Hypertension, Cigarette Smoking, and the Decline in Stroke Incidence in Eastern Finland

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Finland has high rates of both cardiovascular disease and cardiovascular disease risk factors. We studied random samples of the population 30–59 years of age for risk factors in two provinces of eastern Finland in 1972 and 1977. We then followed both cohorts until 1985 through linkage with national hospital discharge and death certificate registers. The prevalence of hypertension and smoking in both provinces declined between 1972 and 1977, as did the stroke incidence in the 8-year period of follow-up of each cohort. We observed no differences in stroke incidence between the two provinces. The relative risk of stroke in the later period (1977–1985) was 0.71 and 0.58 for men and women, respectively, when compared with the earlier period (1972–1980). Overall, 28% of all stroke events could be attributed to hypertension, 17% to smoking, and 43% to these two factors jointly. The decrease in the prevalence of hypertension and smoking accounted for about 29% of the decline. (Stroke 1991;22:7-11)

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independent sample of subjects 30–64 years was undertaken.2–4,14 At both surveys and in both provinces, the participants (participation rate, approximately 90%) were told their blood pressure values and, if high, were referred to the local primary health care centers for further check-ups. Casual blood pressure was measured with the subject in a sitting position. Data were also collected on cigarette smoking, height and weight, history of stroke, myocardial infarction, diabetes, and other major diseases. Details of the survey methodology have been previously published.2,3,14

In Finland, practically all stroke patients less than 60 years of age are treated in hospitals. The migration out of country during these study periods was very small. Stroke events in both cohorts were recorded by means of a national hospital discharge register and death certificate data, with the data restricted to the overall category of stroke.

These two independent 1972 and the 1977 cohorts were followed until 1985 through linked national hospital discharge data and death certificate registers using the unique personal identification number assigned to every resident of Finland. For both fatal and nonfatal cases, the diagnosis of stroke was accepted as an end point if the main diagnosis was coded as 430–434 or 436 (International Classification of Diseases Code 8). In the case of multiple events, only the first one was regarded as an end point for the assessment of incidence.
We analyzed our data for ages 30–59 years at baseline, which was common for both (1972 and 1977) samples. Age-standardized rates were calculated by the direct method using the Segi's world population as the standard with the two age categories 30–49 and 50–59 years. A logistic regression model was used to calculate the relative risks and their 95% confidence intervals. The population attributable risk of hypertension (defined as systolic blood pressure/diastolic blood pressure ≥160/95 mm Hg, or on treatment for high blood pressure) and cigarette smoking was calculated separately for men and women and also for both sexes combined using the method of Whittemore.15

The relative decline of stroke incidence was calculated as 1–odds ratio (1–OR). The contributions of the risk factor changes were estimated as the relative differences in the excess risks (1–OR) between the three-variable (adjusted for age and sex) and five-variable model, adjusting additionally for hypertension and smoking as described elsewhere16: 

\[
\frac{1-OR_s - (1-OR_h)}{1-OR_s} \]

where OR_s denotes the age-adjusted odds ratio and OR_h the odds ratio adjusted additionally for hypertension and smoking.

Results

In the 1972 cohort (North Karelia and Kuopio combined), there were 146 stroke events; 40 of the subjects died during the 8-year follow-up period. In the 1977 cohort (North Karelia and Kuopio combined), there were 105 stroke events, and 25 subjects died within 8 years.

Table 1 shows the change in the prevalence of smoking and hypertension for both North Karelia and Kuopio between 1972 and 1977. In both North Karelia and Kuopio the proportion of smokers in men decreased significantly. In both provinces, the proportion of women who smoked increased slightly, but still remained low. The prevalence of hypertension fell markedly for both sexes and in both provinces between 1972 and 1977, in North Karelia more than in Kuopio.

Table 2 shows the age-adjusted stroke incidence for North Karelia, Kuopio, and both provinces combined for the 8-year periods 1972–1980 and 1977–1985. No significant differences in stroke incidence were observed between North Karelia and Kuopio, so data for both areas were combined in all subsequent analyses comparing the time periods. The decline in incidence in men and women was 30% and 36%, respectively; overall, stroke incidence declined by 33% from 15.5 per 1,000 population to 10.4 per 1,000.

