Declining mortality due to stroke has been a constant feature of differential mortality in the United States. The fact that this decline has been accompanied by an improvement in hypertension detection and control has led to the conclusion that hypertension control has played a major role in the recent lower trend. However, factors such as decreased severity of the disease and improved diagnostic and/or therapeutic modalities may also have contributed. To determine whether changes in case severity and case fatality ratios have contributed to the decline between 1971 and 1980, we examined mortality rates due to stroke in Allegheny County, Pennsylvania, and case fatality ratios in two hospitals in the same county (including the city of Pittsburgh) in 1971-1980. A further objective was to examine the effect of computed tomography (CT scanning) on the diagnostic subclassification of stroke cases.

Subjects and Methods

Stroke Mortality Rates

Death details for the residents of Allegheny County who had cerebrovascular disease (CVD) cited as the underlying cause of death during the period 1971-1980 were obtained by examination of the computer data file that was created from the available statewide vital statistics for the purpose of this study. The variables in the data file include age, sex, race, and underlying cause of death coded according to the Eighth and Ninth Revisions of the International Classification of Disease. Ages were adjusted using the 1940 one million standard population, which is used extensively in the literature to render results comparable with other data. The formula used to detect significance of the decline in mortality rates is

\[ R - S > 2 \times \sqrt{\frac{R^2}{N} + \frac{S^2}{M}} \]

where \( R \) = rate in \( N \) events during baseline year compared with \( S \) rate in \( M \) events during the second year. The difference between the two rates is significant if it exceeds the calculated value.

Case Fatality Ratios

Two large hospitals that lie in and serve two distinct areas were chosen to evaluate case fatality ratio. The choice of these two centers enabled us to obtain data from both a private hospital and a more general community hospital with fairly constant catchment areas. Criteria of selection include all those patients discharged from the two hospitals with the primary or secondary diagnosis of stroke (codes 430-438 of the Eighth and Ninth Revisions of the International Classification of Disease) in June and July of 1971, 1974, 1977, and 1980. Selection of a fixed time frame for sampling each year minimized any possible impact of seasonal variation on stroke mortality so that inferences on trends are unlikely to be biased.

By reviewing the discharge lists, 840 study patients were identified: their medical records were retrieved, and all information was recorded on the data collection form designed for this study. Accuracy of the diagnosis of the study patients was determined by applying strict...
diagnostic criteria used in the National Survey of Stroke.  

Results

Stroke Mortality Rates

Our data suggest that a moderate decline in stroke mortality has occurred in Allegheny County during the period 1971–1980. This decline is estimated to be 29% of the original rate in 1970 and is consistent for almost all age groups, both sexes, and two races (black and white).

While the maximum decline in rates occurred between the ages of 65 and 74 years (43%), the smallest recorded decline was among those 85 years and older (17%); reductions of 27–41% of the original rates occurred in the other age groups. According to our data, the age-adjusted mortality rates dropped from 61 to 38 per 100,000 population during the same time period. Both men and women showed comparable declines (25 and 21%, respectively). The declining trend with and without age adjustment was more pronounced in blacks (Figure 1).

Case Fatality Ratios

Characteristics of the study patients are shown in Table 1. About 45% were discharged in the first 2 years of the study. The majority of cases were older than 65 years (71.8%), and >50% were men. Whites formed >90% of the study population.

One hundred thirty patients with the diagnosis of acute or chronic CVD (15.5%) died during their hospital stay. Hemorrhagic strokes were usually more severe than nonhemorrhagic strokes as evidenced by the higher proportion in coma and their higher case fatality ratio compared with other types of acute stroke (Table 2).

Figure 2 shows the percent of comatose patients and case fatality ratios for the period 1971–1980. There is a significant association between case fatality and coma. The occurrence of coma reflects severity of the disease and is a more common comorbid event in hemorrhagic than in other types of stroke. Comatose patients have a greater risk of dying from stroke than noncomatose patients (odds ratio 3.07), as shown in Table 3. The practice of CT scanning was accompanied by lower case fatality ratios. While 15% of those without CT scans died, only 9% of the scanned patients died; however, this difference was not significant. Chances of survival were higher in scanned than in nonscanned patients.

