Stroke Incidence and Survival in the Beginning of the 21st Century in Southern Sweden
Comparisons With the Late 20th Century and Projections Into the Future

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Methods—Lund Stroke Register, a prospective population-based study, included all first-ever stroke patients, between March 1, 2001 and February 28, 2002, in the Lund-Orup health care district. Institution-based studies for 1983 to 1985 and 1993 to 1995 were used for comparison. We calculated age-standardized incidence and Cox proportional hazards analysis of survival (stroke subtype, sex, age group, and study period in the analysis). Minimum follow-up was 46 months. Based on our register’s stroke incidence and the official Swedish population projection, a projection for future stroke incidence on a national basis was calculated.

Results—We included 456 patients with first-ever stroke in 2001/2002. The age-standardized incidence (to the European population) was 144 per 100 000 person-years (95%CI 130 to 158) in 2001/2002, 158 (95%CI 149 to 168) in 1993 to 1995, and 134 (95%CI 126 to 143) in 1983 to 1985. Cox proportional hazard analysis indicated decreased risk of death after stroke in 2001/2002 (hazard ratio 0.80; 95%CI 0.67 to 0.94) compared with 1993 to 1995. Up to year 2050, the annual number of new stroke patients in Sweden may increase by 59% based solely on demographic changes.

Conclusions—Despite possible underestimation of stroke incidence during the previous institution-based studies, the increased stroke incidence between 1983 to 1985 and 1993 to 1995 did not continue in 2001/2002. The long-term survival after stroke continues to improve. As the elderly population is growing in Sweden, stable incidence and increasing survival will result in a rapidly increasing prevalence of stroke patients in Sweden. (Stroke. 2008;39:10-15.)

Key Words: case-fatality ■ epidemiology ■ incidence ■ population-based ■ projection ■ stroke ■ survival

Stroke is a major cause of death and serious long-lasting neurological disability. The temporal trends of stroke epidemiology have been studied in Sweden1–4 and other countries during the last decades,5–17 but although stroke mortality has decreased for many decades, stroke incidence trends have been more divergent. As the elderly population is growing in the developed countries and stroke incidence is much higher among the elderly, time trends for stroke incidence are important in planning of health strategies and to evaluate primary and secondary preventive measures. Recently it was shown that the number of stroke events in Europe would increase from 1.1 million per year in 2000 to more than 1.5 million per year in 2025, based only on demographic changes.18 During the same period the projected European population (medium variant) would decrease from 728 million to 715 million inhabitants.19 However, the Swedish population is projected to increase from 9.05 to 9.87 million inhabitants between 2005 and 2025.20

The stroke incidence and survival rates have been studied in the Lund-Orup health care district during 1983 to 198521 and 1993 to 1995.1,22 These studies were institution-based and retrospective in design, and may have underestimated the true stroke incidence. Time-trend analyses indicated increasing incidence for persons aged <75 years and increasing long-term survival for patients 75 years and older. In the present study, Lund Stroke Register (2001/2002), we prospectively screened for patients with first-ever stroke, using multiple overlapping case ascertainment methods,23 based on recommended ideal criteria.24 We here present incidence and survival analyses for the period 2001/2002. We also present a projection of stroke incidence in the whole of Sweden up to year 2050 based on our results and population pyramid changes.
Materials and Methods

Study Population

The area of the Lund-Orup health care district consists of 8 municipalities with 234,505 inhabitants at December 31, 2001 (according to official population statistics). In the area there are 18 primary health care centers and 1 emergency hospital (Lund University Hospital). The proportions of persons aged ≥75 years within the study area were 6.2% 1983 to 1985, 6.5% 1993 to 1995, and 7.1% 2001/2002.

