Secular Trend of Mortality From Cerebral Infarction and Cerebral Hemorrhage in Taiwan, 1974–1988

Chung-Chung Chang, MS, and Chien-Jen Chen, ScD

Background and Purpose: Pathological patterns of stroke are different in various races, with the predominant stroke type in the Chinese being intracerebral hemorrhage. A total of 31,078 deaths from cerebral infarction and 77,773 deaths from cerebral hemorrhage in Taiwan were reported for groups of subjects aged 40–79 years during the period 1974–1988 to elucidate their secular trends.

Methods: Vital statistics and demographic data were collected for analyzing the truncated age-adjusted mortality rates. Poisson regression analysis was used to estimate the relative risk and 95% confidence interval.

Results: The mortality rates for cerebral hemorrhage were greater than those for cerebral infarction. The mortality rates increased exponentially with age for both subtypes. The decline in age-specific mortality for the period 1974–1983 was much more striking for cerebral hemorrhage than for cerebral infarction. Mortality from cerebral infarction and hemorrhage increased with age for all birth cohorts except the cerebral hemorrhage mortality of the oldest cohort. Male/female ratios for both cerebral infarction and hemorrhage were greater in the younger age groups. The cerebral hemorrhage/infarction ratio during the period 1984–1988 was highest for the younger age groups and lowest for the oldest age groups.

Conclusions: The different secular trends of mortality from cerebral infarction and hemorrhage imply that these two patterns of stroke may be associated with some different risk factors. (Stroke 1993;24:212–218)

Key Words: cerebral infarction • cerebral hemorrhage • epidemiology • mortality • Taiwan

Pathological patterns of cerebrovascular disease (CVD) and distributions of cerebrovascular lesions are different in various races. Only 6.3–11.9% of strokes in whites were reported to be intracerebral hemorrhage,1–4 whereas 21–48% of strokes were estimated to be hemorrhagic in the Chinese.5–7 This racial discrepancy may be attributable to differences in admission policy, diagnostic accuracy, and age distribution as well as related risk factors.8 Blacks and the Japanese have more intracranial occlusive CVD, whereas whites have more extracranial CVD.9–12 The preponderance of intracranial vascular lesions in the Chinese is similar to that seen in blacks and the Japanese.13,14 This difference in the distribution of lesions is not readily explained by the differences in incidence of transient ischemia, hypertension, diabetes, hypercholesterolemia, or ischemic heart disease.

CVD has been the most common cause of death in mainland China and Taiwan. It was the leading cause of death from 1963 to 1982 and has become the second most common cause of death in Taiwan.15 Many epidemiological studies of CVD reported a downward trend in stroke mortality and morbidity in developed countries in the past 30 years.16–22 Stroke mortality has been decreasing in Taiwan since 1967,23 but the magnitude of decline is not as striking as that in the United States and Japan. During the period 1972–1979, stroke mortality declined 13.8% for men and 16.6% for women in Taiwan; these percent changes were approximately half those in the United States and Japan.24 In other words, stroke mortality in Taiwan decreased by approximately 2% per year from 1972 to 1983 and approximately 4–5% per year after 1984.25 Because the pattern of CVD is important for diagnostic, therapeutic, rehabilitative, and preventive purposes, the present study reports the secular trend of mortality from cerebral infarction (CI) and cerebral hemorrhage (CH) in Taiwan between 1974 and 1988 by age, calendar year, and birth year by use of Poisson regression analysis.

Subjects and Methods

In Taiwan, because it is mandatory to register any event of birth, death, marriage and divorce, migration, and employment in the household registration offices, the vital statistics and demographic data are very complete.26 Information on all deaths from CVD in Taiwan was abstracted from annual vital statistics published by the Department of Health from 1974 to 1988.25 More than 95% of the death certificates are issued by physicians in public or private hospitals. Another 4% of the death certificates, primarily those in which accidents are

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involved, are issued by coroners. Only about 0.7–1% of the death certificates are completed by other health personnel and local officers, who may not be familiar with the form of death certificates and diagnostic criteria for CVD. In other words, the causes of death listed in the certificates are considered accurate to an acceptable level. Mortality data were grouped by sex, age in 5-year groups, and detailed cause of death. Mortality from CI and CH was identified as 433–434 and 431, respectively, in both the eighth and ninth editions of the International Classification of Diseases (ICD-8 and ICD-9, respectively). Only few or no deaths were observed among groups of subjects aged <40 years, and therefore mortality rates were calculated for groups aged 40–79 years. A total of 171,022 deaths from CVD, 31,078 deaths from CI, and 77,773 deaths from CH were reported for groups aged 40–79 years during the period 1974–1988.

