Socioeconomic Status and Ischemic Stroke
The FINMONICA Stroke Register

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Background and Purpose—It has been shown that low socioeconomic status is associated with death from stroke. More-detailed data have, however, remained scanty. The purpose of the present study was to examine the association of socioeconomic status with ischemic stroke. Besides mortality, we analyzed the incidence, case-fatality ratio, and prognosis of ischemic stroke events.

Methods—Our population-based study included 6903 first stroke events registered by the FINMONICA Stroke Register in 3 areas of Finland during 1983 to 1992. Indicators of socioeconomic status, such as taxable income and education, were obtained by record linkage of the stroke register data with files of Statistics Finland.

Results—Incidence, case-fatality ratio, and mortality rates for ischemic stroke were all inversely related to income. Furthermore, 28 days after the onset of symptoms, a greater proportion of patients with low income than of those with high income was still in institutionalized care and/or in need of help for their activities of daily living. Population-attributable risk of the incidence of first ischemic stroke due to low socioeconomic status was 36% for both sexes. For the death from first ischemic stroke, it was 56% for both sexes.

Conclusions—Persons with low socioeconomic status have considerable excess rates of morbidity and mortality from ischemic stroke in Finland. A reduction in this excess could markedly decrease the burden of ischemic stroke to the society and thus constitute an important public health improvement. (Stroke. 2001;32:1492-1498.)

Key Words: population surveillance ■ socioeconomic factors ■ stroke, ischemic ■ World Health Organization

A
cute stroke events and disability among stroke survivors produce an enormous burden to the social and health care systems.1,2 Although there are differences among subtypes of stroke, the main impact of this disease stems from ischemic stroke (IS), which in European populations represents up to 80% of all stroke events and occurs as either an embolic or a thrombotic stroke. IS is frequent in middle-aged and older individuals and often leads to prolonged hospitalization, disability, or death. It is likely that the aging of Western populations will increase the number of IS events in the future. Therefore, the prevention and better treatment of IS have considerable public health significance.3

It has already been shown that low socioeconomic status (SES) is associated with the risk of stroke.4-5 These results are mainly based on mortality data,6,7 whereas only a limited amount of information exists on the relationship of SES to the incidence of first IS events.8,9 Even less is known about the association of SES with case-fatality ratio and prognosis of IS, particularly at the population level. The main objective of the present study was to investigate the association of SES with the incidence and mortality of IS, as well as with the prognosis, treatment, and diagnostic patterns of IS events. We also estimated the population-attributable risk of the incidence of first IS events and death from IS due to the low SES.

Methods
Data originated from the FINMONICA Stroke Register, a Finnish contribution to the World Health Organization’s MONICA Project (MONItoring of trends and determinants of Cardiovascular disease). The population-based register operated in 3 areas of Finland.10,11 All stroke events occurring in persons aged 25 to 74 years with permanent residence in one of the study areas were recorded during the 10-year study period that included 1982 to 1991 in North Karelia and 1983 to 1992 in Kuopio and Turku/Loimaa. Trained nurses, supervised by the register physicians, collected data on treatment practice patterns, need for help in activities of daily living, and other clinical details from the hospital documents or by interviewing the patient. Population sizes of the FINMONICA areas remained stable.
during the study, and in 1988, there were 390,564 inhabitants aged 25 to 74 years living in these areas. The FINMONICA Stroke Register followed the protocol, diagnostic criteria, and quality control procedures of the WHO MONICA project. A full report on data quality control is available. The Ethical Committee of the National Public Health Institute approved the study plan of the stroke register.

To ascertain the completeness of case finding, the stroke register data were cross-checked with the National Death Register using computerized record linkage on the basis of personal identification number unique to every inhabitant of Finland. Cases identified from the National Death Register but not included in the stroke register were sent back to the local registration teams for review and, if found to fulfill the registration criteria, were added to the register. On average, 6 IS deaths were annually added to the stroke register in this manner. This equals ~6% of all IS deaths in the register.