The relative risk of stroke in the 1977 cohort as compared with risk in the 1972 cohort was 0.71 and 0.58 in men and women, respectively (Table 3). The overall relative risk (men and women combined) was 0.65, and was 0.75 after controlling for hypertension. Relative risk did not change after controlling for smoking. The contribution of the changes in hypertension and smoking to the overall decline in stroke incidence was estimated to be 29%.

In both sexes the relative risk of stroke for hypertension (controlling for age, sex, and cohort) was greater than that for smoking (Table 4). Hypertensive people had a twofold increased risk of stroke (relative risk, 2.2); in smokers, the risk was slightly lower (relative risk, 1.6). The effect of smoking and hypertension was not altered when controlling for the other. In the logistic model, when a smoking–hypertension interaction term was added, the coefficient was very small, indicating that the effect of the two variables is multiplicative.

The population attributable risk of stroke for both hypertension and smoking calculated for the two provinces combined showed that 28% of all stroke events could be attributed to hypertension and 17% to smoking (Table 5). The population attributable risks of stroke for each sex were clearly different: 36% and 18% for men and women, respectively, for hypertension and 27% and 4% for men and women, respectively, for smoking.

Discussion

A comparison of two prospective 8-year follow-ups of random samples of the population aged 30–59 years from two provinces in eastern Finland, one beginning in 1972 and the other in 1977, shows that stroke incidence declined significantly. The control of hypertension improved in this period, explained by a decline in mean blood pressure levels, an increase in the proportion of hypertensives on treatment, and improvements in the proportion of hypertensives aware of their blood pressure status.2,12,14,17 Our data suggest that the intervention in North Karelia resulted in a greater fall in the prevalence of hypertension than that observed in Kuopio, the reference

<table>
<thead>
<tr>
<th>Province</th>
<th>Sex</th>
<th>No.</th>
<th>Prevalence (%)</th>
<th>Smoking</th>
<th>Hypertension</th>
</tr>
</thead>
<tbody>
<tr>
<td>1972</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>North Karelia</td>
<td>Men</td>
<td>1,825</td>
<td>53.9</td>
<td>43.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>2,014</td>
<td>10.0</td>
<td>48.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>3,839</td>
<td>39.9</td>
<td>46.5</td>
<td></td>
</tr>
<tr>
<td>Kuopio</td>
<td>Men</td>
<td>2,559</td>
<td>51.0</td>
<td>44.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>2,704</td>
<td>11.0</td>
<td>42.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>5,263</td>
<td>30.8</td>
<td>43.8</td>
<td></td>
</tr>
<tr>
<td>1977</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>North Karelia</td>
<td>Men</td>
<td>2,098</td>
<td>47.3</td>
<td>29.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>2,186</td>
<td>15.1</td>
<td>23.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>4,284</td>
<td>30.9</td>
<td>26.0</td>
<td></td>
</tr>
<tr>
<td>Kuopio</td>
<td>Men</td>
<td>2,104</td>
<td>47.0</td>
<td>37.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>2,191</td>
<td>13.6</td>
<td>27.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>4,295</td>
<td>29.9</td>
<td>32.6</td>
<td></td>
</tr>
</tbody>
</table>

*Defined as current cigarette smoker.
†Defined as systolic blood pressure/diastolic blood pressure ≥160/95 mm Hg or on treatment for hypertension.

Table 1. Prevalence of Cigarette Smoking and Hypertension by Province (Men and Women Aged 30–59 Years at Baseline)
area. Blood pressure levels were reduced not only among patients receiving antihypertensive drug treatment, but also among people without drug therapy. Increased screening activities during 1972-1977 made a considerable number of individuals with mild elevation of blood pressure aware of their condition. It is likely that in these people with mild hypertension the decline in blood pressure has been particularly effective. In men, smoking decreased significantly, and in women, it increased but remained relatively low.