The data of midyear population by age and sex in Taiwan were obtained from Demographic Facts, which is published annually by the Taiwan Ministry of the Interior. From 1974 to 1988, a total of 64,796,035 person-years were observed for groups aged 40–79 years. To examine the secular trend of mortality in the last 15 years, truncated age-adjusted mortality rates were calculated using the direct standardization method and world population in 1976 as the standard population. In the data analysis, mortality as grouped by age (eight 5-year groups: 40–44, 45–49, 50–54, 55–59, 60–64, 65–69, 70–74, and 75–79), calendar year (three 5-year groups: 1974–1978, 1979–1983, and 1984–1988), and birth year (six 5-year groups: 1909–1913, 1914–1918, 1919–1923, 1924–1928, 1929–1933, and 1934–1938). The mortality of CVD is assumed to follow a Poisson distribution. The Poisson regression analysis was used to estimate the relative risk with a 95% confidence

**FIGURE 1.** Graphs showing the secular trend of age-adjusted mortality from cerebrovascular disease (CVA), cerebral hemorrhage (CH), and cerebral infarction (CI) for men (panel A) and women (panel B) aged 40–79 years in Taiwan, 1974–1988.

**FIGURE 2.** Graphs showing mortality rates from cerebral infarction by age and calendar year for men (panel A) and women (panel B) aged 40–79 years in Taiwan, 1974–1988.
interval for each age, calendar period, and birth cohort group based on a maximum-likelihood method. The statistical package EGRET was used in the computation.

Results

Secular trends of age-adjusted mortality from CVD, CI, and CH for men and women in Taiwan from 1974 to 1988 are shown in Figure 1. There was a significant decline of CVD and CH mortality for both men and women, but no decrease in CI was observed until after 1979 for men and after 1981 for women. The mortality rates of CH were greater than those of CI, and men had higher mortality rates than women, particularly for CH. Figure 2 illustrates secular trends of age-specific mortality rates of CI by calendar year. CI mortality rates of men and women increased exponentially with age. The relative risks of CI in the group aged 75–79 years compared with the group aged 40–44 years were 152.4 and 185.9, respectively, for men and women, with a 95% confidence interval of 130.1–177.5 and 157.4–219.2, respectively. The changes in age-specific mortality rates from the period 1974–1978 to the period 1979–1983 were smaller than those from the period 1979–1983 to the period 1984–1988. The age-adjusted relative risks (95% confidence interval) of CI in the periods 1974–1978 and 1979–1983 compared with the period 1984–1988 were 1.60 (1.54–1.66) and 1.41 (1.36–1.46) for men and 1.45 (1.40–1.51) and 1.36 (1.30–1.41) for women.

As shown in Figure 3, CH mortality rates also increased exponentially with age for both men and women. The relative risks of CH in the group aged 75–79 years compared with the group aged 40–44 years were 28.3 and 52.8, respectively, for men and women, with a 95% confidence interval of 26.8–30.0 and 48.9–56.9, respectively. The change in age-specific mortality rates of CH from the period 1974–1978 to the period 1979–1983 was similar to that from the period 1979–1983 to the period 1984–1988 for both men and women. The age-adjusted relative risks (95% confidence interval) of CH in the periods 1974–1978 and 1979–1983 compared with the period 1984–1988 were 2.84 (2.77–2.91) and 1.73 (1.69–1.78) for men and 2.65 (2.58–2.73) and 1.64 (1.59–1.68) for women.

The changing pattern for CH between these two calendar periods was similar for all age groups of men and women, as was the pattern for CI except for the group of women aged 50–54 years. The decline in age-specific mortality from the period 1974–1988 was much more striking for CH than for CI, especially for groups aged ≥50 years.

Table 1. Male/Female Ratio of Cerebral Infarction and Cerebral Hemorrhage by Age and Calendar Year in Taiwan, 1974–1988

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Cerebral infarction</th>
<th>Cerebral hemorrhage</th>
</tr>
</thead>
<tbody>
<tr>
<td>40–44</td>
<td>0.92</td>
<td>1.35</td>
</tr>
<tr>
<td>45–49</td>
<td>0.85</td>
<td>1.02</td>
</tr>
<tr>
<td>50–54</td>
<td>0.82</td>
<td>1.40</td>
</tr>
<tr>
<td>55–59</td>
<td>1.05</td>
<td>0.91</td>
</tr>
<tr>
<td>60–64</td>
<td>1.15</td>
<td>1.10</td>
</tr>
<tr>
<td>65–69</td>
<td>1.24</td>
<td>1.06</td>
</tr>
<tr>
<td>70–74</td>
<td>1.11</td>
<td>1.03</td>
</tr>
<tr>
<td>75–79</td>
<td>0.98</td>
<td>0.94</td>
</tr>
</tbody>
</table>
Mortality rates for CH were higher than those for CI, and the male/female (M/F) ratio (as shown in Table 1) ranged from 0.94 to 2.17 for CH and from 0.82 to 1.57 for CI in various age groups during the periods 1974–1978, 1979–1983, and 1984–1988. The M/F ratio of CH was greater in the younger age groups. The ratio increased with the calendar period in groups aged <55 years but decreased with the calendar period in the older age groups. The M/F ratio of CI increased with the calendar period for groups aged <60 years and decreased with the calendar period for the older age groups.