Case Ascertainment

As described previously for 2001/2002,23 we used the WHO definition of stroke.25 Subarachnoid hemorrhage but not intraceregic or traumatic stroke was included. Only first-ever-in-a-lifetime strokes were included. The medical history of the stroke patients was carefully reviewed to exclude prior stroke. Patients with TIA and recurrent stroke were examined to detect possible first-ever-in-a-lifetime strokes. Between March 1, 2001 and February 28, 2002, we screened for possible stroke patients using multiple overlapping prospective and retrospective methods (90.4% of the included patients were detected by prospective methods).23 Our prospective methods for case ascertainment consisted of daily (Monday through Friday) screening of the patient lists of the Emergency Unit at Lund University Hospital. We performed regular inquiries (every third month by mail or e-mail) to the nurses in community health care (including nursing homes) and the general practitioners (GPs) in primary health care as well as the departments of Lund University Hospital. The neurologists at the Department of Neurology were asked to report all newly diagnosed stroke patients or if they had performed carotid ultrasound examination on any stroke patients (not yet registered by the study). This topic was regularly addressed at morning conferences at the Department of Neurology.

Retrospectively, we screened for stroke patients by searches in the Swedish Cause of Death Register, the discharge diagnosis register at Lund University Hospital, the outpatient diagnosis register of the Department of Neurology at Lund University Hospital, and the autopsy registers of the Department of Pathology and the Department of Forensic Medicine. Diagnoses indicating possible stroke or TIA were screened (International Classification of Diseases, Tenth revision [ICD-10]; G45, G46, G81, G83, and I60–I69).

We also performed a retrospective screening of all computerized medical records of the Lund health care district (14 primary health care centers; 177,940 inhabitants in 2001). The screening was performed by 2 methods: diagnosis codes (ICD-10; G45, G46, G81, G83, I60–I67, and I69) and by stroke-related words in the text of the medical records (translated from Swedish: cerebrovascular insult, cerebral infarction, intracerebral hemorrhage, subarachnoid hemorrhage, SAH, stroke, brain infarction, vascular insult, and TIA). Patients treated when residing in nursing homes are generally treated in hospital, so the nursing home patients were also screened.

Within the Orup health care district (4 primary health care centers; 56,565 inhabitants) this screening was not possible to perform because of noncomputerized medical record system. We used the ideal criteria for epidemiological population-based stroke research proposed by Sudlow and Warlow,24 with one exception: we did not screen for possible stroke patients among the brain and carotid imaging referrals. The study was approved by the Lund University Ethics Committee. Informed consent was obtained from the prospectively included patients (or in some cases from next of kin).

During the earlier studies in 1983 to 1985 and 1993 to 1995, possible stroke patients were screened retrospectively in the discharge diagnosis registers at Lund University Hospital.12,21,22 In brief, we reevaluated discharge abstracts collected for 1983 to 1985 (with possible stroke diagnoses) to determine definite first-ever stroke.1,21 For 1993 to 1995, discharge abstracts (with any ICD-9 diagnosis 430 to 438) and other parts of the medical records were evaluated retrospectively for possible first-ever stroke. We screened the Departments of Neurology, Neurosurgery, and Internal Medicine, as well as the Departments of Pathology and Forensic Medicine.1

Stroke Classification

The included patients were categorized into main types of stroke: brain infarction (BI), intracerebral hemorrhage (ICH), subarachnoid hemorrhage (SAH), and Undetermined stroke main type (UND). CT, MRI, or autopsy of the brain was used to determine the main type of stroke. Patients having BI, ICH, or UND were further categorized according to the OCSP (Oxfordshire Community Stroke Project) classification system based on clinical findings.26 The OCSP subtypes were: TACS (total anterior circulation syndrome); large anterior circulation syndrome with both cortical and subcortical involvement, PACS (partial anterior circulation syndrome); more restricted and predominantly cortical syndromes, LACS (lacunar syndromes; syndromes confined to the territories of deep perforating arteries), and POCS (posterior circulation syndromes; syndromes clearly associated with the vertebralbasilar arterial territory). In cases when the clinical findings were incomplete to determine the OCSP subtype, patients were classified as Unspecified OCSP subtype.

