Incidence of Stroke in a Finnish Prospective Population Study

ANTTI REUNANEN, M.D., KARI AHO, M.D., ARPO AROMAA, M.D., PAUL KNEKT, M.Sc.

SUMMARY The incidence of stroke was investigated in a large Finnish prospective population study. The study population consisted of 11,984 men and 11,682 women aged 15 years and over drawn from four geographical regions of the country. In a mean follow-up time of six years, 174 men and 109 women suffered a fatal or non-fatal stroke. The age-adjusted mean annual incidence of stroke in men, 4.0/1000, was statistically significantly higher than the annual incidence in women, 3.3/1000. In twelve percent of the cases, cerebral infarction was ascertained as the cause of the stroke; while in 49 percent of the cases, the type of stroke could not be specified with certainty. The incidence of stroke was significantly higher in men from eastern Finland than in men from southwestern Finland.

THE INCIDENCE OF CEREBROVASCULAR DISEASES has recently been studied in many countries by means of stroke registers. The completeness of ascertainment of cases makes them invaluable in stroke epidemiology. However, incidence studies of stroke in connection with prospective population studies provide a more valid basis for the study of stroke precursors. Large population studies are also a good basis for the description of variation of the incidence of stroke by various demographic and social factors. Little is known about regional variation of stroke incidence in Finland although morbidity and mortality of coronary heart disease are known to differ substantially between various parts of the country. The Social Insurance Institution's (SII) Mobile Clinic Health Examination Survey is a large prospective population study in which special emphasis is being paid to risk factors and incidence of various atherosclerotic cardiovascular diseases in different parts of Finland. This report describes the incidence rates of stroke in this study.

Population and Methods

The study population comprised 12,602 men and 12,145 women aged 15 years and over invited to the baseline examination of the SII Mobile Clinic Health Examination Survey carried out in 12 cohorts from the southwestern, western, central and eastern parts of Finland (fig. 1). Details of the study population has been presented earlier. In brief, nine of the cohorts consisted all or a random sample of the population from a defined geographical area. Four of these areas were urban or semiurban and five rural. Three of the study population, consisted of all employees of a factory (two paper mills, one steel factory). The first nine cohorts were studied in 1966–68 and the last three in 1972. The participation rate in the initial survey was 83 percent.

After a mean follow-up time of six years all persons invited to the initial survey were invited to the re-
examination if they were known to be alive; 1,468 people had died during the observation period and were not invited. Of the 23,279 persons who were alive, 19,518 (84 percent) participated; 2,681 did not participate but responded to a postal questionnaire dealing with reasons for non-attendance and known diseases diagnosed by a doctor. Information on health status was unavailable from a mere 1,080 (5 percent) persons alive and invited to the re-examination. They were excluded from the subsequent analyses. Thus, the incidence rates in the present report are given for 11,984 men and 11,682 women, who had either died during the follow-up or who were alive and on whom information on previous diseases was available.

Copies of death certificates were obtained for all who died during the follow-up. If the principal or additional cause of death was cerebrovascular disease medical records and any necropsy reports were examined.

To identify non-fatal cases all participants and non-participants were asked whether they had had a stroke diagnosed by a doctor. Details of dates and hospital treatment were requested of those who answered in the affirmative. A few non-fatal cases were identified from additional information in the questionnaire. The identification of non-fatal cases has been described in more detail in the report dealing with the prevalence of stroke in our study.

All medical records, necropsy reports and any other medical information were checked by one of the authors (KA), a neurologist. The criteria for stroke were the same as those applied in the WHO stroke register study.

The incidence rates were estimated as average annual rates based on the exponentiality assumption. The age-adjusted rates were calculated using the direct method. The standard population comprised the whole population of Finland aged 15 years and over in 1970. Because of the wide range of individual follow-up times the statistical significance of differences in the age-adjusted incidence rates was tested by Wald's test based on the exponential loglinear life-table regression model.

Results

One hundred and two men and 122 women died from stroke in the follow-up time (table 1). The mortality from stroke increased steeply with age in both sexes. Age-specific mortality rates were higher in men than in women between the ages of 45 and 74 years and were higher in women than in men in those aged 75 years and over. There was no statistically significant difference between the age-adjusted mean annual stroke mortality rates, 2.7/1000 in men and 2.5/1000 in women.

The death certificate was based on a necropsy in only 19% of the fatal cases. The frequency of necropsy decreased sharply with age. Necropsy was performed in half of the decedents aged 54 years and under but in only 9 percent of those aged 75 and over. Sixteen percent of all cases with stroke were dead within 24 hours after the symptom debut and 53 percent within three weeks of the onset of symptoms. In many patients, however, the exact time of onset of symptoms was poorly entered in medical records. Therefore the fatality rates based on different time cut-off points since the onset of symptoms cannot be established on a firm data basis.

