Trends in the Incidence, Severity, and Short-Term Outcome of Stroke in Perth, Western Australia

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Background and Purpose—This report describes trends in the key indices of cerebrovascular disease over 6 years from the end of the 1980s in a geographically defined segment of the city of Perth, Western Australia.

Methods—Identical methods were used to find and assess all cases of suspected stroke in a population of approximately 134,000 residents in a triangular area of the northern suburbs of Perth. Case fatality was measured as vital status at 28 days after the onset of symptoms. Data for first-ever strokes and for all strokes for equivalent periods of 12 months in 1989–1990 and 1995–1996 were compared by age-standardized rates and proportions and Poisson regression.

Results—There were 355 strokes in 328 patients and 251 first-ever strokes (71%) for 1989–1990 and 290 events in 281 patients and 213 first-ever strokes (73%) for 1995–1996. In Poisson models including age and period, overall trends in the incidence of both first-ever strokes (rate ratio = 0.75; 95% confidence limits, 0.63, 0.90) and all strokes (rate ratio = 0.73; 95% confidence limits, 0.62, 0.85) were obviously significant, but only the changes in men were independently significant. Case fatality did not change, and the balance between hemorrhagic and occlusive strokes in 1995–1996 was almost indistinguishable from that observed in 1989–1990.

Conclusions—Our results, which are the only longitudinal population-based data available for Australia for key indices of stroke, suggest that it is a change in the frequency of stroke, rather than its outcome, that is chiefly responsible nationally for the fall in mortality from cerebrovascular disease. (Stroke. 1999;30:2105-2111.)

Key Words: epidemiology • incidence • stroke • survival • Western Australia

Mortality from stroke has been falling in Australia since the early 1950s, although the rate of decline has decelerated recently. The contributions of changes in incidence and improved survival to the downward trend in mortality from stroke in Australia have not been quantified, chiefly because of the difficulties faced in measuring the incidence of stroke accurately. An additional consideration is that changes in mortality from cerebrovascular disease (CeVD) might reflect alterations in the balance between hemorrhagic and ischemic strokes without either the overall incidence or cause-specific survival having changed. Survival from primary intracerebral hemorrhage (PICH) is lower than that after ischemic stroke, and changes in the relative incidence of PICH, perhaps as a result of better detection and management of hypertension, would therefore have a differentially large impact on mortality from stroke.

Untangling this puzzle is a matter of pressing importance because stroke is a leading cause of physical disability in the community, and the elderly, the most stroke-prone age group, constitute the fastest-growing segment of the Australian population. If the relationships between the key epidemiological indices of CeVD—incidence, survival, and resultant disability—remain constant but the overall incidence stabilizes rather than continues to fall, there will soon be an absolute increase in the numbers of disabled survivors of stroke, with major consequences for both the health system and informal caregivers. Data on trends in the cause-specific incidence of CeVD provide important feedback for preventive strategies, while patterns of case fatality and outcome should bear a closer relationship to the management of acute stroke. Both are required for the planning of services that will inevitably come under increasing pressure just from the aforementioned demographic changes.

We have previously used data from the Perth Community Stroke Study (PCSS) to describe the incidence and outcome of stroke and its various subtypes in a geographically defined segment of the city of Perth, the capital of Western Australia, at the end of the 1980s. In this report, we describe trends in the key indices of CeVD in this population over a period of 6 years. These are the only longitudinal population-based data available for Australia for these indices of stroke.

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Outcome of Stroke

For the present report, the chief outcome of interest is short-term case fatality after stroke, as reflected by vital status at 28 days after the onset of symptoms. Most deaths were discovered by ongoing surveillance of official mortality statistics for new cases, but some were found through contact with the caregiver of the patient as part of a related study.

Statistical Methods

Figures for overall and cause-specific incidence in 1989–1990 and 1995–1996 are presented as 10-year age- and sex-specific rates per 100 000 person-years with corresponding standard errors. As recommended by Malmgren et al.,15 principal comparisons are based on cases of first-ever-in-a-lifetime stroke occurring during 2 periods of 12 months from March 1989 to February 1990, inclusive, and from March 1995 to February 1996, inclusive. The frequency of first-ever-in-a-lifetime stroke is referred to as the “incidence rate,” whereas the frequency of all strokes (first-ever and recurrent events combined) is denoted the “attack rate.”16 Sex-specific trends in rates have been examined with Poisson regression.