Previous published reports have emphasized the greater improvements in cardiovascular risk factor levels in North Karelia than in Kuopio, the reference area. Therefore, it may be surprising that no differences in stroke incidence between the two provinces were observed despite the considerable efforts of the North Karelia project. However, all survey participants in both areas were told about their risk factors, and people with hypertension were advised to visit a doctor. Earlier studies have shown that even the participation in a risk factor survey will result in changes in the respondent's behavior. It should also be noted that the use of antihypertensive drugs in Finland increased markedly during the 1970s not only in North Karelia.

The population attributable risk is a measure of the effect of these major remedial risk factors. Few studies have estimated the proportion of stroke cases in the community attributable to high blood pressure and cigarette smoking. In the present study, 28% of all strokes (36% in men and 18% in women) occurring in the period under study could have been attributed to hypertension. This finding is lower than other estimates of population attributable risk. Women had a lower population attributable risk, although part of the explanation for this finding is that a small group of women in the 50-59 age group in 1972 were normotensive nonsmokers yet had a higher stroke incidence than the hypertensive nonsmokers. If the corresponding 1977 rate for that age group was applied, 45% of all stroke events in women would have been attributed to hypertension instead of 18%. The low number of stroke events in women attributed to smoking was expected, given the low prevalence of smoking. However, an increase in smoking in women to the level of men could cause a sevenfold increase in the proportion of stroke cases attributable to smoking in women.

Table 2. Age-Adjusted 8-Year Stroke Incidence by Study Cohort and Province (Men and Women Aged 30-59 Years at Baseline)

<table>
<thead>
<tr>
<th>Study Cohort</th>
<th>1972-1980 Cohort</th>
<th>1977-1985 Cohort</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stroke (n)</td>
<td>Incidence per 1,000 (95% CI)</td>
</tr>
<tr>
<td>North Karelia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>35</td>
<td>18.9 (12.5, 25.1)</td>
</tr>
<tr>
<td>Women</td>
<td>28</td>
<td>13.9 (8.2, 17.8)</td>
</tr>
<tr>
<td>Total</td>
<td>63</td>
<td>16.4 (11.8, 19.5)</td>
</tr>
<tr>
<td>Kuopio</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>46</td>
<td>18.2 (13.1, 23.4)</td>
</tr>
<tr>
<td>Women</td>
<td>37</td>
<td>12.8 (8.7, 16.9)</td>
</tr>
<tr>
<td>Total</td>
<td>83</td>
<td>15.4 (12.2, 18.7)</td>
</tr>
<tr>
<td>Both provinces</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>81</td>
<td>18.5 (14.5, 22.5)</td>
</tr>
<tr>
<td>Women</td>
<td>65</td>
<td>12.8 (9.7, 15.9)</td>
</tr>
<tr>
<td>Total</td>
<td>146</td>
<td>15.5 (13.0, 18.0)</td>
</tr>
</tbody>
</table>

CI, confidence interval.

Table 3. Age-Adjusted Relative Risk of Stroke in 1977 Cohort Compared With 1972 Cohort and Contribution of Hypertension and Smoking to Overall Decline in Stroke Incidence (Men and Women Aged 30-59 Years at Baseline)

<table>
<thead>
<tr>
<th></th>
<th>RR (95% CI)*</th>
<th>RR (95% CI)†</th>
<th>RR (95% CI)‡</th>
<th>% Decline§</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>0.71 (0.51, 0.98)</td>
<td>0.78 (0.56, 1.09)</td>
<td>0.80 (0.57, 1.12)</td>
<td>31</td>
</tr>
<tr>
<td>Women</td>
<td>0.58 (0.39, 0.87)</td>
<td>0.70 (0.46, 1.05)</td>
<td>0.69 (0.46, 1.03)</td>
<td>26</td>
</tr>
<tr>
<td>Total</td>
<td>0.65 (0.51, 0.84)</td>
<td>0.75 (0.58, 0.97)</td>
<td>0.75 (0.58, 0.98)</td>
<td>29</td>
</tr>
</tbody>
</table>