Multivariate analysis. Multiple logistic regression analysis was carried out to detect which variables affected the outcome of stroke. Only acute stroke due to intracerebral hemorrhage, thromboembolism, and ill-defined cerebrovascular accident was considered. Based on the results of univariate analyses, those clinical features significantly associated with outcome (coma, type of stroke) were entered into the multivariate analysis. Other relevant patient characteristics for which data were available (age, history of high blood pressure or cerebrovascular accident) were also added to the model. Stepwise regression analysis showed that neither patient characteristics nor hospital and year of discharge were significant predictors of the outcome of acute stroke. Of the clinical features, coma was the most significant predictor of hospitalized stroke deaths ($R^2 = 0.36, F = 133, p<0.00001$).

Discussion

In Allegheny County, stroke mortality rates declined during the period 1971–1980, paralleling the nationwide trend reported by Cooper in 1984 and by us (Figure 3). The consistent decline for all ages, both sexes, and two races corresponds with findings of
Declining Mortality in Allegheny County

Table 2. Distribution of Coma and Outcome in Different Types of Acute Stroke in Two Allegheny County Hospitals

<table>
<thead>
<tr>
<th>Type of stroke</th>
<th>Coma Yes</th>
<th>No</th>
<th>Total</th>
<th>Outcome Alive</th>
<th>No</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>%</td>
<td></td>
<td>No.</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Hemorrhagic brain infarct</td>
<td>13</td>
<td>59</td>
<td>22</td>
<td>10</td>
<td>43</td>
<td>23</td>
</tr>
<tr>
<td>Ischemic brain infarct</td>
<td>24</td>
<td>16</td>
<td>46</td>
<td>115</td>
<td>79</td>
<td>146</td>
</tr>
<tr>
<td>Ill-defined cerebrovascular accident</td>
<td>30</td>
<td>21</td>
<td>114</td>
<td>99</td>
<td>68</td>
<td>146</td>
</tr>
<tr>
<td>Total</td>
<td>67</td>
<td>21</td>
<td>246</td>
<td>224</td>
<td>71</td>
<td>315</td>
</tr>
</tbody>
</table>

\[ \chi^2 = 18.9, p \leq 0.0005 \] for coma; \[ \chi^2 = 13.6, p \leq 0.005 \] for fatality.

*Data were not available for 2 patients.

Soltero et al\(^\text{16}\) and the National Survey of Stroke.\(^\text{12}\)

The drop in stroke mortality rates may be secondary to a reduced prevalence of hypertension, the main risk factor, especially among blacks. Support for this hypothesis comes from the national estimates of prevalence rates of hypertension since a decline from 18.4 to 16.9 per 100 adults aged 25–74 years has occurred during the period 1971–1975 and from the recent Minnesota Heart Survey findings in 1985.\(^\text{4,17,18}\)

Racial differences in mortality due to stroke have been a constant feature of mortality in the United States,\(^\text{19,20}\) where higher rates are consistently reported for blacks. In Allegheny County, though blacks initially had much higher mortality rates than whites and though they experienced a steeper and faster decline in mortality rates than whites, after age adjustment blacks still had higher stroke mortality rates. The proportionately greater decline in black rates may reflect a greater impact of recent hypertension control efforts in blacks in the latter part of this decade. Unfortunately, no data on hypertension control by race are available for Allegheny County.

