Continuous 15-Year Decrease in Incidence and Mortality of Stroke in Finland
The FINSTROKE Study

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Background and Purpose—The purpose of this study was to analyze the incidence and mortality trends in stroke events among persons 25 to 74 years of age in Finland from 1983 to 1997.

Methods—The population-based FINSTROKE register recorded 5650 new strokes among persons 25 to 74 years of age in 2 geographical areas of Finland: 2770 in the Kuopio area (east central Finland) and 2880 in Turku (southwestern Finland). Of these, 3065 were men and 2585 were women.

Results—The rates of acute stroke events fell during the whole study period in both men and women. In both FINSTROKE areas combined, the average annual decline in the age-standardized incidence of first stroke events was 2.0% (95% confidence interval [CI], −2.8 to −1.2; P<0.001) among men and 1.7% (95% CI, −2.6 to −0.8; P<0.001) among women. The decline in the incidence of ischemic stroke was even steeper, 2.9%/y (95% CI, −4.9 to −1.1; P<0.001) among men and 3.1%/y (95% CI, −5.0 to −1.1; P<0.001) among women, whereas the incidence of intracerebral hemorrhage and subarachnoid hemorrhage did not change. Mortality from all stroke events declined in the FINSTROKE areas by 3.7%/y (95% CI, −5.3 to −2.0; P<0.001) among men and by 4.1%/y (95% CI, −5.9 to −2.4; P<0.001) among women. The 28-day case fatality of all stroke events also tended to decline, but the decline was of borderline statistical significance only (P=0.07 among men, P=0.05 among women).

Conclusions—Incidence and mortality of stroke events declined significantly in these 2 register areas in Finland during the 15-year period of 1983 to 1997. (Stroke. 2004;35:420-425.)

Key Words: epidemiology ■ Finland ■ incidence ■ mortality ■ stroke

Cardiovascular disease mortality has declined in many industrialized countries since the early 1970s.1-3 In the 1980s, data on incidence trends did not agree with falling mortality, and there was even an increase in some countries.4,5 During the 1980s and early 1990s, very small variations in stroke incidence were seen in New Zealand,6 western Europe,6,7 and North America.8 However, consistently declining trends have been observed in northern Europe, Sweden, Norway,9,10 and Finland.11-14

The World Health Organization Monitoring Trends and Determinants in Cardiovascular Disease (WHO MONICA) stroke study was launched in the early 1980s to monitor stroke occurrence in populations around the world.15,16 To meet this challenge in Finland, the Finnish MONICA (FINMONICA) stroke register was set up in 3 distinct geographical areas.17 Ten-year trends in stroke events in the FINMONICA study showed that both the incidence and case fatality of stroke declined.13,14 After the end of the FINMONICA period, stroke registration was continued for an additional 5 years, ie, until 1997, in the framework of the FINSTROKE project. The aim of the present study was to analyze the incidence, mortality, and case fatality trends in stroke for the whole registration period from 1983 to 1997 and in stroke subtypes for the 10-year period of 1988 to 1997.

Materials and Methods

Three populations in Finland participated in the WHO MONICA study: the province of North Karelia, the province of Kuopio, and the city of Turku and its neighboring town, Loimaa. The FINMONICA stroke register operated from 1988 to 1997. The investigators, together with the National Public Health Institute, decided to continue the register under the name FINSTROKE for 1993 to 1997 in the Kuopio area and Turku. North Karelia was not able to continue its stroke register. The register area was reduced in Kuopio to consist of the cities of Kuopio, Varkaus, and Isalini, as well as 3 small rural areas with a combined population of 87 133 inhabitants (42 175 men, 45 134 women).
44,958 women) 25 to 74 years of age in 1995. Loimaa was no longer included in the Turku register; thus, its population consisted of 106,233 inhabitants (49,982 men, 56,000 women). A detailed description of the FINMONICA stroke register, including its casefinding and registration procedures, has been published.13 The FINSTROKE study was based on the same criteria. Together, the population-based FINMONICA and FINSTROKE registers recorded 5,650 new stroke patients among those 25 to 74 years of age in the FINSTROKE areas during 1983 to 1997. Of these, 2,770 strokes took place in Kuopio area, and 2,880 occurred in Turku; 3,065 were men, and 2,585 were women.

The diagnosis of stroke was based, as specified in the WHO MONICA protocol, on clinical signs lasting ≥24 hours, except in cases of sudden death or if the development of symptoms was interrupted by surgical intervention. All suspected acute strokes were registered and classified as “definite stroke,” “not stroke,” or “unclassifiable.” This final category was restricted, with few exceptions, to fatal events occurring before arrival at hospital and when no autopsy was performed. All hospital admission and discharge diagnoses, as well as cerebrovascular deaths, were routinely checked as source data, and all suspected stroke cases were entered and validated for stroke classification.