Seventy-two men and 47 women suffered a non-fatal complete stroke during the follow-up (table 1). In men the age-specific annual incidence of non-fatal events increased with age until the age group 55-64 years, after which it levelled off. In women the incidence of non-fatal events increased throughout the age range. The mean annual incidence of non-fatal events in men, 1.4/1000 was statistically significantly higher than the rate in women, 0.8/1000.

 Altogether 174 men and 169 women had a fatal or non-fatal stroke in the follow-up time (table 1). The mean annual incidence of all complete strokes in men, 4.0/1000, was significantly higher than that in women.
INCIDENCE OF STROKE IN FINLAND

Reunanen et al.

TABLE 1  
Mean Annual Incidence (/1000) of Fatal and Non-fatal Stroke

<table>
<thead>
<tr>
<th>Age group</th>
<th>15–44</th>
<th>45–54</th>
<th>55–64</th>
<th>65–74</th>
<th>75+</th>
<th>Total age-adjusted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>7,634</td>
<td>1,887</td>
<td>1,566</td>
<td>695</td>
<td>202</td>
<td>11,984</td>
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<td>fatal</td>
<td>0.2</td>
<td>1.1</td>
<td>4.0</td>
<td>8.7</td>
<td>29.6</td>
<td>2.7</td>
</tr>
<tr>
<td>non-fatal</td>
<td>0.3</td>
<td>1.6</td>
<td>3.7</td>
<td>3.7</td>
<td>4.0</td>
<td>1.4</td>
</tr>
<tr>
<td>all</td>
<td>0.5</td>
<td>2.6</td>
<td>7.7</td>
<td>12.4</td>
<td>33.7</td>
<td>4.0</td>
</tr>
<tr>
<td>N</td>
<td>6,849</td>
<td>1,871</td>
<td>1,592</td>
<td>991</td>
<td>379</td>
<td>11,682</td>
</tr>
<tr>
<td>fatal</td>
<td>0.2</td>
<td>0.8</td>
<td>2.0</td>
<td>6.4</td>
<td>39.7</td>
<td>2.5</td>
</tr>
<tr>
<td>non-fatal</td>
<td>0.2</td>
<td>0.7</td>
<td>2.0</td>
<td>2.2</td>
<td>4.3</td>
<td>0.8</td>
</tr>
<tr>
<td>all</td>
<td>0.4</td>
<td>1.4</td>
<td>3.9</td>
<td>8.6</td>
<td>44.0</td>
<td>3.3</td>
</tr>
</tbody>
</table>

Women

<table>
<thead>
<tr>
<th>Age group</th>
<th>15–44</th>
<th>45–54</th>
<th>55–64</th>
<th>65–74</th>
<th>75+</th>
<th>Total age-adjusted</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>6,849</td>
<td>1,871</td>
<td>1,592</td>
<td>991</td>
<td>379</td>
<td>11,682</td>
</tr>
<tr>
<td>fatal</td>
<td>0.2</td>
<td>0.8</td>
<td>2.0</td>
<td>6.4</td>
<td>39.7</td>
<td>2.5</td>
</tr>
<tr>
<td>non-fatal</td>
<td>0.2</td>
<td>0.7</td>
<td>2.0</td>
<td>2.2</td>
<td>4.3</td>
<td>0.8</td>
</tr>
<tr>
<td>all</td>
<td>0.4</td>
<td>1.4</td>
<td>3.9</td>
<td>8.6</td>
<td>44.0</td>
<td>3.3</td>
</tr>
</tbody>
</table>

Number of cases with stroke in parentheses.

3.3/1000 caused almost exclusively by the difference in non-fatal cases.

There were 128 men and women at the baseline investigation who gave a history of verified stroke. After excluding these prevalence cases the incidence rates for first stroke in the study population were calculated (table 2). The mean annual incidence of first stroke was 3.8/1000 in men and 3.0/1000 in women. The stroke incidence in cases with a history of stroke at the baseline was about seven times higher than the rate in stroke-free population.

In twelve per cent of the incidence cases the stroke was caused by subarachnoid hemorrhage and in ten per cent by cerebral hemorrhage. In 30 per cent of the cases cerebral infarction was ascertained as the cause of the stroke; in 49 per cent the type of stroke could not be specified with certainty. The mean annual incidence of subarachnoid hemorrhage was 0.3/1000 in both sexes (table 3). The incidence of cerebral hemorrhage was also the same, 0.3/1000, in men and women. The incidence of ischemic infarction due to thrombosis or embolus was significantly higher in men, 1.3/1000,
The mean annual incidence of stroke in men was lowest in the study region in southwestern Finland, increasing step-wise from the western and central regions to the eastern study region (fig. 3). The incidence of stroke was almost significantly higher (p < .05, one-tailed t-test) in men from eastern Finland than in men from the southwestern part of the country. The women showed no significant differences in the incidence rates of stroke by study region. The incidence of subarachnoid hemorrhage, cerebral hemorrhage and non-specified stroke did not vary by region. The incidence of ischemic infarction was highest in men and women from eastern Finland. The mean annual incidence of ischemic infarction was almost significantly (p < .05, one-tailed t-test) higher in men from eastern Finland than in men from southwestern Finland.