RR, relative risk; CI, confidence interval.
*Adjusted for age.
†Adjusted for age and hypertension.
‡Adjusted for age, hypertension, and smoking.
§Adjusted for age, hypertension, smoking, and sex.
¶Attributable to hypertension and smoking.
risk factor for stroke, after adjusting for age and hypertension, with relative risks ranging from 1.5 to 1.7,2,10-26 The epidemiological evidence suggests that smoking is causal because risk increases for smokers versus nonsmokers independently of other risk factors, because a dose–response relationship exists, and because risk decreases after smoking cessation.

The recent data from the Framingham study show that the risk of stroke increased as the number of cigarettes smoked increased.25 Also, the meta-analysis of the published data on the association between cigarette smoking and stroke demonstrated a significant dose–response relationship: the relative risk was 1.37 in people smoking fewer than 10 cigarettes a day and 1.82 in those who smoked more than 20. In our present study, the smaller population attributable risk of cigarette smoking in women than in men may reflect both the lower prevalence of smoking in general and the lesser amount of smoking in women compared with men in Finland.2,13

Estimates based on population attributable risk provide the maximum likely effect on stroke rates of improvements in the treatment of hypertension. With regard to smoking, such an estimation would assume that smokers would approach the incidence rate of nonsmokers, which in turn suggests a smoke-free environment. The decrease in the population blood pressure level in eastern Finland was associated with the subsequent fall in stroke incidence and mortality. Even though the decline in stroke incidence in eastern Finland during 1972–1985 was clearly significant, the data show that less than one third of this can be explained by the decline in hypertension and smoking during this period. Therefore, much of the decline in stroke incidence is due to factors other than antihypertensive treatment.27,28

Effective antihypertensive treatment is an efficient method for stroke prevention. Data from controlled clinical trials suggest that a permanent reduction of 6 mm Hg in diastolic blood pressure in hypertensive patients will result in an approximate 35–40% decrease in the risk of stroke.29,30 Furthermore, the observed benefit in the prevention of stroke events in these trials has been very close to that expected, which was derived from prospective epidemiological trials.7,11,21,22 However, none of the earlier studies has directly assessed the effect of improved hypertension control in the community on the decline in stroke incidence and mortality. All previous inferences on this issue have been based on indirect evidence, often with the use of sets of data from various nonstandardized sources. Our present data are well-standardized and based on populations in which participation rates were high—about 90% in the survey with the complete mortality and morbidity surveillance. We also have provided previous indirect data on trends in blood pressure, effectiveness of antihypertensive drug therapy, and stroke mortality in eastern Finland.17,21

It has been proposed that changes in hygienic factors such as diet23,24 and smoking25–26 may have been more important for the decline in stroke mortality than antihypertensive drug therapy alone. Our present results show that blood pressure control had a greater effect on the decrease in the risk of stroke than changes in smoking. During the study period, the fall in the population blood pressure level was larger than the fall in the prevalence of smoking; therefore, our findings were not unexpected. Other factors that might have contributed to this decline are likely to be related to diet and medical care. Serum cholesterol levels fell significantly during the follow-up period in our study communities,2,4,22 but it is unlikely that salt intake changed much,33 although we do not have data on salt intake for the early 1970s.

Although the trends in the two major risk factors (hypertension and smoking) have been generally favorable in eastern Finland since 1972, the situation is still far from satisfactory. The mean blood pressure level was found to be one of the highest worldwide,24 and the favorable trend in the prevention and control of hypertension has not progressed in the 1980s any more than it did during the 1970s.20,30 The same largely applied to the trend for smoking. Thus, it is understandable that the steep decline in stroke mortality in Finland leveled off during the 1980s.31 Further efforts to prevent both elevated blood pressure and smoking are necessary to bring the high incidence of stroke and stroke mortality in Finland35–37 to a more acceptable level, as seen in many other countries.

**References**

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