Acute stroke events in patients with no previous history of stroke were coded as first (incident) events. All subsequent attacks occurring after 28 days from onset were registered as recurrent strokes; if they occurred within 28 days, they were considered to belong to the same event. Twenty-eight days from the onset was also the cut point used to define fatal stroke. If the subject was alive 28 days from the date of symptom onset, the event was considered nonfatal. We also present routine mortality data for the whole country derived directly from the National Causes of Death Register, in which the numerators for the annual mortality rates are the subjects who died of stroke (International Classification of Diseases [ICD] codes I60 through I69 as the underlying cause of death in the death certificate) during that year regardless of the date of stroke onset.

In Finland, the 8th revision of the ICD was used until 1986; the 9th revision, from 1987 on, and the 10th revision, from 1996 on. The WHO MONICA protocol recommended that, if possible, the codes for specific stroke subcategories should be confirmed by examinations. For subarachnoid hemorrhage (SAH), necropsy, CT scan, or bloody cerebrospinal fluid was required to corroborate the diagnosis; for intracerebral hemorrhage (ICH), the diagnosis had to be confirmed by CT scan, MRI, or necropsy. If it was impossible to assign a definite stroke event to 1 of these categories, the code “unspecified stroke” was used. In this analysis, unspecified stroke and unclassifiable cases were combined with the ischemic stroke group. In the 25- to 64-year-old group, 1.4% of patients had unspecified or unclassifiable stroke; in the 65- to 74-year group, 5% of patients had that classification. The proportions did not vary through years among fatal or nonfatal or incident or recurrent events.

Because the specific imaging investigations, CT and MRI, were often not available in the beginning of our study period, we present the 15-year trends for all strokes combined and the type-specific trends for the 10-year period of 1988 to 1997. CT was performed in 1983 for 22% of men and 27% of women; after that, the CT rate rapidly rose annually until it stabilized at 90% by 1993. The combination of CT, MRI, and autopsy approached 100% at the end of the study period.

The Finnish Population Register provided us with the population data for calculation of the rates. Segi’s European standard population was used for direct age standardization of the rates.6 The 28-day case fatality rate was age standardized by use of weights derived from the combined age distribution of myocardial infarction and stroke patients in the WHO MONICA Project.17 We assumed Poisson distribution for the annual number of events to calculate 95% confidence intervals (CIs) for the rates. A log-linear model was used to estimate incidence and mortality trends, thus obtaining the CI for the trends from the standard error of the regression coefficient. To increase precision, estimates from the log-linear model are presented in the text as the rates for the first and last years of the study period.

## Results

The numbers of all first (incident) stroke events during the study period and the stroke subtypes during 1988 to 1997 are shown in Table 1. The incidence of all strokes declined from 1983 to 1997 in the Kuopio area and Turku in both men and women. The decline in the Kuopio area was steeper; the rate fell from 379/100,000 per year in the first year to 246/100,000 at the end of the study period (Figure 1). This represents a trend of −3.1%/y and −3.0%/y (P < 0.001) in men and women, respectively. The trends were less steep in Turku (−1.2%/y for men, P = 0.05; −0.6%/y for women, P = 0.39).

The incidence of ischemic stroke (Figure 2) declined particularly steeply in the Kuopio register area; it fell during the 10-year period of 1988 to 1997 by 5.2%/y in both men and women (P < 0.001). The rates fell from 289 to 182 per 100,000 in men and from 158 to 99 per 100,000 in women. In Turku, these trends were rather flat and nonsignificant. The trends in ICH and SAH remained stable in both areas and in both sexes during the 10-year period (Figure 3).

Mortality from stroke declined significantly from 1983 to 1997 in both areas and in both sexes (Figure 4). The mortality rate in the entire FINSTROKE register population fell from 85 to 51 per 100,000 in men (−5.3%/y; P < 0.001) and from 50 to 30 per 100,000 in women (−4.1%/y; P < 0.001). It decreased in the Kuopio area by 49% in men and 46% in women (86 to 44 per 100,000 and 54 to 29 per 100,000, respectively) and in Turku by 33% in men and 42% in women (from 79 to 53 per 100,000 and from 50 to 29 per 100,000, respectively). Compared with stroke mortality statistics for all of Finland from the official mortality statistics, the trends are very similar, but the mortality rates in the official mortality
statistics were slightly higher than those in the FINSTROKE register (Figure 4).

