
Andreas Terént, MD, PhD

Background and Purpose—Stroke mortality rates have declined in many countries. Stroke incidence rates have also declined, but not to the same extent and not always in parallel with stroke mortality. The aim of the present study was to investigate trends in stroke incidence and long-term survival in a Swedish population.

Methods—A population-based survey of the incidence of first-ever stroke was performed prospectively in the periods 1975 to 1977, 1983 to 1986, and 1987 to 1990. Case fatality ratios and survival rates were followed to 2001.

Results—Crude incidence rates increased between 1975 to 1977 and 1983 to 1986, but age- and sex-adjusted incidence rates were stable during the whole period of 1975 to 1990. The incidence of intracerebral hemorrhage decreased by approximately two thirds, whereas the incidence of mild brain infarction almost doubled. The case fatality ratio at 28 days did not change, but the 10-year survival ratio increased from 13% to 35%. Mean survival time increased significantly among patients with intracerebral hemorrhage and brain infarction but not among patients with subarachnoidal hemorrhage or stroke of undetermined origin.

Conclusions—Stroke incidence and short-term case fatality did not change between 1975 and 1990 in the Söderhamn population. Long-term survival after stroke, on the other hand, has continued to improve to 2001. The implication of these changes is that the burden of stroke is likely to increase unless strokes are becoming less severe. (Stroke. 2003; 34:1353-1358.)

Key Words: fatal outcome incidence stroke survival

Stroke mortality rates have declined in many countries. Stroke incidence rates have also declined, but not to the same extent and not always in parallel with stroke mortality. In some populations, the incidence rates decreased up to the end of the 1970s, but since then, they have remained essentially unchanged. In others, the incidence rates have not changed, have continued to decrease, or have increased. Case fatality ratios have also decreased in some populations but not in all. It is not clear whether these opposing trends are real, suggesting improved stroke care or less severe strokes in some populations, or biased by methodological issues of case ascertainment. Increased use of CT and better awareness of stroke symptoms among the public may result in an observed increase of mild strokes in epidemiological studies without a real change in incidence.

The aim of the present study was to investigate trends in stroke incidence and long-term survival in a Swedish population. The survey was performed in the community of Söderhamn in the middle of the country. In a previous study in this community, the incidence rate for women rose from the 1970s to the 1980s. Moreover, 3-year survival rates were found to increase in the same period when changes in life expectancy were taken into account. More recently, it has been shown that the incidence rates in the Söderhamn population are fairly high in an international perspective. In the present study, the observation period has been extended to 1991 for incidence rates and to 2001 for case fatality and survival ratios.

Subjects and Methods

Study Area and Population
All residents in the town of Söderhamn and its rural surroundings were subjected to a prospective epidemiological study of stroke and transient ischemic attack (TIA). Three time periods in which CT was used to different extents are compared: May 1, 1975, to April 30, 1978 (1975 to 1977); September 1, 1983, to August 31, 1987 (1983 to 1986); and September 1, 1987, to August 31, 1991 (1987 to 1990). The population of Söderhamn was 32,230 on December 31, 1974; 30,736 on December 31, 1983; and 29,686 on December 31, 1987. The proportions of people of 65 years of age in Söderhamn were 18% (n=5860), 20% (n=6111), and 20% (n=6083) in the 3 study periods, respectively, compared with 15%, 17%, and 18% in the whole of Sweden.

Case Ascertainment
The method for identifying patients with first-ever stroke has been described in detail previously. A nurse traced persons with suspected stroke or TIA at hospital wards, general practitioner offices, and nursing institutions in the area. Multiple sources of
Stroke June 2003

TABLE 1. Crude and Adjusted Incidence Rates (Numbers per 100 000 and Year) of First-Ever Stroke in Söderhamn, Sweden

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CI indicates confidence interval.

*Age and sex adjusted to the Swedish population of 1990,15
†Age adjusted to the European population of 1999,18

information were used for case ascertainment, including death certificates for permanent residents of Söderhamn. The proportion of stroke patients who were hospitalized was 89% in the first period and 95% in the second and third periods. All patients were followed up until October 2001. No patient was lost to follow-up. The Söderhamn stroke study was approved by the ethics committee of Uppsala University.

