Population-based stroke registries are the most important sources in providing information about stroke epidemiology in different geographical regions. Stroke registries are the only reliable sources allowing for the evaluation of the efficiency of local health promotion programs, the influence of newly introduced treatment and management strategies on the incidence and case-fatality of stroke, and also determination of the overall burden of stroke in a population. Although the stroke incidence studies are complex and hard to conduct, the estimation of stroke time trends, in the same population, requires a continuous registry or several incidence studies at certain time intervals. Several studies, in different geographical regions, have been published.1–8 The design of studies mentioned above differ remarkably: registry-based,2,4,7 hospital-based,1 data from official statistics,3,5,8 or cases from limited age groups.1,2,3,6 All of these results are valuable but cannot be extrapolated to the whole population at risk of stroke, and the described variations in mortality and incidence between different regions and time periods may be mistaken for methodological biases.

There is a long history of stroke epidemiology in Estonia. The stroke registers, on a regular basis, give us a unique possibility to assess stroke trends in the same population over several decades. In addition, the compatibility of the study designs enables the comparison of results with other populations. Three studies have been conducted in Tartu, Estonia: first in 1970 to 1973,9 second in 1991 to 1993,10 and third in 2001 to 2003.11 The purpose of the present study was to estimate the time trends of stroke during the last 10 years, in the Estonian population, by comparison with the results from the 2 latest stroke registries from Tartu. The comparison of 2 first periods has been published previously.12

Methods

Tartu is the second largest town in Estonia. The Third Stroke Registry in Tartu was conducted from January 12, 2001 to November 30, 2003. The previous registry was carried out from January 1, 1991 to December 31, 1993. The data from these 2 periods have been compared in the current study.

The mean population of Tartu during the first period was 110 631 inhabitants and 101 122 inhabitants during the second period.13 The proportion of people ≥70 years of age was 8% for the first and 10% for the second period.

The design of both studies was similar, using the same study criteria and classification schemes.10,11,14 Both registries used prospective “hot pursuit” case ascertainment techniques, which provided a good chance of finding stroke cases treated outside the neurology department. General practitioners were contacted monthly to find the cases of first-ever stroke treated at home; medical documentation from the emergency department of the hospital was evaluated twice a month; information about the cases from the other departments of the Tartu University Clinics was collected by

Background and Purpose—The purpose of the present study was to estimate the time trends of stroke during the last 10 years in an Estonian population by comparison of the results from the 2 previous stroke registries from Tartu.

Methods—The Third Stroke Registry in Tartu was conducted from January 12, 2001, to November 30, 2003. The previous registry was composed from January 1, 1991, to December 31, 1993. The design of both studies is similar, using the same study criteria and classification schemes.

Results—A total of 1280 patients with first-ever stroke were registered during the 5-year study period. The overall incidence rate of 230 per 100 000 declined between the studies to 188 per 100 000 age-standardized to the European standard population. The age-adjusted incidence rate for women decreased from 204 to 164 per 100 000 between the 2 periods. In most of the age groups, the overall case-fatality rates declined during the second period; the trend in the age group 75 to 84 years was statistically significant.

Conclusions—The incidence of first-ever stroke in Tartu has declined significantly during the past decade and reached the level of the first registry. The 28-day case-fatality rate has declined from 30% to 26%. The prevalence of cardiovascular risk factors, incidence of stroke, and ischemic heart disease has been high in Eastern European countries. Our data show that the situation has improved. (Stroke. 2005;36:2544-2548.)

Key Words: stroke ■ epidemiology ■ trends

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computer search. Death certificates and autopsy reports for fatal cases outside the hospital were also regularly checked. The stroke cases detected from death certificates were confirmed by contacting the physician who gave out the certificate, and medical documents were checked. The subjects were registered only if death was preceded by a clinical stroke according to the World Health Organization (WHO) definition. The 1 major difference of these 2 periods is the availability of computerized tomography (CT) scans.

