region divided by rate for Mountain area.
†Ratio significantly greater than one ($P < 0.05$).

TABLE 4  Age-Adjusted Prevalence Rates (per 100,000) of Risk Factors of Stroke at Time of Death in 1969 According to Entry of Stroke on Death Certificate, Region of State and Ratio Between Regions (White Men Age 35 to 69, All Entries)

<table>
<thead>
<tr>
<th>Stroke Mentioned on Death Certificate</th>
<th>Mountains</th>
<th>Piedmont</th>
<th>Plains</th>
<th>Coastal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypertension (ICD 400-404)</td>
<td>25</td>
<td>22.0</td>
<td>63</td>
<td>19.0</td>
</tr>
<tr>
<td>Ratio*</td>
<td>1.00</td>
<td>0.86</td>
<td>1.23</td>
<td>1.03</td>
</tr>
<tr>
<td>Diabetes (ICD 250)</td>
<td>11</td>
<td>9.1</td>
<td>34</td>
<td>10.3</td>
</tr>
<tr>
<td>Ratio*</td>
<td>1.00</td>
<td>1.13</td>
<td>1.54</td>
<td>1.24</td>
</tr>
<tr>
<td>Ischemic heart disease (ICD 410-414)</td>
<td>39</td>
<td>33.1</td>
<td>126</td>
<td>38.2</td>
</tr>
<tr>
<td>Ratio*</td>
<td>1.00</td>
<td>1.15</td>
<td>1.73f</td>
<td>1.32</td>
</tr>
<tr>
<td>Other heart disease (ICD 390-398, 420-429)</td>
<td>13</td>
<td>11.1</td>
<td>55</td>
<td>16.6</td>
</tr>
<tr>
<td>Ratio*</td>
<td>1.00</td>
<td>1.49</td>
<td>2.23</td>
<td>1.61</td>
</tr>
<tr>
<td>All Other Deaths</td>
<td>40</td>
<td>34.6</td>
<td>125</td>
<td>37.8</td>
</tr>
<tr>
<td>Hypertension (ICD 400-404)</td>
<td>1.00</td>
<td>1.09</td>
<td>1.43</td>
<td>1.37</td>
</tr>
<tr>
<td>Diabetes (ICD 250)</td>
<td>70</td>
<td>60.8</td>
<td>198</td>
<td>59.8</td>
</tr>
<tr>
<td>Ratio*</td>
<td>1.00</td>
<td>0.98</td>
<td>1.58f</td>
<td>0.85</td>
</tr>
<tr>
<td>Ischemic heart disease (ICD 410-414)</td>
<td>583</td>
<td>517.2</td>
<td>1,896</td>
<td>571.6</td>
</tr>
<tr>
<td>Ratio*</td>
<td>1.00</td>
<td>1.11f</td>
<td>1.28f</td>
<td>1.26f</td>
</tr>
<tr>
<td>Other heart disease (ICD 390-398, 420-429)</td>
<td>214</td>
<td>189.9</td>
<td>784</td>
<td>236.2</td>
</tr>
<tr>
<td>Ratio*</td>
<td>1.00</td>
<td>1.24†</td>
<td>1.55†</td>
<td>1.27†</td>
</tr>
</tbody>
</table>

*Ratio = rate for each region divided by rate for Mountain area.
†Ratio significantly greater than one ($P < 0.05$).
region being slightly higher than those in the Mountains but lower than those in the Plains and Coastal regions. The findings in the present study confirm previous reports which showed differences in the years 1950 to 1959 and 1959 to 1961. These reports, however, were based only on entries of stroke as the underlying cause of death, and it seemed possible that regional differences in certification practices could account for these findings. In the present study, the regional differences in mortality were present when stroke was certified as either the underlying or secondary cause of death, and it seems unlikely that the variation in mortality is an artifact related to the place of entry of stroke diagnoses in the death certificate. Regional differences in mortality were also present for each age decade except for those in the 35 to 44 age range. As stated earlier, death from stroke in this age group may be caused by congenital vascular abnormalities of the brain such as berry aneurysm, rather than by atherosclerosis or hypertensive disease. The fact that these geographic variations exist only for white men, and not for white women or blacks, also was noted in other areas of the country by Kuller and his associates. This observation suggests that the geographic determinants of stroke mortality within or between states are sex-race related.

The mortality ratios between the four regional areas of the state were essentially the same for hemorrhagic stroke, occlusive vascular disease (thrombosis or embolism), and ill-defined types of disease. This finding suggests that hypertension may not be the major factor accounting for the geographic pattern in stroke mortality, since high levels of blood pressure would be more likely to produce higher rates of cerebral hemorrhage. In some geographic areas of the country, mortality from stroke does not correspond to mortality from ischemic heart disease. However, persons with coronary heart disease (even in the absence of hypertension) have an excess risk of cerebral infarction. In such cases, strokes may be due to impaired circulation caused by poor cardiac output, to cerebral embolism due to mural thrombi and arrhythmias, or simply to the presence of diffuse atherosclerotic lesions in the cerebral and coronary arteries.

In addition to these known risk factors, it has been suggested that the observed geographic patterns in stroke mortality may be caused by differences in case-fatality rates from this illness. Studies by Kuller, however, have shown that the case fatality from stroke in one of the high stroke mortality areas of North Carolina did not differ significantly from that in low mortality areas elsewhere in the country.

A number of cultural and environmental factors have been proposed by Sauer as contributing to geographic differences in stroke mortality. Included among them are personality patterns, smoking habits, occupational and socioeconomic factors, hardness of drinking water, physical exercise, diet and intake of salt and trace elements. Studies of several of these variables in the high and low stroke mortality areas of the country are now being carried out, and it is hoped that some of the causative factors responsible for the excess stroke mortality will be identified.

Acknowledgments

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Geographic differences in mortality from stroke in North Caroline. 1. Analysis of death certificates.
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