Information on SES was obtained by record linkage of the stroke register with the files of Statistics Finland on the basis of the personal identification number. Taxable income, level of education, and profession for the years 1980, 1985, and 1990 were used as the indicators of SES. Because the results regarding profession were similar to those regarding income and education, only result for the latter 2 are presented. The closest income record before the event was taken. For analyses, the income data were adjusted for inflation and classified into 3 broad categories: low, middle, and high. The income distribution depended on age, but on average, 26.2% of men belonged to the low-income group, 31.9% belonged to the middle-income group, and 41.9% belonged to the high-income group. Among women, the corresponding proportions were 38.9%, 21.4%, and 39.7%. Education was stratified into 2 categories: basic, secondary or higher education.

During the early years of the FINMONICA study, the availability of CT was still limited. Therefore, and to enable a consistent classification of strokes into subtypes (IS, intracerebral hemorrhage, subarachnoid hemorrhage) was carried out on the basis of clinical criteria and cerebrospinal fluid examination. Strokes of embolic and thrombotic origin were combined in the IS category. The classification was made without regard to SES. Of the events classified as ISs in the FINMONICA Stroke Register, the diagnosis could be confirmed by necropsy, CT, MRI, or angiography in 72% among men of the high-income group, in 58% among men of the middle-income group, and in 47% among men of the low-income group. Among women, the corresponding proportions were 76%, 59%, and 44%. In the remainder of the events, the diagnosis of IS was made on the basis of lumbar puncture and clinical examination.

The 95% CI of the IS event was included in the present study. An event was considered to be the patient’s first if no evidence was found of a clinically recognized previous IS. Survival status was examined at 28 days and at 1 year after the onset of symptoms. The survival status at 1 year was obtained through record linkage with the National Death Register. The follow-up was 100% complete.

Statistical Analysis

SES-specific annual incidence and mortality rates were age-standardized to the European standard population and expressed per 100,000 persons. The 95% CIs were calculated using normal approximation of the Poisson distribution for the number of events in different age groups. Case-fatality ratio was defined as the proportion of fatal events of all events and was age-standardized to the age distribution of the combined stroke and coronary events in the WHO MONICA Project. The 95% CIs for the case-fatality ratio were calculated using the normal approximation of binomial distribution for the number of deaths. Survival for different follow-up intervals was estimated using Kaplan-Meier curves, and differences between the income groups were compared using log-rank tests. Hazard ratios (HRs) for dying after IS were computed with Cox proportional hazards models. The 95% CIs for the HRs were calculated in the usual manner: exp(\hat{β} ± 1.96 \hat{σ}_{\hat{β}}). Persons with a high income were taken as the reference category, and persons with a middle or low income were compared with them. Proportions of patients receiving different treatments and examinations were age-standardized using weights derived from the age distribution of all stroke and myocardial infarction patients in the WHO MONICA Project. To examine the linear trends in treatments across the income categories, the event numbers in each category were divided into 2 groups on the basis of the age-standardized proportions, and the Mantel-Haenszel test was performed for the ensuing 2×3 table. The population-attributable risk of IS death and the incidence of first IS events due to low and middle income were calculated using the formula AR=(D−D0)/D0, where AR is attributable risk, D is IS mortality in the population overall, and D0 is IS mortality in the high-income group. The statistical analyses were carried out using SAS (SAS Institute).

Results

A total of 6903 first IS events were registered during the 10-year period. The age-standardized incidence of first IS events was almost 2 times higher among persons with a low or middle income than among those with a high income, both in men and women and in all age groups (Table 1). In incidence, the main gap was observed between the high- and middle-income groups, but in mortality, there was a gradual decrease from the low- to the middle- and high-income groups. Among men aged 25 to 59 years, the 28-day mortality rate ratio was 5.7 (95% CI 3.2 to 10.0) in the low-income group and 3.5 (95% CI 2.0 to 6.3) in the middle-income group compared with the high-income group. Among women aged 25 to 59 years, the 28-day mortality rate ratio in the low-income group compared with the high-income group was 2.9 (95% CI 1.3 to 6.7). Among older men and women, the findings were consistent with those observed in the younger age groups. Differences in mortality between the 2 education groups were somewhat smaller than differences between the 2 extremes of the 3 income groups (Table 1). However, persons with a basic education only had significantly higher incidence and mortality rates than did persons with a secondary or higher education.