The 28-day case fatality of all stroke events also tended to decrease in both areas and in both sexes. In the entire FINSTROKE population, it decreased in men from 21.7% to 18.2% ($P=0.010$) and in women from 22.2% to 19.2% ($P=0.005$) during the 15-year period of 1983 to 1997. The case fatality of ischemic stroke remained stable and similar in men and women, $\approx 11\%$, during the 10-year period of 1988 to 1997. There was a slightly diminishing trend for case fatality of SAH and ICH in men, whereas the case fatality of ICH decreased significantly in women, from 55.2% to 32.6% ($P<0.01$).

**Discussion**

The present study comprises individuals 25 to 74 years of age in the FINMONICA and its successor, the FINSTROKE
The strict criteria established by the WHO MONICA Project were applied in our study to ensure that secular trends in the incidence of stroke were not affected by changes in diagnostic practices or incomplete ascertainment of cases. A strength of this study was the consistency in event classification as a result of the long-term involvement of the same investigators. In Kuopio, 1 neurologist (J.S.) was responsible for classifying all events during these 15 years. In Turku, 1 neurologist (V.N.) was responsible until his death; an internist (P.I.-R.) continued his work until 1997. Consistency and reliability were also ensured by the very high percentage of diagnostic investigations performed on each patient. CT, MRI, angiography, or autopsy was performed in 73.3% of men and 70.8% of women in 1988; in the last year

**Figure 3.** Age-standardized incidence in ICH and SAH by sex during 1988 to 1997 in patients 25 to 74 years of age. Rates are 3-year moving averages for both FINSTROKE areas combined. Numbers give the trend (percentage annual average change), its 95% CI, and probability value for the test trend = 0.

**Figure 4.** Age-standardized stroke mortality in the FINSTROKE study population and whole population of Finland (official mortality statistics, ICD-9 codes 430 through 438; ICD-10 codes I60 through I69; source: Statistics Finland) during 1983 to 1997 in patients 25 to 74 years of age. Data from both FINSTROKE areas are combined and presented as 3-year moving averages. Numbers give the trend (percentage annual average change), its 95% CI, and probability value for the test trend = 0.
of the study, these examinations were performed on 99.6% of men and 97.4% of women. Therefore, the classification of patients to stroke subgroups seems to be valid.

Previous reports from the United States, Europe, Russia, and New Zealand have shown little change in stroke incidence (or event) rates during the last decades. However, a marked decrease was seen in northern Europe (Denmark, Finland, and northern Sweden) and in Australia, and an increase was seen in Estonia. Lund-Orup, and the Malmö and Örebro areas in southern and central Sweden. No decline in mortality was observed in Warsaw, Poland. In Shanghai, China, virtually no decline in stroke incidence occurred, but a clear decline in stroke mortality was reported. In general, stroke mortality increased in eastern Europe in the second half of the 1980s and the early 1990s.

In the present study, the major emphasis was on the trends in incidence and mortality of stroke and its subgroups over time. In the past, stroke mortality in Finland was the highest in western Europe and one of the highest in the world. Furthermore, Finland has had one of the highest reported incidences of stroke in the world. The 10-year results of the FINMONICA stroke study showed a highly significant downward trend in both the incidence and mortality of stroke. This study reports a continuing decline in the incidence rate of all stroke events, incidence rate of ischemic stroke, and mortality from stroke but no decline in the corresponding rates of hemorrhagic strokes. The 28-day case fatality of all stroke events also tended to decline, although the decline did not quite reach statistical significance. Our data suggested that the decline was seen mainly in the case fatality of hemorrhagic strokes, whereas the case fatality of ischemic strokes did not change.

A major reason for the decline in stroke incidence and mortality during these 15 years is that the cardiovascular risk factor levels, which used to be very unfavorable in Finland, have improved considerably. Systematic work to lower the risk factors for cardiovascular diseases started in the early 1970s with the North Karelia Project and rapidly expanded to cover the whole country. The main aim was to change the lifestyle of the people to monitor their blood pressure values and to strive for lower vegetable and fruit consumption. Furthermore, it encouraged people to use acetylsalicylic acid has increased in Finland and in other Western countries. Acetylsalicylic acid has often been prescribed to patients with symptoms of transient ischemic attack to prevent a cerebral infarction, but perhaps more importantly, it has been prescribed to patients with coronary artery disease who are at increased risk of stroke.

In conclusion, both the incidence and mortality of stroke continued to decline until 1997 in both sexes in these 2 areas of Finland. Primary prevention and better control of cardiovascular risk factor levels in the population are the most likely reasons for this favorable development.

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