Stroke Definition and Classification

Stroke was defined in accordance with the World Health Organization as clinical symptoms of focal and/or global disturbance of cerebral function lasting >24 hours or leading to death, with no apparent cause other than vascular. TIA was defined as reversible ischemic neurological symptoms (RIND) lasting <3 weeks.16 TIA and RIND were recorded prospectively on each patient’s card.

Intracranial bleeding was identified at autopsy, CT, or lumbar puncture (LP). Among patients who died within 28 days after stroke, autopsy was performed in 24% in 1975 to 1977, in 39% in 1983 to 1986, and in 32% in 1987 to 1990. CT was carried out in 1% of patients in the first period, 38% in the second, and 61% in the third; LP was done in 60%, 52%, and 18%, respectively. To optimize the detection of intracranial bleeding, LP was performed on day 3 after symptom onset except in cases of suspected subarachnoid hemorrhage (SAH), when it was done as soon as possible. All cerebrospinal fluid (CSF) specimens were analyzed spectrophotometrically with respect to oxyhemoglobin, bilirubin, and methemoglobin.17 Thus, the diagnosis of intracranial bleedings was based mainly on CSF analyses in the first period and on CT in the third, whereas it was based on both methods in the second period. BI was divided into RIND and major BI. A diagnosis of undetermined stroke (UND) was given to those patients who did not undergo CT, LP, or autopsy within 28 days.

Statistical Analysis

Incidence rates of first-ever stroke and TIA were calculated for each study period. These rates were age and sex adjusted by the direct method to the Swedish population of 199016 and age adjusted to the European population of 1999.18 Confidence intervals for a Poisson distribution were calculated.19 Linear regression was performed to disclose trends in stroke incidence after age and sex adjustment to the Söderhamn population of 1990.15 Pearson product-moment correlation coefficients were estimated. Case fatality ratios from 7 days to 3 months and survival ratios from 1 to 10 years were calculated by cross-tabulating survival status and age by study period. Significance was tested by $\chi^2$ statistics. Survival times were calculated by the Kaplan-Meier method, and significance was estimated by the log-rank test. Logistic regression modeling was used to estimate the main effects of stroke subtype, age, sex, and period (independent class variables) on case fatality/survival ratios (dependent variable). Significance was tested by the likelihood ratio. Data were analyzed by SAS/STAT, version 6.12.

Results

The number of patients with first-ever stroke was 1186 (53% female, 47% male). The number of patients with first-ever TIA was 178. The mean±SD age of stroke patients was 73±11 years in the first period, 75±10 years in 1983 to 1986, and 76±10 years in 1987 to 1990. Crude incidence rates increased significantly for women and for both sexes combined but not for men between 1975 to 1977 and 1983 to 1986 (Table 1). On the other hand, age- and sex-adjusted incidence rates did not change (Table 1).

Stroke Subtypes and TIA

Trend curves for stroke subtypes and TIA are shown in the Figure. The incidence of intracerebral hemorrhage (ICH) decreased by approximately two thirds between 1975 and 1990. The incidence of RIND almost doubled, whereas the incidence of major BI just tended to increase. The incidence rates of SAH, UND, and TIA showed no significant changes.

Case Fatality and Survival

The case fatality ratio at 7 and 28 days did not change over time (Table 2). At 3 months, case fatality was significantly reduced in the last 2 periods. The reduction was most pronounced in the 65-to-74-year age group, in which the ratio was halved, and in the 75-to-84-year age group, in which it was reduced by one quarter.

The survival ratios at 1, 5, and 10 years increased significantly except among patients 15 to 64 years of age (Table 3). The increase in 5- and 10-year survival ratios was remarkably high in the oldest age groups (>75 years), in which 15% to 20% more patients were alive in the third period compared with the first. The 10-year survival ratio for all age groups increased from 12.9% in 1975 to 1977 to 22.3% in 1983 to 1986 and 34.7% in 1987 to 1990.