Age-standardized rates have been derived by the direct method and with the use of Segi’s “world” population as the external reference.7 The rates for 1989–1990 were calculated with the use of estimates from the national censuses held in 1986 and 1991; they are compared with rates for 1995–1996, calculated with estimates from the national censuses held in 1991 and 1996, to minimize any artifact arising from different relationships between periods of registration of events and enumeration of the corresponding populations. Mortality rates from the PCSS are calculated in the equivalent fashion, with the numerator consisting of all fatalities occurring within 28 days of the onset of a new stroke (first or recurrent) within a given period of registration. We have assumed stable annual rates of change in all of these parameters in summarizing trends over the 6 years between the 2 periods of registration.

For each of 1989–1990 and 1995–1996, scores on the Glasgow Coma Scale (15, 10 to 14, 3 to 9) and the Motricity Index (95 to 100, 51 to 94, 0 to 50) were subdivided into categories denoted as normal, mild impairment, and severe impairment, respectively. These data for the 2 periods, together with the proportions of different subtypes of stroke and the proportions of patients who had been incontinent of urine after the ictus, were compared with the χ² test. Figures for case fatality were age standardized by the direct method, with 5 strata (0 to 54, 55 to 64, 65 to 74, 75 to 84, and ≥85 years) and weights of 1, 2, 5, 8, and 4, respectively, drawn from the sum of events from the 2 periods of registration in which the final diagnosis made by the PCSS was a stroke. The age-standardized proportions were compared with a Z test. All calculations were performed with SAS18 and Excel software.19

Ethical Considerations

The protocol for the PCSS has been approved by the Ethics Committee of Royal Perth Hospital, the Committee for Human Rights of the University of Western Australia, and the Confidentiality of Health Information Committee of the Health Department of Western Australia. All patients or their next of kin provided written consent to participation in the PCSS before the initial assessment began. One patient declined to participate in 1989–1990.

Results

Over a period of 18 months from February 1989, the PCSS registered 536 events with a final diagnosis of stroke. These episodes occurred in 492 individuals whose median age was 76 years, and 370 events (69%) were cases of first-ever-in-a-lifetime stroke. The most recent period of registration for the PCSS ran for 13 months from March 1995 and included 305 events with a final diagnosis of stroke. These episodes occurred in 296 individuals whose median age was 79 years, with 213 events (73%) being cases of first-ever-in-a-lifetime
stroke. The corresponding figures for the 2 periods of 12 months defined above were 355 events, 328 patients (median age, 76 years), and 251 first-ever strokes (71%) for 1989–1990, and 290 events, 281 patients (median age, 79 years), and 213 first-ever strokes (73%) for 1995–1996. In 1989–1990, 79% of the 355 events resulted in admission to the hospital; 30% of all patients with a final diagnosis of stroke were seen by the study registrar (C.S.A.) within 48 hours and 54% within 7 days. For the 290 events registered in 1995–1996, the corresponding proportions were 88%, 27%, and 48%.

### Incidence and Attack Rates for Stroke

Figures 1 through 4 show that, in 1995–1996, the age- and sex-specific incidence and attack rates were systematically lower than those recorded by the PCSS for the same population in 1989–1990. Not surprisingly, the sex-specific age-standardized rates for the 2 periods also show a decrease (Table 1). In Poisson models including age and period, overall trends in the incidence of both first-ever strokes (rate ratio [RR]=0.75; 95% confidence limits [CLs], 0.63, 0.90) and all strokes (RR=0.73; 95% CLs, 0.62, 0.85) were obviously significant. The changes in men were independently significant (first-ever: RR=0.70 [95% CLs, 0.54, 0.90]; all strokes: RR=0.63 [95% CLs, 0.51, 0.79]), while those in women were more modest (first-ever: RR=0.82 [95% CLs, 0.63, 1.06]; all strokes: RR=0.84 [95% CLs, 0.67, 1.04]).

### Severity of Strokes

Table 2 shows, for first-ever strokes, scores on the Glasgow Coma Scale, the patterns of function, and the proportions of patients who developed urinary incontinence for the 2 periods of registration. Compared with 1989–1990, fewer patients in 1995–1996 had a normal score on the Glasgow Coma Scale (P=0.001), but motor impairment at the initial assessment was milder (P<0.02) and urinary incontinence less common (P<0.05). Scores on the Barthel and Rankin scales were very similar for the 2 periods.