Statistics

The stroke incidence was age- and sex-standardized to the European Standard population27 and to the Swedish population (December 31, 2001).20 The stroke incidence is presented as patients per 100,000 person-years. Ninety-five per cent confidence intervals (CI) were calculated for incidence assuming the Poisson distribution.28 The cut-off point at 75 years when studying incidence trends was used, because this represents approximately the median age of our stroke patient population. To decrease the effects of differences in study design between the 3 study periods, the incidence changes for patients aged <75 years were also calculated separately (assuming a higher hospitalization proportion in that age group).

Survival status of the included patients from 2001/2002 was assessed in mid-January 2006, using the official Swedish population register (for the patients in 1983 to 1985 and 1993 to 1995, the survival status was assessed in mid-1999). We here report survival status until the end of the year 2005 for the latest study period. Case-fatality rate at 28 days, 1 year, and 3 years were calculated. Log-rank test was used to test differences in survival between the 3 study periods. To evaluate whether survival changes were influenced by changes in age, sex, or OCSP subtype we used a Cox proportional hazards analysis (including age group, sex, OCSP subtype, and study period in the analysis). Hazard ratios and 95% CI are presented.

Based on the age- and sex-specific incidence for 2001/2002, we calculated a prognosis of the number of stroke patients in Sweden on a national basis each year from 2005 and up to 2050. The incidence was age- and sex-standardized to the projected Swedish population made by Statistics Sweden from 2004 up to 2050.20 We used 4 different scenarios for changes in age- and sex-specific incidence: (1) 2% increase every 5 years, (2) stable rates over time, (3) 2% decrease every 5 years, and (4) 7.25% decrease for every 5 years, based on a report from OXVASC (Oxford vascular study).10 We also performed an analysis to calculate how much the incidence would have to decrease every 5 years to maintain a stable number of incident (first-ever) stroke patients in Sweden in 2025 and 2050 (compared with 2005).

All statistical tests were 2-tailed, and a probability value of <0.05 was considered statistically significant. SPSS software package (Version 12.0.1) was used for statistical analysis (www.spss.com).

Results

The 2001/2002 Study Period

During the 1-year period (2001/2002) of this study we registered 456 patients with first-ever stroke (256 males and 200 females). Their median age was 74.2 years for males (range 17 to 94 years) and 80.4 years for females (range 44 to 105 years). The proportions of the main types of stroke were: BI 80%, ICH 10%, SAH 4%, and UND 6%.23 For patients with BI, ICH, and UND the proportions for the OCSP subtype...
subtypes were: TACS 17%, PACS 35%, LACS 29%, POCS 18%, and Unspecified OCSP subtype 1%.

In the Table, the age-specific incidences for the present study are shown as well as the age and sex standardized stroke incidences. The total stroke incidence for 2001/2002 (age standardized to the European population) was 144 per 100 000 person-years (95% CI 130 to 158). The crude case-fatality for patients with stroke in 2001/2002 was 14.3% at 28 days, 23.7% at 1 year and 35.3% at 3 years after stroke.

Comparisons With Previous Study Periods
It is important to note that there were different study designs during the 3 study periods, which might influence the analyses. The incidence (age standardized to the European population) for 1983 to 1985 was 134 (95% CI 126 to 143), and for 1993 to 1995 it was 158 (95% CI 149 to 168).1 The corresponding rate for 2001/2002 was 144 per 100 000 person-years (95% CI 130 to 158). There was a nonsignificant (NS) trend toward decreasing total stroke incidence (9% decrease) between 1993 to 1995 and 2001/2002. This decrease was confined to females (18% decrease; NS), whereas the incidence was unchanged for males. The stroke incidence in different age groups for the 3 study periods are shown in Figure 1.

For patients aged <75 years (for whom hospitalization proportion is generally higher23) the age standardized incidence (to the European population) was 87 (95% CI 75 to 101) in 2001/2002 compared with 98 (95% CI 90 to 107) in 1993 to 1995. The corresponding figure for 1983 to 1985 was 78 (95% CI 70 to 86). The tendency of decreasing incidence between 1993 to 1995 and 2001/2002 for persons aged <75 years was more pronounced for females (18% decrease; NS) than for males (8% decrease; NS).