**Discussion**

The study population in our investigation is not representative of the whole adult Finnish population. However, the study cohorts were drawn from four geographical regions with different cardiovascular mortality and the distribution of age, occupations and social classes of the attendants was very close to that of all persons of similar age in the whole country. The slight excess of males in the study population was due to the male excess in the employees of the factories. Furthermore according to the mortality follow-up experience the cardiovascular mortality in the specific cohorts was fairly similar to that in the counties from which the cohorts were drawn. Thus, while strictly speaking the cohorts were representative only for the defined areas, the distribution of demographic factors and the mortality follow-up experience was very close to that of the whole population of the country. Some general conclusions can thus be made.

The ascertainment of deaths from stroke was complete in our prospective study. Copies of death certificates were obtained for all those who died in the course of the follow-up. The coverage of all non-fatal events was impeded firstly because information on past diseases could not be obtained for five per cent of the people invited to the re-examination and hence they were excluded from analyses. The incidence of non-fatal stroke among them is unknown but it is probably somewhat higher than among those included in our analyses. This conclusion has been reached because the prevalence of stroke in non-attendants at the follow-up examination was significantly higher than in attendants. Secondly people, who had suffered a non-fatal stroke in the follow-up time, may not have mentioned it in the questionnaire. The extent of under-reporting of known stroke could be partly analyzed in this study by cross-checking our data with national register of hospital discharges. Unfortunately, this could not be performed throughout the follow-up but only in the last three years. According to this analysis the number of persons discharged from hospital with a diagnosis of stroke exceeded the number of persons
TABLE 4  Mean Annual Incidence ((1/1000) of Stroke in Participants (P) and Non-participants (NP) at the Baseline Investigation

<table>
<thead>
<tr>
<th></th>
<th>Fatal stroke</th>
<th>Non-fatal stroke</th>
<th>All events</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>p</td>
<td>p</td>
</tr>
<tr>
<td>Men</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>10,151</td>
<td>2.4 (77)</td>
<td>1.5 (67)</td>
</tr>
<tr>
<td>NP</td>
<td>1,833</td>
<td>3.6 (25)</td>
<td>0.6 (5)</td>
</tr>
<tr>
<td>Women</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>10,033</td>
<td>2.0 (71)</td>
<td>0.8 (38)</td>
</tr>
<tr>
<td>NP</td>
<td>1,649</td>
<td>3.9 (51)</td>
<td>0.9 (9)</td>
</tr>
</tbody>
</table>

p: NS = not significant, * = < .01, † = < .001.
Number of incidence cases in parentheses.

ascertained to have had a stroke according to the present study by 10–20 per cent. Scrutiny of the data available on the cases established only from the discharge register revealed that although medical records were obtained for about half of them, the diagnostic criteria were not met. Thus the incidence of non-fatal stroke in our study is underestimated, but there is no way of calculating exactly by how much. Nevertheless we suggest that the incidence of non-fatal stroke presented in our report is about 90 per cent of the “true” incidence in the study population and that the underestimation is relatively largest in the oldest age groups.

In this report, stroke cases were included even when the diagnosis was only possible in agreement with the protocol applied in the WHO collaborative stroke register study.10 In scrutinizing the incidence cases the certainty of diagnosis was categorized in three grades. In the first grade the diagnosis was unequivocal with diagnostic procedures performed in elderly persons in which often the only document available was the diagnosis on the death certificate.

The age trend and differences by sex in the incidence rates of stroke obtained in our study are in agreement with findings in earlier studies.1–4, 12 The proportion of subarachnoid hemorrhages in our study is consistent with that in previous reports.3, 4, 15, 16 In a substantial number of incidence cases the type could not be determined by the data available from medical records; in most of them the stroke was probably caused by ischemic infarction. If this suggestion holds true the overall distribution of the types of stroke agrees well with previous findings.3, 4, 15, 16

In most prospective population studies dealing with the incidence of stroke only attendants at the study were investigated; our study included non-attendants as well. As in some other population studies17, 18 according to which morbidity and mortality are substantially higher in non-attendants than in attendants, mortality from stroke was higher in non-attendants in the present study, too. The incidence of non-fatal stroke in non-attendants in our study was not, however, statistically different from the incidence in attendants. This is certainly mainly due to the under-reporting of past stroke history in non-attendants. Previously mentioned cross-checking of hospital discharge data corroborates this assumption. Most of the additional cases detected by the discharge register were non-attendants at the initial survey.