The mean survival time of all stroke patients increased significantly from 3.3 years in 1975 to 1977 to 4.1 in 1983 to 1986 and 4.8 in 1987 to 1990 ($P=0.0001$). Mean survival times rose in patients with ICH from 2.3 to 5.0 years ($P=0.0065$), in patients with major BI from 3.3 to 4.5 years ($P=0.0009$), and in patients with RIND from 4.7 to 6.7 years ($P=0.0003$). Mean
survival times did not change significantly in those with SAH, UND, or TIA.

In logistic regression analyses, only stroke subtype \( (P=0.0001) \) and age \( (P=0.0001) \) had an effect on case fatality at 7 days to 3 months. Period had no effect on case fatality \( (P=0.22) \). In the same type of analysis, stroke subtype \( (P=0.0008) \), age \( (P=0.0001) \), and study period \( (P=0.0001) \) had an effect on survival from 1 to 10 years. Sex did not have any effect on case fatality or survival.

**Discussion**

The present study supports the observation that stroke incidence rates have been stable in most industrialized countries from the latter half of the 1970s to the end of the 1980s.\(^2\)-\(^4\) This study does not verify previous reports that case fatality ratios have been falling during the same period.\(^2\)-\(^4\),\(^5\),\(^9\),\(^20\) Long-term survival, 10 years in the present study, seems to have increased, particularly among the oldest patients. This

### TABLE 2. Case Fatality Ratios for Patients With First-Ever Stroke in Söderhamn, Sweden

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CFR indicates case fatality ratio; CI, confidence interval.
TABLE 3. Survival Ratios for Patients With First-Ever Stroke in Söderhamn, Sweden

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SR indicates survival ratio; CI, confidence interval.

has not been reported previously from a population-based study covering all age groups and all stroke subtypes. In a Finnish study in which stroke mortality was compared between different areas and time periods, the 1-year case fatality ratios declined significantly.\(^20\) In the Monitoring of Determinants in Cardiovascular Disease (MONICA) study of patients \(<75\) years of age in northern Sweden, 5-year survival rates gradually improved.\(^21\) A hospital-based study in Lund-Orup (Sweden) showed an increase in 3-year survival rates, particularly among the oldest patients.\(^22\)

In the period of the present study, mild BI seemed to become more frequent, although there were no definite indications for a shift from TIA to RIND. This is probably not a methodological issue, because both diagnoses were recorded prospectively from the very beginning of the study. The incidence of TIA was stable, but the number of patients was fairly small. Stable incidence rates of TIA have also been reported from Dijon (France), Rochester (Minn), and Novosibirsk (Russia).\(^10,23,24\)

In Söderhamn, there have been no indications of a shift from BI to ICH since the introduction of CT in the 1980s; rather, the opposite has occurred. In Rochester, the incidence of ICH was reported to have increased after the introduction of CT in the 1970s.\(^25\) However, in a more recent report from the same study, the incidence rates of ICH were claimed to be unchanged from 1955 to 1989.\(^2\) In Söderhamn, there was a remarkable decrease in the incidence of ICH. This finding might simply be a methodological issue, but real changes cannot be excluded. In the beginning of the study, the diagnosis of ICH was based mainly on CSF analyses; at the end, it was based mainly on CT. Autopsy was performed to the same extent throughout the study period. All CSF specimens were examined by spectrophotometry, which is a sensitive method for detecting intracranial bleeding\(^17\) but not for discriminating between ICH and hemorrhagic infarction. Thus, large infarcts may have been mistaken for hematomas in the first period of the study. It is also possible that hypertension, the major risk factor for ICH,\(^26\) has become better controlled in the Söderhamn population. In 1980, local guidelines for the detection and treatment of hypertension were published, and these have become widely used and accepted. At the same time, a screening program for hypertension was introduced in the Söderhamn population. During that survey, 104 cases of unrecognized hypertension were detected and treated.\(^27\) It is not known, however, whether the blood pressure (BP) values decreased in the background population, as has been reported elsewhere.\(^28–30\) In the MONICA study in northern Sweden, diastolic BP was found to have decreased in women but not in men, whereas systolic BP was unchanged in both sexes.\(^31\) In the MONICA study in Göteborg in southern Sweden, no changes in BP were observed with time.\(^32\) It is noteworthy that neither the incidence rate nor the survival time changed among patients with SAH. This may be the main reason for the unaltered case fatality and survival in the youngest patients, in whom SAH is a relatively common diagnosis.