The 28-day case-fatality ratio of IS among men aged 25 to 59 years was nearly 3 times higher in the low-income group (13.6%) than in the high-income group (5.1%) (Table 2). At 1-year follow-up, the difference in case-fatality ratio between the low- and high-income groups remained similar. A similar trend but with a smaller gap was observed among older men at day 28. Among women of all age groups, the low-income group had a marginally higher case-fatality ratio than the high-income group (Table 2). Only at the 1-year follow-up among older women was the difference between the low- and high-income groups more significant.

The Kaplan-Meier survival curves stratified according to age, sex, and income group are presented in the Figure. The differences in survival between the income groups were statistically significant among both sexes and among the 2 age groups.

Cox proportional hazards regression analyses confirmed that income was associated with the case-fatality ratio of IS among men, independent of age, study area, and living conditions (Table 3). At day 28, the low-income group in the age group of 25 to 59 years had a 2.61 (95% CI 1.46 to 4.68) times higher case-fatality ratio than the high-income group. Also at 1 year, the middle-income group had a significantly
higher case-fatality ratio than the high-income group (HR 1.71, 95% CI 1.06 to 2.75). Among older men, the differences between the income groups were smaller than those for the age group of 25 to 59 years, but also among the older men, the low-income group had a significantly higher HR than did the high-income group both at day 28 and at 1 year. The age group × low-income group interaction was nonsignificant at day 28 ($P=0.17$) but was of borderline statistical significance at the 1-year follow-up ($P=0.06$). A consistent trend toward a higher risk of IS death with decreasing income category was also observed in women, but it was not statistically significant except at the 1-year follow-up among women aged 60 to 74 years. Low educational attainment was not significantly associated with IS death, except among women aged 25 to 59 years (Table 3).

The association between income and diagnostic and treatment practice patterns was analyzed for IS patients who reached a hospital alive and stayed alive for $\geq 1$ day after the onset of symptoms. Both male and female IS patients with a high income were more often treated at a university hospital and less often treated at a health center ward than were their counterparts with a low income (Table 4). Accordingly, patients with a high income were more often examined by a specialist in neurology than were patients with a low income. The high-income group was more often examined with CT or MRI, whereas the low-income group was more often examined with a lumbar puncture. Almost half of the IS patients with a low income were still in institutionalized care at day 28 after the onset of symptoms. Among men with a high income, the proportion remaining in an institution was significantly less (37.3%), and among women, there was a significant trend toward a smaller proportion remaining in institutionalized care with increasing income. Almost 60% of IS patients with a low income needed help in their activities of daily living at day 28. Among patients with a high income, this proportion was significantly lower: 43.5% in men and 46.5% in women.

The population-attributable risk was estimated with the high-income group taken as the nonexposed category and combined low- and middle-income groups taken as the category exposed to low SES. Accordingly, the population-attributable risk of the incidence of first IS event due to low SES was 36% for both sexes. Corresponding estimates for the death from first IS within 1 year from the onset of the event were 56% for both sexes.

**Discussion**

The present study demonstrated that low SES was associated with a considerable excess mortality from IS in Finland. We also showed that both the incidence and the case-fatality ratio of first IS events were higher in persons with low SES than in persons with high SES. Among survivors, there was a significant SES difference in the prognosis of the first IS event: a greater proportion of persons with low SES than those with high SES remained in an institution and/or needed...
help in their activities of daily living 28 days after the onset of the event. Estimates of the population-attributable risk indicated that low SES accounted for one third of the incidence and more than half of the mortality of IS in the population. In terms of socioeconomic gradient, these results are analogous to our earlier findings for subarachnoid hemorrhage and intracerebral hemorrhage, although both case-fatality ratio and the age distribution of the patients are different for hemorrhagic strokes than for IS.