Figure 4 illustrates secular trends of age-specific mortality rates for CI for various cohorts according to their birth years. The mortality rates increased with age in all birth cohorts for both men and women. But as shown in Figure 5, the CH mortality of men increased with age only in the younger cohorts.

There was a decline in CH mortality with age in cohorts born before 1929. However, the CH mortality of women either increased or remained similar for all birth cohorts except the oldest cohort, born in 1909–1913. Figure 6 presents the secular trends of CH/CI ratio by age and calendar year. CH/CI ratios of 1974–1978 were greater than those of 1979–1983 in all age groups for men and in groups aged >50 years for women. But the ratios in 1984–1988 were highest in groups aged <50 years for both sexes and lowest in groups aged >49 years for men and in groups aged >55 years for women.

Discussion

Striking contrasts are evident in mortality from CVD compared with mortality from arteriosclerotic heart disease within countries and internationally. Interna-
tional comparisons have shown that in areas with high stroke and low arteriosclerotic heart disease rates such as Japan, the predominant CVD is hypertensive intracerebral hemorrhage.\textsuperscript{51,52} A large-scale epidemiological study held in mainland China reported that CI accounted for the majority of completed strokes, the same as elsewhere in the world.\textsuperscript{6} But compared with white and Japanese populations, the percentage of CH (44\%) among incident cases in China was much higher than that reported for white populations (6–12\%)\textsuperscript{1–4} and somewhat higher than that for Japanese populations (17\%).\textsuperscript{33} We present here the first study on the secular trend of CI and CH among the Chinese population in Taiwan.

Data from vital statistics may have problems of validity. Revisions of codes for the ICD and changes of the diagnostic pattern should be taken into consideration in the assessment of long-term variations in mortality. In Taiwan, the ICD-8 (codes 431 for CH and 433–434 for CI) was used from 1974 to 1980, and the ICD-9 (codes 431 for CH and 433–434 for CI) was used from 1981 to 1988. According to the Japanese Ministry of Health and Welfare, the comparability ratio for change of CVD classification from ICD-8 (=1) to ICD-9 was estimated at 0.9822.\textsuperscript{34} In the present analysis, this ratio was not used, and data were taken as part of a continuous trend. To indicate that there was no movement from one diagnostic category to another, secular trends of heart disease, hypertension, and diabetes mellitus against stroke are shown in Figure 7. There has been an increase in the mortality from diabetes mellitus and heart disease. However, the slight increase in these two diagnostic categories cannot explain the striking decline in CVD mortality. Because both incidence and case fatality have impacts on mortality, the interpretation of mortality data should be cautious. In a large-scale hospital-based registry in Taiwan, the 30-day case-fatality rate was 30.7\% for CH and 8.4\% for CI in 1985, and it was 26.8\% for CH and 10.1\% for CI in 1990.\textsuperscript{35} The slight decrease in the fatality rate for CH may be due to the increased proportion of fewer life-threatening stroke events resulting from improved diagnosis of cases of milder stroke that previously went undetected. Because the fatality rate remained rather constant in

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{graph1.png}
\caption{Graphs showing cerebral hemorrhage/cerebral infarction (CH/CI) ratio of cerebrovascular disease by age and calendar year for men (panel A) and women (panel B) aged 40–79 years in Taiwan, 1974–1988.}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{graph2.png}
\caption{Graphs showing comparison of secular trends of age-adjusted mortality rates from cerebrovascular disease (CVA), heart disease (HD), diabetes mellitus (DM), and hypertension (HT) for men (panel A) and women (panel B) aged 40–79 years in Taiwan, 1974–1988.}
\end{figure}
the study period, the decline of CVD mortality is perceived as a decrease in stroke incidence of both CI and CH. Because computed tomography was not widely used to evaluate patients with completed stroke before 1980, small CH might be misdiagnosed as CI. By 1989 there were 153 computed tomodagrams in 21 counties throughout Taiwan, with a coverage rate of 90%. The actual proportion of CH may be slightly larger than that shown in the figures.36

Only population-based incidence studies may monitor changes over time and determine whether the decline in mortality is explained by improvements in incidence; however, the secular trend of stroke incidence is not available in Taiwan, as in many other countries. Over the past 30 years, stroke mortality declined in the United States and Japan as well as some other developed countries. There is little doubt that the decline is real rather than an artifact of reporting or death certificate coding. The striking decline in stroke morality suggests the presence of modifiable environmental factors in the development of stroke.