### Mortality From Stroke

The last line of Table 1 gives the age-standardized mortality rates for all strokes combined. These figures are based on deaths within 28 days of the onset of an acute stroke (first or recurrent) occurring during the period of 12 months covered by the respective registers compiled by the PCSS. As such, they will omit late deaths after delayed complications of acute CeVD, such as a fatal pneumonia in a bed-bound hemiplegic survivor of a stroke, which, depending on the exact wording of the death certificate, could be included in official mortality statistics for CeVD. Regardless of any systematic under-
counting relative to the official figures, the mortality rates from the PCSS show an obvious decrease between 1989–1990 and 1995–1996, particularly in men.

Pathology of Strokes
The balance between hemorrhagic and occlusive strokes in 1995–1996 was almost indistinguishable from that observed in 1989–1990. In the earlier period, 13% of events with a final diagnosis of stroke were cases of PICH, and 4% were cases of SAH. Six years later, the corresponding figures were 10% and 2%. There was also little difference in the proportion of events with a final diagnosis of stroke in which at least 1 objective anatomic study (CT scan, MRI, or necropsy) was not performed (20% in 1989–1990 versus 22% in 1995–1996).

Short-Term Outcome
The 28-day case fatality for all strokes within the population covered by the PCSS remained stable over the 6 years from 1989–1995; the crude figure varied only slightly, from 23% (95% CLs, 18%, 27%) in the earlier period to 24% (95% CLs, 19%, 29%) in the later one. The respective age-standardized proportions were also 23% and 24%. The short-term outcomes for major subtypes of stroke changed very little (Table 3). There was also no change in case fatality for cases managed in the hospital (stable at 22%) and no significant change in case fatality for cases not admitted to the hospital (33% in 1989–1990, 37% in 1995–1996; Z=0.39).

Discussion
Using identical methods to identify and classify all strokes occurring in the same carefully defined population during 2 periods 6 years apart, we have demonstrated significant decreases in the incidence, attack, and mortality rates but can find no evidence of a change in case fatality at 28 days after the onset of a stroke. During this period, on the basis of official statistics derived from the single underlying cause of death ascribed for each fatality, the mortality rate from stroke in Australia fell by 3.5% per annum.1 If all of the decrease in mortality had been due to an improvement in case fatality, the latter should have fallen in the PCSS population from 23% in 1989–1990 to 18% in 1995–1996. Since our study had a statistical power of 68% for detecting such a difference, it is unlikely that we have failed to detect major changes in case fatality after stroke. By contrast, our figures show an average annual rate of decline in the attack rate for stroke of 6.0% over the 6 years from 1989. This suggests that it is a change in the frequency of stroke, rather than its outcome, that is...
chiefly responsible nationally for the fall in mortality from CeVD.

Aside from the use of identical methods and multiple sources of ascertainment, including surveillance of deaths and hospital admissions for the whole of Western Australia, additional strengths of our study are that both strokes and cases of TIA were sought and that each register was population based. Seeking all acute cerebrovascular events is important because the distinction between a TIA and a stroke is an arbitrary one based on the persistence of symptoms and signs beyond 24 hours, and careful inquiry of a patient may result in an event initially regarded as a TIA finally being

### TABLE 1. Age-Standardized Incidence and Attack Rates per 100 000 for Stroke and its Major Subtypes and Overall Mortality From Acute Stroke