Earlier studies have reported mainly death from cerebrovascular disease taken from routine mortality statistics, which have a varying degree of validity in different countries. Carefully standardized and more-detailed data have remained scant. However, several authors have previously shown increased stroke mortality rates for lower SES groups both in Finland and elsewhere. Kunst et al described higher stroke mortality rates in men with manual occupations compared with men with nonmanual occupations in 11 European countries and in the United States. Finland was one of the countries with the largest SES differences in stroke mortality rates. In keeping with our findings, recent studies from northern Sweden and from the Netherlands have reported an association between low SES and the incidence of stroke. The case-fatality ratio was analyzed in the Swedish study only, and its relationship to SES did not reach statistical significance, although the category of “employed and self-employed professionals” had the lowest case-fatality ratio. In a study carried out among white men in the United States, SES, expressed as the median family income of the zip code of residence, was significantly associated with death from nonhemorrhagic stroke. Our study is in agreement with this previous literature but provides a more precise assessment of the relationship between SES and IS by presenting population-based data on the incidence, case-fatality ratio, and prognosis of validated first IS events.

The strengths of the present study include its population-based design and the large number of IS events collected according to a standardized protocol and under rigorous quality control of the WHO MONICA Project. Another major strength was the possibility of record linkage with the files of Statistics Finland, which provided us with accurate information on taxable income and education for each stroke patient before the stroke occurred. In countries in which such a register linkage is not possible, zip codes for the area of residence have been used as surrogates of SES. It has, however, been argued that the zip codes do not always correctly indicate the SES of an individual and that the ensuing misclassification tends to reduce the mortality differences.

A limitation of the study was that we did not have the household income, which may have caused some misclassification of the income category among women. However, a large proportion of Finnish women are economically independent; according to Statistics Finland, 85% of Finnish women aged 35 to 59 years were working outside of the home in 1997. Therefore, the possible misclassification is not as substantial as it might have been in some other countries. Furthermore, the results for income were similar to those for education, which were not biased by the lack of family income.

Another limitation was the fact that the diagnosis of IS was not always based on CT or MRI and that the use of these diagnostic examinations depended on income. Even though the classification of the subtype of stroke in the FINMONICA

### Table 2. Age-Standardized Case Fatality Rates of First Ischemic Stroke Events by Age Group, Income Group, and Education Level Among Men and Women Aged 25 to 74 Years in the FINMONICA Stroke Register