The crude 28-day case-fatality was 14.3% in 2001/2002, 15.3% in 1993 to 1995, and 15.4% in 1983 to 1985 (these results for 1983 to 1985 and 1993 to 1995 have been reported previously22). Figure 2 shows the survival after stroke for the 3 study periods up to 3 years after stroke onset. The survival increased between the 3 study periods (P<0.0001; log rank test). The observed trends were similar for both men and women and for patients aged <75 years and ≥75 years (data not shown). The increased survival could neither be explained by changes in age and sex distribution, nor by changes in the OCSP subtype proportions, because the hazard ratios (Cox proportional hazards analysis; age group, sex, OCSP subtype, and study period included in the analysis) indicated decreasing risk of death after stroke during 2001/2002 (hazard ratio 0.80; 95% CI 0.67 to 0.94) compared with 1993 to 1995. In a corresponding analysis using the study period 1983 to 1985 as a reference, the hazard ratio for 2001/2002 was 0.67 (95% CI 0.56 to 0.80) and for 1993 to 1995 the hazard ratio was 0.85 (95% CI 0.75 to 0.95).

Stroke Incidence Projection
The projected increase of the Swedish population is 16% during 2005 to 2050.20 Different scenarios for the projection of the number of first-ever stroke patients in Sweden between

### Table. Age- and Sex-Specific Annual Incidence of First-Ever Stroke per 100 000 Person-Years in Lund-Orup, Sweden, 2001/2002

<table>
<thead>
<tr>
<th>Age Group, y</th>
<th>Men</th>
<th>Women</th>
<th>Men and Women</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No./Person-Years</td>
<td>Rate</td>
<td>95% CI</td>
</tr>
<tr>
<td>15–24</td>
<td>1/16 041</td>
<td>6</td>
<td>0.2–35</td>
</tr>
<tr>
<td>25–34</td>
<td>3/17 064</td>
<td>18</td>
<td>3–52</td>
</tr>
<tr>
<td>Total ASR (1)</td>
<td>257</td>
<td>226–291</td>
<td>203</td>
</tr>
<tr>
<td>Total ASR (2)</td>
<td>190</td>
<td>167–215</td>
<td>104</td>
</tr>
</tbody>
</table>

(1) Age-standardized rates (ASR) adjusted to the Swedish population December 31, 2001 (all ages).
(2) Age-standardized rates (ASR) adjusted to the European population (all ages).
Incidence is shown per 100 000 person-years.

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Figure 1. Age-specific incidence for the 3 different study periods. Error bars denote 95% confidence intervals. The study designs differed between the 2 first periods and the last (possible underestimation of rates during 1983 to 1985 and 1993 to 1995; see text).
The long-term survival after stroke continued to improve in the present, third study period. To avoid an increase in the number of annual stroke patients in Sweden up to year 2050, stroke incidence would have to decline by 2% every 5 years. The corresponding decrease to maintain a stable number of incident stroke patients in Sweden in 2025, the incidence would have to decrease by 5.5% every 5 years. The change would be either a 33% increase or a 20% decrease of the number of first-ever strokes during the forthcoming decades.

Despite possible underestimation of stroke incidence during the 2 previous study periods, we found that the increased incidence observed between 1983 to 1995 and 1993 to 1995 did not continue in the present study period in 2001/2002. The long-term survival after stroke continued to improve in the present, third study period. To avoid an increase in the future number of annual stroke patients in Sweden up to year 2025 and 2050, stroke incidence would have to decline considerably (ie, 5.5% and 4.6% every 5 years, respectively) to counterbalance the effects of the projected demographic changes during the forthcoming decades.

**Discussion**

Despite possible underestimation of stroke incidence during the 2 previous study periods, we found that the increased incidence observed between 1983 to 1985 and 1993 to 1995 did not continue in the present study period in 2001/2002. The general life expectancy in the Swedish population is increasing steadily. This could influence our finding of increased survival for the stroke patients, but it can probably not solely explain the detected significant increase in long-term survival. Additional reasons for increasing long-term survival might be improved secondary prevention after acute stroke (eg, hypertension treatment, antithrombotic drugs, glycaemic control in diabetics, anticoagulant therapy, and carotid endarterectomy) and long-term effects of stroke unit treatment. In a wider perspective, improved management of other diseases with high case-fatality such as cancer and ischemic heart disease also may influence the long-term survival trends for stroke patients.