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<td><strong>Incidence rates</strong></td>
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<tr>
<td>Occlusive stroke</td>
<td>97 (10.2)</td>
<td>77 (8.7)</td>
<td>51 (6.6)</td>
<td>41 (5.2)</td>
<td>72 (5.8)</td>
<td>58 (4.9)</td>
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<td>PICH</td>
<td>22 (5.2)</td>
<td>7.3 (2.7)</td>
<td>8.1 (2.5)</td>
<td>11 (3.2)</td>
<td>15 (2.8)</td>
<td>8.9 (2.1)</td>
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<td>SAH</td>
<td>5.3 (2.6)</td>
<td>2.6 (1.8)</td>
<td>5.9 (2.7)</td>
<td>3.4 (2.0)</td>
<td>5.8 (1.9)</td>
<td>3.0 (1.3)</td>
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<tr>
<td>Uncertain type</td>
<td>13 (3.3)</td>
<td>9.3 (3.0)</td>
<td>13 (3.7)</td>
<td>4.1 (1.4)</td>
<td>12 (2.3)</td>
<td>6.0 (1.5)</td>
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<td><strong>Incidence of all first-ever strokes</strong></td>
<td>137 (12.2)</td>
<td>96 (9.7)</td>
<td>78 (8.4)</td>
<td>59 (6.6)</td>
<td>104 (7.1)</td>
<td>76 (5.7)</td>
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<td><strong>Attack rates</strong></td>
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<tr>
<td>Occlusive stroke</td>
<td>144 (12.4)</td>
<td>99 (9.7)</td>
<td>71 (7.7)</td>
<td>57 (6.2)</td>
<td>103 (7.0)</td>
<td>76 (5.6)</td>
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<tr>
<td>PICH</td>
<td>26 (5.6)</td>
<td>12 (3.5)</td>
<td>11 (2.9)</td>
<td>14 (3.6)</td>
<td>18 (3.1)</td>
<td>13 (2.5)</td>
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<td>SAH</td>
<td>5.3 (2.6)</td>
<td>2.6 (1.8)</td>
<td>5.9 (2.7)</td>
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<td>5.8 (1.9)</td>
<td>3.2 (1.4)</td>
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<tr>
<td>Uncertain type</td>
<td>22 (4.5)</td>
<td>11 (3.2)</td>
<td>17 (4.1)</td>
<td>7.7 (1.9)</td>
<td>19 (2.8)</td>
<td>9.1 (1.7)</td>
</tr>
<tr>
<td><strong>Attack rates for all strokes</strong></td>
<td>197 (14.5)</td>
<td>124 (10.9)</td>
<td>105 (9.5)</td>
<td>82 (7.7)</td>
<td>146 (8.4)</td>
<td>101 (6.5)</td>
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<td><strong>Mortality</strong></td>
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<tr>
<td>All strokes</td>
<td>40 (6.5)</td>
<td>22 (4.3)</td>
<td>25 (4.8)</td>
<td>20 (3.2)</td>
<td>31 (3.8)</td>
<td>20 (2.6)</td>
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Values are rates per 100 000 person-years; see text for details of calculations. Values in parentheses are SE.

### TABLE 2. Measures of Severity of First-Ever Acute Strokes During 2 Periods of Registration in the Perth Community Stroke Study

|--------------------------------------|---------------------|---------------------|---
| Glasgow Coma Scale                   |                     |                     |  
| Normal (score 15)                    | 57.1                | 28.9                |  
| Mild impairment (score 10–14)        | 26.3                | 42.2                |  
| Severe impairment (score 3–9)        | 16.5                | 28.9                | 0.001  
| Motricity Index                      |                     |                     |  
| Normal (score 95–100)                | 38.1                | 39.5                |  
| Mild impairment (score 51–94)        | 36.3                | 46.5                |  
| Severe impairment (score 0–50)       | 25.6                | 14.1                | 0.017  
| Urinary incontinence                 |                     |                     |  
| 48.1                                | 38.5                | 0.042               |  
| Barthe Index at initial assessment   |                     |                     |  
| Mild or no impairment (score 16–20)  | 35.8                | 37.9                |  
| Significant impairment (score ≤15)   | 64.2                | 62.1                | NS  
| Barthe Index before event            |                     |                     |  
| Mild or no impairment (score 16–20)  | 88.4                | 87.8                |  
| Significant impairment (score ≤15)   | 11.6                | 12.2                | NS  
| Rankin score before event            |                     |                     |  
| Independent (score 1 or 2)           | 75.5                | 81.2                |  
| Assistance required (score 3–5)      | 24.5                | 18.8                | NS  

Values are crude proportions (percentages).

*Cases with missing information have been excluded from individual comparisons.
registered as a stroke. In addition to providing a complete picture of acute CeVD through inclusion of the sizable fraction of patients with strokes who are not admitted to the hospital, population-based ascertainment "protects" a register from artifacts arising from changes in the extent to which acute stroke is managed in the hospital. Comparing data collected over different seasons is also a pitfall that we have avoided.