The study area is served by the Department of Neurology and Neurosurgery (DNN) of the University Clinics of Tartu. Most of the first-ever stroke patients from the study area are routinely admitted to the DNN of the University Clinics of Tartu, where they are immediately assessed by a neurologist. All of the patients living in Tartu who were diagnosed first-ever stroke were registered.

The diagnosis of stroke was based on clinical evaluation, using the WHO criteria. Cases with subarachnoid hemorrhage were included. The cutoff point, used to define fatal stroke, was 30 days (however, no fatal cases were registered from 28 to 30 days) during the first and 28 days during the second period.

Recorded information includes demographic and administrative data; concomitant diseases and stroke risk factors; clinical signs at stroke onset; CT findings, and so forth. Stroke risk factors were registered based on case history and clinical evaluations. The study purpose and design was explained in advance to all general practitioners, on-call neurologists, and administrative specialists of other data sources before both studies.

The management of patients consisted of monitoring of vital functions and treatment of concomitant diseases, acute rehabilitation, prevention of complications, and secondary prevention of stroke. We do not have a geographically defined stroke unit in DNN, but all of the required therapies, interventions, qualified personnel, and monitoring equipment are available for our patients. The study was approved by the Ethics Review Committee on Human Research at the University of Tartu.

Statistical Methods
The incidence of stroke is expressed in number per 100,000 persons by age and gender with corresponding 95% CIs. For the comparison of the results with that observed in other studies, rates were adjusted by age to the European standard population using the direct method. The 95% CIs for the rates were calculated using normal approximation to the binomial distribution. Exact confidence limits were calculated when the expected number of outcomes was <5. The χ² test, stratified by gender when appropriate, was used when analyzing the difference between the subgroups. The presented mean values are followed with the SD denomination in parentheses. For calculations, the statistical package S-PLUS CIA was used.

Results
A total of 1280 patients (501 men and 779 women) with first-ever stroke were registered during the 5-year study period, with 829 patients from 1991 to 1993 and 451 patients from 2001 to 2003. The mean age of patients was 69.5 ± 13.8 years (64.1 for men and 73.2 for women) for the first and 71.6 ± 12.3 years (67.5 for men and 74.3 for women) for the second period.

There were 660 patients (80%) hospitalized during the first period and 395 patients (88%) hospitalized during the second period. The proportion of patients treated in DNN was 72% and 82%, respectively. For both periods, 89% of patients were seen by a neurologist. Cases outside the DNN during the first study were ascertained from the following data sources: 166 (20%) from general practitioners, 60 (8%) from other departments in the hospital, and 3 (<1%) from death certificates and autopsy protocols. The corresponding figures for the second period were 34 (8%), 34 (8%), and 12 (2%), respectively. The CT scan was done in 19% of patients during the first and 90% of patients during the second period.

Incidence of Stroke
The crude stroke incidence rate for the first period was 250 and 223 per 100,000 persons for the second period. Age- and gender-specific incidence rates are shown in Tables 1 to 3. The overall incidence rate of 230 per 100,000 declined during the study period to 188 per 100,000 persons age-standardized to the European standard population (P = 0.04). The age-adjusted incidence rate for men decreased from 262 to 224 (P = 0.08) and for women from 204 to 164 (P = 0.03) per 100,000 between the 2 periods. The most evident decline of the overall incidence rate was found among patients aged 45 to 54 years (P = 0.03) and 55 to 64 years (P < 0.01). Significant decline of stroke incidence rate, during the past 10 years, was registered for men aged 45 to 54 years and 55 to 64 years and for women aged 55 to 64 years and 75 to 84 years (Table 1).