The decline in stroke mortality is basically attributable to the identification of hypertension as the major risk factor for stroke, and particularly for CH. It has been demonstrated that treatment of hypertension may reduce stroke incidence and mortality. In the United States stroke mortality has been decreasing rapidly since 1973; it decreased by approximately 2% per year from 1950 to 1972 and approximately 7% per year after 1973.18 Possible factors related to such a decline include the decrease in coronary heart disease mortality, the smoking cessation program, a high intake of potassium, fresh fruits, and vegetables, and control of hypertension.37-39 The sheer magnitude of decline in stroke mortality before 1950 almost certainly reflected a true decrease in stroke incidence, although the mechanism for this decline is uncertain. Antihypertensive therapy certainly could not explain the decline during this early period.18

In Japan the age-adjusted death rate from stroke has decreased for both men and women since 1965, and this downward trend accelerated in 1971.34 The factors attributable to the decline may not be the same as those in the United States. Possible contributing factors were the progress and implementation of detection and treatment of hypertension, a decrease in salt intake, and an appropriate increase in the consumption of animal fat and protein.33,40,41 However, in some European countries such as Finland and Denmark, the total mortality of stroke without specifying subtypes did not show any clear decline.

In Finland the history of heart disease was found to be associated with CVD mortality, but hypertension, diabetes, pure myocardial infarction, and previous transient ischemic attacks were not associated with CVD mortality.21 In Copenhagen the stroke incidence was relatively high, and there was a slight decrease in stroke incidence among younger women but not in older women or men.42 The magnitude of the ratio between the male and the female mean incidence rates by increasing age corresponded exactly to the age distribution of the use of oral contraceptives in Denmark from 1977 to 1982.43 Significant potential risks were found for cigarette smoking, high blood pressure, diabetes, plasma cholesterol concentration, and ischemic heart disease.44 Among Swedish women stroke incidence increased by 38% between the 1970s and 1980s; however, the incidence in men did not change significantly from the first period to the second.45 The cause of increased stroke incidence among women has not been established.

In New Zealand the treatment of hypertension was estimated to account for roughly 10% of the observed reduction in deaths from stroke.46 A greater understanding of the reasons for the decline in mortality from stroke is required. Studies on secular trends of mortality and/or incidence rates for a particular disease can provide clues or hypotheses for testing its etiology. All these inconsistent secular trends of stroke morbidity and mortality in various countries imply that the pattern of stroke varies in countries and races, and subtypes of stroke may not share similar risk factors.

Stroke is a disease of high mortality in Taiwan. The high percentage of CH is definitely a contributing factor to the high mortality. Studies on possible risk factors of stroke in the Chinese are rare; only hypertension and a salty diet have been reported.46 Improved management of hypertension has been proposed as the main reason for the recent decline in mortality from stroke. Effective antihypertensive drugs have been available since the early 1960s in Taiwan, but the range of agents and their acceptability have not increased considerably over the past 20 years. Although the prevalence of hypertension in Taiwan was slightly lower than that in Chicago,46 the proportion of hypertensive patients with adequately controlled blood pressure was approximately 5% in the former in contrast with approximately 70% in the latter. The poor control of hypertension in Taiwan may account for the slow decline of stroke mortality.

Since 1949, the lifestyles of residents in Taiwan have undergone profound and accelerating changes in regard to dietary patterns, employment activity, urbanization, and medical care. All these changes potentially contributed to an evolving spectrum of stroke. In the mid-1970s, community-based nutrition education campaigns and nationwide programs to identify and treat hypertension were implemented to reduce the daily intake of animal fat and salt and to control hypertension.

As shown in the present study, the decline of CI mortality from the period 1974–1978 to the period 1979–1983 might not be influenced by these activities, because CI mortality in each birth cohort year was still increasing. CH mortality in younger cohorts also increased, and only in older cohorts did CH mortality show decline. According to the CH/CI ratio, CH was relatively more important in the younger than in the older age groups. This implies that CH is a predominant type of fatal stroke in the Chinese, particularly in Chinese youth.

In view of the secular trend of CH/CI ratios, control of hypertension seems to have more of an effect on CH than on CI. Some widespread modifiable environmental factors significantly associated with stroke but not with hypertension may exist. Thus, the risk factors for CI and CH may be different. The inconsistent decline pattern of CI and CH may be attributable to the different impacts of risk factors such as cigarette smoking, alcohol consumption, serum cholesterol and triglyceride levels, diabetes mellitus, and coronary heart disease. Future investigations through case–control studies and cohort studies are urgently needed.
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