The apparent case fatality of stroke and the proportion of events for which objective evidence of the pathology is obtained via neuroimaging or postmortem examination are additional indices of the quality of stroke registers. Case fatality will tend to be higher if mild events are omitted, while clinical judgments as to the pathological basis of strokes have limited validity and reliability, undermining the utility of a given register if a sizable proportion of events are classified by this means. For the 2 periods of registration by the PCSS described here, case fatality was acceptably low and the proportion of events with objective confirmation of the pathology was high. Compared with 1989–1990, the proportion of registered events recorded as being managed entirely out of hospital fell by almost half, from 21% to 12%. Conversely, the proportion of events originally discovered by review of hospital discharge data increased from 16% to 26%. That these changes may be related to the opening of a dedicated Stroke Unit at Royal Perth Hospital in 1992 is supported by an increase of 94% in the numbers of patients aged 85 years or older who were admitted to the hospital for the management of their stroke, when the overall number admitted decreased by 10% between the 2 periods of registration. The level and stability of the total and site-specific case fatality across the 2 periods of registration also suggest that the overall completeness of ascertainment was not materially different. This adds to confidence in the robustness of our conclusion that a decrease in incidence was the principal and primary change in the epidemiology of stroke in the study population during the period under review.

There are relatively few communities in which population-based registers of CeVD have been compiled continuously or at least at intervals over a sufficiently long period for secular trends to be apparent. The Auckland Region Coronary or Stroke Study (ARCOSS) showed that, during 1981–1991, the overall incidence of stroke did not change, while short-term survival after stroke improved significantly in both sexes. Trends in the incidence and case fatality of stroke have also been examined as part of the Minnesota Heart Survey, in which, as in Australia, a long-established decline in mortality from stroke first accelerated sharply in the 1970s and then, from the mid-1980s, slowed to the lowest annual rate of fall observed since 1960. However, the published report only included persons aged 30 to 74 years, an age group that accounts for fewer than half of strokes in the PCSS, and omitted entirely nonfatal events not associated with admission to the hospital.

Registers of acute strokes have been maintained over periods of ≥10 years by a number of centers participating in the WHO MONICA Project, which monitored trends and determinants in cardiovascular disease. Judged against the criteria described by Malmgren et al, the quality of these registers is variable, the principal focus has been on patients younger than 65 years, and all of the populations covered by the most recent report were located in the Northern Hemisphere. However, in the latter half of the 1980s, attack and mortality rates from stroke were falling in the majority of the 17 centers participating in the stroke component of the MONICA Project, although the rate of decrease was statistically significant in only a minority of them, and there was a significant increase in the attack rate among men in Warsaw, Poland.

In a more detailed report from the MONICA Center in Northern Sweden, Stegmayr et al described an increase in the frequency of first-ever stroke in men of all ages up to 74 years during 1985–1991 but no significant change in women. The same sex-specific patterns were evident across the Baltic in the municipality of Frederiksborg in Copenhagen, where population-based register of all acute cerebrovascular events was compiled in 1972–1974 and again in 1989–1990. Short-term (28-day) survival improved among patients aged 65 to 74 years in Northern Sweden, where there was also some evidence of a trend among survivors to less impairment of both conscious state and motor function during the first 28 days after the onset of symptoms.

Taken together, the literature suggests that key indices of acute CeVD show obvious heterogeneity of trends over person, place, and time. Thus, even when registers are population based and otherwise of high quality, great care is required in comparing their results. At the very least, data for incidence and attack rates in the 2 sexes should be separated, and only identical historical periods should be considered. With no other data from the mid-1990s yet published, our data must stand alone for the present. Nevertheless, they suggest that a downward trend in the incidence of stroke has continued in at least part of Australia during a period when...
routine national mortality statistics suggested that a fall of approximately 40 years’ duration was coming to an end.2

The divergence of these findings throws into sharp relief the urgent need for validation of the national data and for longitudinal measurement of the incidence and case-fatality of stroke in several different parts of the country. If incidence rates stop falling at a time when treatment is not improving quickly and the population at highest risk of stroke is expanding rapidly,3 services for acute treatment and rehabilitation will face a sharp expansion in demand, and resources, both formal and informal, for continuing care in the community of disabled survivors of stroke will come under severe strain. Confirming or refuting that such a scenario is upon us is a pressing priority for the planning of health services.

Acknowledgments

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