Stroke care changed during the study period. In the 1970s, local guidelines for stroke care were drawn up in Söderhamn, and in the 1980s, a stroke unit was started at the local hospital. Meanwhile, survival rates up to 3 years after stroke improved more than life expectancy in a direct comparison between 1975 to 1977 and 1983 to 1986.\(^13\)

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Cohort effects on stroke survival cannot be excluded.\(^2,7,8\) Life expectancy increased in men and women in Sweden during the study period; for a 65-year-old man, it was 14.1 years in 1971 to 1980, 14.6 years in 1981 to 1985, and 15.1 years in 1986 to 1990,\(^14\) and the corresponding figures for women were 17.5, 18.4, and 18.9 years. Thus, life expectancy improved by 1 year in men and by 1.4 years in women in the background population. In the stroke patients in the present study, mean survival time increased by 1.5 years, both sexes included. In another Swedish study, life expectancy of hos-
pitalized patients increased by 2 years, whereas in the general population, it improved by 1 year.\textsuperscript{33} Taken together, these data indicate a cohort effect on stroke survival.

The mean age of the stroke patients rose between each study period, and the crude incidence rates increased between the first and second periods. This reflects the increasing number of elderly persons in the Söderhamn population. A similar trend has been found in other populations.\textsuperscript{2,5,10} Stable age- and sex-adjusted incidence rates must not be mistaken for unchanged burden of stroke in the aging European populations. Trends in the total burden of stroke, including severe disability and mortality, a common measure of effectiveness in clinical trials, have rarely been presented. The Perth study is a notable exception.\textsuperscript{8} In that study, both the crude and adjusted incidence rates decreased, as did the proportion of patients with severe motor impairment. Case fatality ratios remained unchanged, however, between the study periods 1989 to 1990 and 1995 to 1996.\textsuperscript{8} In Rochester, the functional outcome after BI has been presented for patients registered in 1985 to 1989, but no time trends have been shown.\textsuperscript{34} Thus, further studies are needed to answer the question as to whether the burden of stroke has decreased in parallel with stroke mortality.

The Söderhamn project is 1 of the few studies judged suitable for trend analyses,\textsuperscript{14,35} but the present study has limitations in both methodology and representation. Two of its weaknesses are a small population and low use of CT. The number of strokes was not smaller in Söderhamn, however, than in 3 other studies in an international comparison, a fact resulting from longer periods of case finding and a larger proportion of elderly people.\textsuperscript{14} Classification of stroke subtypes on clinical grounds has also been reported from other studies being carried out in the same time period.\textsuperscript{3,4,9} The Söderhamn population represents a small town with a rather large proportion of industrial workers. The population is slightly older that the average Swedish population. Furthermore, the number of inhabitants <65 years of age decreased when 2 paper mills closed in the beginning of the 1980s. It is known that a lower socioeconomic status is a risk factor for stroke,\textsuperscript{16} but the situation for people >65 years of age did not change in any essential respect within this short time frame. This is confirmed by life expectancy data showing that the remaining numbers of years of life are, at the end of the 1990s, the same for citizens of Söderhamn as for the whole of Sweden.\textsuperscript{15}

Conclusions
Stroke incidence rates and case fatality ratios have not changed in this population. Long-term survival after stroke, on the other hand, is improving. This may in part be a cohort effect because life expectancy in the background population is also increasing. In addition, it may reflect improvements in stroke care and prevention. The implication of these changes in the context of an aging population is that the burden of stroke is likely to increase unless strokes are becoming less severe.

Acknowledgments
The County Council of Gävleborg, Sweden, supported this study. I wish to express my sincere gratitude to the staff at the Department of Medicine at the Hälsingland, formerly Söderhamn, Hospital and especially to stroke research nurses Ingrid Westerberg, RN (1975 through 1979), and Pirjo Pettersson, RN (1983 through 2001), for data collection and follow-up.

References


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