<table>
<thead>
<tr>
<th></th>
<th>25–59 y</th>
<th></th>
<th>60–74 y</th>
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<tbody>
<tr>
<td></td>
<td>28 d*</td>
<td>1 y*</td>
<td>28 d*</td>
<td>1 y*</td>
</tr>
<tr>
<td><strong>Men</strong></td>
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<tr>
<td>Income group</td>
<td></td>
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</tr>
<tr>
<td>Low</td>
<td>13.6 (10.4–16.8)</td>
<td>18.6 (15.0–22.2)</td>
<td>16.6 (14.8–18.4)</td>
<td>27.0 (24.8–29.2)</td>
</tr>
<tr>
<td>Middle</td>
<td>7.9 (5.8–16.8)</td>
<td>12.5 (9.9–15.1)</td>
<td>14.5 (11.8–17.2)</td>
<td>24.4 (21.2–27.6)</td>
</tr>
<tr>
<td>High</td>
<td>5.1 (2.6–7.6)</td>
<td>7.8 (4.5–10.7)</td>
<td>10.2 (5.8–14.6)</td>
<td>19.7 (14.0–25.4)</td>
</tr>
<tr>
<td>Education level</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basic</td>
<td>9.7 (7.9–11.5)</td>
<td>13.9 (11.8–16)</td>
<td>15.6 (14.1–17.1)</td>
<td>26.1 (24.2–28.0)</td>
</tr>
<tr>
<td>Secondary or higher</td>
<td>6.7 (4.1–9.3)</td>
<td>11.1 (7.8–14.4)</td>
<td>15.0 (11.4–18.6)</td>
<td>21.8 (17.6–26.0)</td>
</tr>
<tr>
<td><strong>Women</strong></td>
<td></td>
<td></td>
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<tr>
<td>Income group</td>
<td></td>
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</tr>
<tr>
<td>Low</td>
<td>8.7 (5.4–12)</td>
<td>13.0 (9–17)</td>
<td>18.6 (16.9–20.3)</td>
<td>27.8 (25.9–29.7)</td>
</tr>
<tr>
<td>Middle</td>
<td>6.6 (2.2–11.0)</td>
<td>9.0 (3.9–14.1)</td>
<td>12.5 (8.4–16.6)</td>
<td>22.5 (17.3–27.7)</td>
</tr>
<tr>
<td>High</td>
<td>5.8 (1.6–10.0)</td>
<td>7.5 (2.8–12.2)</td>
<td>11.8 (6.0–17.6)</td>
<td>18.2 (11.3–25.1)</td>
</tr>
<tr>
<td>Education level</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basic</td>
<td>8.8 (6.6–11.6)</td>
<td>12.4 (9.1–15.7)</td>
<td>18.1 (16.5–19.7)</td>
<td>27.3 (25.4–29.2)</td>
</tr>
<tr>
<td>Secondary or higher</td>
<td>1.7 (0.0–3.5)</td>
<td>4.4 (0.5–8.3)</td>
<td>14.7 (10.7–18.7)</td>
<td>22.7 (17.9–27.5)</td>
</tr>
</tbody>
</table>

Values are percent (95% CI).

*After the onset of symptoms of stroke.
Stroke Register was based on clinical criteria and was carried out without regard to SES, we cannot exclude the possibility that a few cases of intracerebral hemorrhage would have been erroneously classified as IS. Because the proportion of these diagnostic examinations was lowest in persons with low SES, the possibility for misclassification is greatest in that group. This is relevant because the resulting bias, if it really existed, would have inflated the incidence, mortality, and case-fatality ratio values of the low-income group. However, clearly more than half of our patients had undergone specific diagnostic procedures, and almost all the remainder had had a lumbar puncture and clinical examination. Thus, it is very unlikely that diagnostic misclassification could explain the large SES differences that were observed. Furthermore, we recently reported that the incidence and mortality rates of intracerebral hemorrhage are also higher in persons with a low SES than in those with a high SES, which also speaks against a substantial misclassification bias and suggests that socioeconomic differences exist in the occurrence of all types of stroke events in Finland.

Because mortality is the product of incidence and case-fatality ratio, it is obvious that incidence and case-fatality ratio contributed to the SES differences in IS mortality rates in Finland. The incidence of first IS events mainly reflects the prevalence of atherosclerosis and its risk factors, especially high blood pressure, in the population. Case-fatality ratio, in turn, reflects both the severity of the event and the efficacy of treatment given. SES differences in the levels of cardiovascular risk factors and in the occurrence of coronary heart disease have been demonstrated in Finland. It is likely that they explain a substantial portion of the observed SES differences in the incidence of IS. There is, however, good evidence that classic risk factors account for only a portion of the SES differences in cardiovascular mortality rates. This may be due in part to the long-acting nature of the influence of SES, which may be cumulative during the lifetime of an individual and even depend on the SES of the previous generation.

Considerable differences by SES were also observed in the patterns of diagnostic and treatment practices for IS. Similar differences were found among acute coronary events and are due in part to the area of residence, because persons in rural areas tend to have lower incomes and longer distances to specialized centers, which can offer more sophisticated diagnostic services. However, essentially similar SES differences were observed when only inhabitants of urban areas were included in the analysis. It is likely that the differences in the diagnostic and treatment practice patterns have contributed to the differences in case-fatality ratio and prognosis. Interestingly, 28 days after the onset of the event, more patients with a low SES than patients with a high SES were still in institutionalized care and/or in need of help in their activities.
of daily living. If this excess need of care could be reduced, it would substantially reduce the burden of IS to the health care system as well as to the families of these patients.