The incidence of and mortality from coronary heart disease and mortality from all cardiovascular diseases are known to show considerable regional variation in Finland.3, 6 The rates are low in the southwestern part of the country and gradually increase eastwards and northeastswards. Much less is known of the regional variation in morbidity and mortality from cerebrovascular diseases. According to a recent regional analysis mortality from cerebrovascular disease is high in central and eastern parts of the country, but the regional variation is not as pronounced as the variation in coronary mortality.19 The regional variation in the incidence rates of stroke in men in our study, although much smaller than variation in incidence rates of coro-
A number of thorough prospective population surveys have been conducted on stroke incidence.20-25 The relatively small number of incidence cases in these studies and the scarcity of detailed information on sex-specific and age-specific incidence rates make the comparison with our results difficult. Thus, in the following only the findings from stroke registers maintained in some countries have been compared with the results of our study. Stroke registers in Finland have been or are kept in Espoo and Kauniainen16 for southern Finland, and in North Karelia1-24 and Kuopio25 for eastern Finland. The incidence of stroke in men established in the present study was very similar to that recorded in Finnish stroke registers (fig. 4). Likewise the incidence of stroke in women in our study did not differ appreciably from that in stroke registers. The incidence of stroke in men in our study (fig. 5) was somewhat higher than that reported in stroke registers in Söderhamn, Sweden,26 Frederiksberg, Denmark1,27 and Tartu, Estonia.4 The relatively high rate in the oldest age group in the present study was mainly due to the great number of possible incidence cases discussed before. The incidence rates obtained from a Japanese stroke register from Akita,5 northern Japan, were, however, clearly higher than the rates in our study, especially in the younger age groups. The stroke inci-

![Figure 4](http://stroke.ahajournals.org/content/17/4/680.full.pdf)

**Figure 4.** Mean annual age-specific incidence of stroke in men in three stroke registers kept in Finland and in the present study.

![Figure 5](http://stroke.ahajournals.org/content/17/4/680.full.pdf)

**Figure 5.** Mean annual age-specific incidence of stroke in men in stroke registers of Söderhamn, Sweden, Frederiksberg, Denmark, Tartu, Estonia and Akita, Japan and in the present study.

dence in this small Japanese rural community is, however, one of the highest ever reported, and rates from all other Japanese registers are lower.1 For example according to a recent report,28 stroke incidence in the Japanese town of Shibata in the region with high stroke mortality was very similar to the rates obtained in our study.

The incidence rates in our prospective study agree well with those given in other studies conducted in Finland and elsewhere. The data form a reliable basis for subsequent analyses dealing with the predictors of stroke.

**References**


7. Aromaa A: Epidemiology and public health impact of high blood
Prevalence of Stroke in Finland

KARI AHO, M.D., ANTTI REUNANEN, M.D., ARPO AROMAA, M.D., PAUL KNEKT, M.Sc., AND JOUNI MAATELA, M.D.

SUMMARY The prevalence of stroke was investigated in a Finnish population study. The results were based on cross-sectional data from a follow-up examination of a prospective study conducted in 1973-1976. The study population drawn from four regions of the country comprised 11,103 men and 11,096 women aged 20 years and over. The age-adjusted prevalence of stroke was 10.3/1000 in men and 5.8/1000 in women. The prevalence was significantly higher in non-attendants at the examination than in attendants. In 15 per cent of the prevalence cases the stroke was caused by subarachnoid hemorrhage, in six per cent by cerebral hemorrhage and in the remainder by cerebral infarction or the type could not be specified. Over half (57 per cent) of the survivors of stroke had no or only slight disability; eight per cent were totally disabled. Some form of organic heart disease and hypertension was significantly more common in the prevalence cases than in the others.

IN FINLAND, as in many other developed countries, stroke lies third on the list of leading causes of death after coronary heart disease and cancer.1, 2 To date, however, the epidemiology of stroke has been based on only a few population studies, in most of which the incidence of stroke has been investigated.3-5 Although the incidence describes the rate of all new cases in the community adequately, the prevalence provides the best measure of the impact that stroke has on the community and provides the information needed for developing health care services.

Very few studies6 have been conducted on the prevalence of stroke, and no reports have been published from Finland. We have studied the prevalence of stroke and risk factors in stroke survivors as part of a survey of cardiovascular diseases in Finland. The incidence of stroke in the same population is presented in another article in this issue.7
Incidence of stroke in a Finnish prospective population study.
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