Case Fatality
A total of 250 patients (30%) during the first period and 188 (26%) during the second period suffered a fatal stroke. The age-specific case-fatality rates are shown in Table 2. In most of the age groups, the overall case-fatality rates declined during the second period, and the trend in the age group from 75 to 84 years was statistically significant (P = 0.03). The number of fatal cases in the younger age groups is small, and moderate changes have been detected, but no statistical significance was found. The analysis of case-fatality trends according to stroke subtype revealed rather stable results; only the proportion of fatal cases among patients with ICH decreased from 57% to 40% between the studies. The overall decline in case-fatality rate did not reach statistical significance (P = 0.07), but the significant decline among women (P = 0.03) is responsible for this trend.

Stroke Risk Factors
The prevalence of different stroke risk factors was quite stable during the study periods. In the first study, 48% of patients had ischemic heart disease, 25% had atrial fibrillation, 12% had diabetes, and 5% had previous transient ischemic attack. The corresponding figures for the second study were 37%, 30%, 14% and 6%, respectively. The diagnostic criteria for hypertension were different for the 2 compared study periods, and, thus, the comparison was not possible.

Discussion
During the 1990s, Estonia has changed from a former Soviet Union republic to an independent country in the European Union. Such remarkable changes in a community may cause stress, change lifestyle, and affect health of residents. At the beginning of the 1990s, reorganization of the health care system and implementation of evidence-based medicine were started in Estonia.

The stroke registers in Tartu from 1970 to 1973 and 1991 to 1993 have shown relatively high stroke incidence and 28-day case-fatality rates. Although the design of all 3 of the studies has been similar, the implement of CT and comput-
The incidence of first-ever stroke in Tartu has declined significantly during the past decade and reached the level of the 1970s.9 Analysis of different age groups revealed that, for both genders, in most groups the incidence has declined. However, among patients aged 65 to 74 years, a slight increase was assessed, but that change was not statistically significant. The remarkable decline in incidence rates during the past 10 years was observed in patients aged 55 to 64 years (P = 0.01) and in women aged 75 to 84 years (P = 0.004). The proportion of elderly inhabitants in the study area has increased between the last 2 study periods, which would have increased the crude incidence rate. One can speculate that the overall decline of the incidence rate could be related to the improvement of primary prevention, especially antihypertensive treatment in the 1990s. The introduction of CT explained by other authors as a possible reason for the increase in the detection of less severe strokes can be related to the increasing stroke incidence rates. This phenomenon cannot be seen in our study, because the proportion of CT scanning was higher for the second study, but the incidence has declined substantially.

The incidence among younger age groups, representing people of working age in Estonia, remains high. Moreover, recent public data show that the life expectancy among Estonian women is ≈5 years and among men is >10 years shorter compared with the European Union average.16 The proportion of elderly inhabitants in the study area has increased between the last 2 study periods, which would have increased the crude incidence rate. One can speculate that the overall decline of the incidence rate could be related to the improvement of primary prevention, especially antihypertensive treatment in the 1990s. The introduction of CT explained by other authors as a possible reason for the increase in the detection of less severe strokes can be related to the increasing stroke incidence rates. This phenomenon cannot be seen in our study, because the proportion of CT scanning was higher for the second study, but the incidence has declined substantially.

The changes in 28-day case-fatality rates, between the study periods, are comparable with the trends in incidence rates. The high 28-day case-fatality of stroke patients in Estonia is probably related to more severe stroke cases and the high prevalence of risk factors and concomitant diseases. The analysis of 28-day case fatality in different age groups
revealed no statistically significant changes. The proportion of hospitalized patients has slightly increased during the past decade. This result is obviously the effect of educational work since the 1970s introducing stroke as an emergency medical situation that needs to be managed in the hospital. The highest increase was accomplished between the 1970s and 1980s, because the hospitalization rate in the first study was only 34%. The increased hospitalization rate could also contribute to the decline in case-fatality rates over time. The management of stroke in Tartu has always been in correspondence with generally approved guidelines. There might have been more aggressive prevention strategies for secondary complications of stroke during the second study period and, as a consequence, the 7-day case-fatality rate has declined from 15% in 1993 to 12% in 2003. The 7-day case-fatality rate during the first registry in 1973 was 31%. The first study period (1971 to 1973) was characterized by an extremely high early case-fatality rate and relatively modest stroke incidence rate. During the 1980s, the incidence rose probably as a result of increased hospitalization (from 34% to 72%), and the overall case-fatality rate decreased substantially. Estonian official mortality data also show that the standardized mortality rate of cardiovascular and cerebrovascular diseases gradually increased from the end of the 1980s to the mid-1990s. The years of significant socioeconomic changes causing stress and instability in the Estonian population in the beginning of the 1990s coincide with the second study in 1991 to 1993. The mortality rates according to the official statistics decreased to the level of the 1980s by the end of the 1990s. The stroke mortality rates continued to decline in the turn of the century. This trend coincides with the positive changes in the incidence and case-fatality rates found in our study and shows that they are real. The improved management of stroke and risk factors has probably resulted in continuous decline both in the incidence and case-fatality rates of stroke in Tartu.