The results of our survival analyses could be influenced by the different study designs during the different time periods. However, the patients who might have been undetected during the earlier study periods may have been either very old patients with high case-fatality or young patients with mild different from that in 1983 to 1985 and 1993 to 1995, comparisons of incidence trends should be made with caution. Our present study for 2001/2002 was a prospective population-based stroke study with a high case ascertainment, fulfilling the main criteria of an ideal stroke study, whereas the studies from 1983 to 1985 and 1993 to 1995 were institution-based and retrospective (risk of underestimation of the stroke incidence during the previous study periods because nonhospitalized stroke patients might not have been detected). We estimate, based on the results from the 2001/2002 study, that around 10% of the first-ever stroke patients might have remained undetected during the earlier studies (17 patients treated within primary care and 36 patients examined at the hospital but not hospitalized). Therefore, our finding of a stable or slightly decreasing incidence during the latest study period, makes a continuing increase of stroke incidence highly unlikely.

**Stroke Survival**

Similar to our previously reported time trend study, where we compared the study periods 1983 to 1985 and 1993 to 1995, the present study indicates that the long-term survival is improving more than the short-term survival.
strokes with low case-fatality. Taken together, this probably had little influence on our results of overall survival trends.

**Stroke Incidence Projection**

The absolute number of stroke patients is closely related to the proportion of elderly in the population, because the age-specific incidence of stroke increases steeply by increasing age (see Figure 1). Our projection of the number of incident stroke patients in Sweden up to year 2050 shows the pronounced effects of the anticipated changes in the population pyramid. Even with stable age-specific incidence of stroke, there will be a dramatic increase of no less than 59% in the number of stroke patients up to year 2050, whereas the projected increase of the total Swedish population is only 16%. Even a declining stroke incidence of 2% every 5 years would not counterbalance the effects of the demographic changes, as this would still result in a 33% increase in the annual number of stroke patients up to year 2050. In Europe the population is projected to decrease during the same period, but even so the number of European stroke events is projected to increase up to year 2025 (despite stable incidence) by approximately 36% (the corresponding figure for Sweden would be 33%). Stroke is therefore a major and increasing health care problem for many countries.

**Comparisons With Other Studies**

Through the 1970s and the early 1980s there was a declining trend in the incidence of stroke. In the late 1980s and early 1990s this trend seemed to have come to an end, and in some cases it was even reversed to an increasing incidence trend. However, in some studies there was a continuing decline in stroke incidence even past 1990. During the first decade of the 21st century incidence trends have been declining or stable. The case-fatality trends were declining in most studies, but in a minority they were stable. More recent studies of case-fatality at 28 or 30 days have also shown declining or stable trends. In the Framingham study the incidence of stroke has decreased during the last 50 years for men and women, but the 30-day case-fatality decreased significantly only among men. The 28-day case-fatality is already relatively low in our study (14%) compared with other international studies. In a recent Swedish study from Örebro the 28-day case-fatality was 19%, with a 1-year case-fatality of 33%. Increased long-term stroke survival has been observed in other Swedish studies. Our present study from Lund-Orup showed increased long-term survival and a stabilized stroke incidence, compared with our institution-based previous studies.

**Conclusion**

The age standardized stroke incidence did not continue to increase during 2001/2002 but the long-term survival continued to increase. However, based on changes in the population pyramid the number of stroke patients in the future will increase, despite stable or slightly decreasing age-specific incidence. This, in combination with the increased survival of stroke patients, will result in a considerably higher prevalence of stroke patients in the population.

**Sources of Funding**

This study was supported by the Research Funds of Lund University Hospital, the Swedish Stroke Association, the County Council of Skåne, the Swedish Research Council (K2007-61X-20378-01-3), Lund University and Elsa Schmitz’ foundation.

**Disclosures**

None.

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