It is probably unrealistic to expect that the socioeconomic differences in IS mortality and morbidity rates could be totally eliminated. Differences observed in the present study were, however, very large, and a substantial narrowing of the gap should be possible. In principle, this could be achieved in 2 ways. First, the incidence differences can be influenced by focusing more attention to the primary prevention of IS and other atherosclerotic diseases in persons with low SES. Those persons who already have coronary heart disease have an increased risk of IS, and coronary patients with a low SES should receive adequate treatment and secondary prevention measures. Second, differences in case-fatality ratio and prognosis can be reduced by ensuring that the IS patients with a low SES receive diagnostic, treatment, and rehabilitation services that are equal to those of their wealthier counterparts.

In conclusion, in Finland, persons with a low SES have considerable excess mortality and morbidity of IS. Reduction

### TABLE 3. Age-Standardized Hazard Ratios of Death Among Ischemic Stroke Patients Within 28 Days and 1 Year After the Onset of First Ischemic Stroke in Men and Women Aged 25 to 59 and 60 to 74 Years by Income Group and Education Level in the FINMONICA Stroke Register

<table>
<thead>
<tr>
<th>Income Group</th>
<th>25–59 y</th>
<th>60–74 y</th>
</tr>
</thead>
<tbody>
<tr>
<td>28 d</td>
<td>1 y</td>
<td>28 d</td>
</tr>
</tbody>
</table>

*Values in parentheses are 95% CI adjusted for age, urban/rural residence, study area, and living alone or with a family member.

### TABLE 4. Age-Standardized Proportions of Treatments and Examination Procedures of Patients With First Ischemic Stroke by Income Group Among Men and Women Aged 25 to 74 Years in the FINMONICA Stroke Register

<table>
<thead>
<tr>
<th>Income Group</th>
<th>Treatment at University Hospital</th>
<th>Treatment at Health Center Ward</th>
<th>Examination by a Neurologist</th>
<th>Lumbar Puncture</th>
<th>CT Scan or MRI</th>
<th>Still in Institution*</th>
<th>Needs Help in ADL*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Low</td>
<td>32.7 (30.5–34.9)</td>
<td>18.5 (16.7–20.2)</td>
<td>75.7 (73.8–77.6)</td>
<td>37.7 (35.4–39.9)</td>
<td>44.6 (42.4–46.9)</td>
<td>49.5 (47.1–52.0)</td>
<td>59.3 (56.9–61.7)</td>
</tr>
<tr>
<td>Middle</td>
<td>42.7 (39.8–45.5)</td>
<td>10.4 (8.6–12.2)</td>
<td>84.0 (81.8–86.2)</td>
<td>35.2 (32.4–37.9)</td>
<td>48.6 (45.8–51.4)</td>
<td>43.5 (40.4–46.5)</td>
<td>52.1 (49.1–55.1)</td>
</tr>
<tr>
<td>High</td>
<td>50.2 (45.0–55.4)</td>
<td>4.2 (2.1–6.3)</td>
<td>86.1 (82.2–90.0)</td>
<td>29.3 (24.7–33.8)</td>
<td>60.8 (55.8–65.9)</td>
<td>37.3 (32.0–42.5)</td>
<td>43.5 (38.1–48.9)</td>
</tr>
<tr>
<td>P value for trend†</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
</tr>
</tbody>
</table>

*Status at day 28 since the beginning of symptoms; includes only patients who have survived at least until day 28.
†Mantel-Haenszel test for a linear trend.
in this excess could increase equity in health, markedly reduce the burden of IS on the society, and thus produce a substantial public health improvement.

Acknowledgments

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