The results from several studies, considering stroke time trends, have been conflicting. Mostly, the decline in stroke mortality is reported, and some centers even show a trend of increasing stroke incidence. In the community-based stroke registry in Germany, the increasing incidence rates were explained by unfavorable changes in the risk factor profile, especially concerning blood pressure. The latest comprehensive information on major health indicators in Estonia is available from WHO databases. Blood pressure trends have been evaluated in a longitudinal study including subjects aged 20 to 54 years. The analysis of 3 independent random samples from different time points revealed a substantial decrease in blood pressure values by the early 1990s, and this trend continued to a smaller extent during the late 1990s. The prevalence of hypertension was 50% in 1991 to 1993 and 61% in 2001 to 2003. However, because the cutoff points were different (165/95 mm Hg and 140/90 mm Hg, respectively), the trend cannot be estimated. The prevalence of cigarette smokers in Estonia is high. In 1998, 42% of men and 20% of women were regular smokers. These proportions were on the highest level in 1994 and have constantly declined.

<table>
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<tr>
<th>Age, y</th>
<th>1991 to 1993</th>
<th>2001 to 2003</th>
<th>Trend per Year, %</th>
<th>$\chi^2$</th>
<th>$P$ Value</th>
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<tr>
<td>Men</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0–44</td>
<td>0</td>
<td>2</td>
<td>1.0</td>
<td>4.4</td>
<td>0.1*</td>
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<td>1</td>
<td>-5.4</td>
<td>0.6</td>
<td>0.4</td>
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<tr>
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<td>5</td>
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<tr>
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<td>&gt;=85</td>
<td>12</td>
<td>8</td>
<td>+1.8</td>
<td>0.3</td>
<td>0.6</td>
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<tr>
<td>Total</td>
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<td>44</td>
<td>+0.7</td>
<td>0.002</td>
<td>1.0†</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
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<td>65–74</td>
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<td>178</td>
<td>74</td>
<td>-2.1</td>
<td>4.7</td>
<td>0.03†</td>
</tr>
</tbody>
</table>

*Fisher exact $P$ value; †Stratified by age.

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Table 2. Age-Specific 28-Day Case-Fatality Rates and Trends of Patients From Different Time Periods in Tartu, Estonia
evaluating blood pressure changes also revealed a positive trend of decreasing body mass index during the 1990s. As a consequence, the overall trends in risk factor profiles can be considered positive, and the decline in the stroke incidence and case-fatality rates can be associated with this trend.

We report both declining stroke incidence and case-fatality rates in Estonia. The prevalence of cardiovascular risk factors and incidence of stroke and ischemic heart disease has been high in Eastern European countries. Our data show that the situation has improved in Estonia. However, the incidence in younger age groups has remained higher compared with many other European countries. Other stroke incidence studies in East Europe would indicate whether this trend is characteristic merely to Estonia or broadens also to other countries in this region. Therefore, sustained stroke risk factor control and aggressive primary prevention measures, as well the increasing of public awareness of stroke risks, must, in the future, in preference, be aimed at the younger population.

Acknowledgments
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References