Declining mortality from CVD in Allegheny County was accompanied by a reduction in case fatality ratios in the two hospitals of the study. Although the decline in total CVD mortality may have resulted in part from the reduction in case fatality, caution is indicated in comparing these rates because case fatality ratios were derived from selected hospital samples that did not necessarily represent the general population of Allegheny County. However, the Minnesota Heart Survey reported a 30% decline in hospital case fatality ratios for men aged 30–64 between 1970 and 1980.\(^*\)

The acute stroke case fatality ratio provided by our study is comparable to that of the National Survey of Stroke. This is supported by the similarity of case fatality ratios for thromboembolic and hemorrhagic brain infarctions in our study and in the National Survey of Stroke (hemorrhagic brain infarction case fatality ratios 57 and 67%, respectively). Our findings agree with the 1-month case fatality ratios reported from New Zealand\(^\text{21}\) and from most of the 15 centers in the World Health Organization Collaborative Stroke Register.\(^\text{14}\)

Lower case fatality ratios may be associated with reduced severity of the disease and with hospitalization of milder cases as well as with improved management of acute stroke. Several investigators have attempted to relate some clinical findings, such as walking ability, ocular mobility, disturbed alertness, and coma, to the severity and outcome of the disease. They have found significant correlations between case fatality on one hand and hemorrhagic stroke and coma on the other.\(^\text{12,13,22}\) Results of our study support previous findings since mortality was noticeably higher among comatose than noncomatose patients and among cases of hemorrhagic than of ischemic stroke.

Table 3. Comparisons of Deaths and Survivors of Stroke Among Study Patients in Two Allegheny County Hospitals

<table>
<thead>
<tr>
<th>Features</th>
<th>Deaths</th>
<th>Survivors</th>
<th>Total</th>
<th>Odds ratio</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coma</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>69</td>
<td>25</td>
<td>94</td>
<td>30.7</td>
<td>0.0001</td>
</tr>
<tr>
<td>Row %</td>
<td>73</td>
<td>27</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>61</td>
<td>678</td>
<td>739</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Row %</td>
<td>8</td>
<td>92</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>130</td>
<td>703</td>
<td>833</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Row %</td>
<td>16</td>
<td>84</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of stroke</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hemorrhagic</td>
<td>13</td>
<td>10</td>
<td></td>
<td>3.6*</td>
<td>0.0001</td>
</tr>
<tr>
<td>Thromboembolic</td>
<td>31</td>
<td>115</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ill-defined CVA</td>
<td>47</td>
<td>99</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computed tomography</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>12</td>
<td>126</td>
<td></td>
<td>0.6</td>
<td>NS</td>
</tr>
<tr>
<td>No</td>
<td>48</td>
<td>277</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CVA, cerebrovascular accident. NS, not significant at 0.05. For coma, \[ \chi^2 = 263.8; p \leq 0.0001 \].

*Odds ratio for hemorrhagic vs. thromboembolic strokes and ill-defined CVA combined.
The outcome of acute stroke was basically determined by the presence of coma in our study population, a finding that is supported by Wade et al and by the Collaborative Stroke Register studies. The proportion of patients with well-defined stroke (cerebral hemorrhage, thromboembolism) was higher among CT-scanned than -nonscanned patients in 1980 (28 and 8%, respectively), while the proportion of all CVD cases diagnosed as thromboembolic or hemorrhagic brain infarcts remained the same. Moreover, the proportion of milder cases (transient ischemic attacks and other cerebrovascular disorders) was almost the same in CT-scanned and -nonscanned patients. Therefore, it is speculated that physicians may now limit a specific diagnosis of stroke type to cases with information from CT scanning in addition to other clinical findings.

It may be concluded that in addition to the possible impact of CT scanning on the management of stroke, changing disease severity between 1971 and 1980 as manifested by decreasing proportions of comatose patients (from 16 to 6%) may have significantly contributed to the declining case fatality ratio of stroke patients in our study. Further studies are needed to examine our findings and to identify other reasons for the changing severity and the declining case fatality ratio of stroke using data on hypertension control, stroke mortality, and hospital case fatality ratios in defined communities.

References

Key Words: cerebrovascular disorders • epidemiology • mortality
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