A SIGNIFICANT CROSS-NATIONAL COVARIATION between stomach cancer and stroke mortality was found in 1964. This relationship existed for both sexes over time and between countries. Finland does not seem to be an exception to this phenomenon. Nevertheless, according to the further analyses, Finland had probably the highest mortality rates of cerebrovascular accidents (CVA), i.e. strokes, and one of the highest of stomach cancer (sc) in Europe during the fifties, but since then the vital statistics suggest a steep declining trend in both causes of death. However, in the early 1970's the incidence of stroke in Finland was still higher than in most other western countries. In this paper we have compared the declining trends in mortality rates for both diseases in Finland from 1952 to 1979 to the trends in other countries.

**Methods**

Raw mortality data available up to 1979 were obtained from the Central Statistical Office of Finland. Using ten-year age intervals, the mortality rates were standardized with the direct method using the age distribution of the population in England and Wales in 1951 as the standard. The denominators in the adjustment were 599, 457, 324 and 156 for the age groups 45-54, 55-64, 65-74, 75+ respectively (Table 1). During the same period the mortality from all cardiovascular diseases declined by 16% in men and by 44% in women, that from all cancer (ICD - 7: 330-334; ICD - 8: 430-438) mortality, and also for comparison for all cardiovascular (ICD - 7: 330-334 and 400-468; ICD - 8: 390-458), all cancer (ICD - 7 and 8: 140-209) and all causes mortality for the age group 45-74. Data about subcategories of stroke, i.e. subarachnoid haemorrhage (ICD - 7: 330; ICD - 8: 430), intracerebral embolism and thrombosis (ICD - 7: 332; ICD - 8: 433-434) are available in Finland from 1963 until 1979.

The relative change in mortality over a 10-year period was computed using unsmoothed data according to the formula:

\[
\text{relative change} = 100 \times \frac{b}{M(X)}
\]

where \( b \) is the slope of the linear regression equation and \( M \) is the mean mortality for cause \( X \) over the period 1969 to 1979, or the latest available year.

A trend plot was made for mortality data of selected countries and for men and women separately. The smoothing method used was a 5-year moving mean, i.e. each data point \( X_i \) was replaced by

\[
X_i^* = \frac{X_{i-2} + X_{i-1} + X_i + X_{i+1} + X_{i+2}}{5}
\]

If \( N \) represents the total number of available data points, a small modification of the above formula is needed for \( X_{N-1} \) and \( X_{N} \) for \( X_{N-1} \) the rightmost point \( X_{N+2} \) is left out and the smoothing factor lowered by one (4 instead of 5); for \( X_{N} \) the two rightmost points \( X_{N+1} \) and \( X_{N+2} \) are discarded and the smoothing factor lowered by two. The data analysis was performed using programs of the ‘‘Leuven Mortality Monitoring System’’ (M.M.S.).

**Results**

The linear relative decline in SC mortality over the 10 year period 1969-1979 was 44% in males and 46% in females and that in CVA mortality 39% and 64% respectively (Table 1). During the same period the mortality from all cardiovascular diseases declined by 16% in men and by 44% in women, that from all
TABLE 1  Linear Regression and Adjusted Relative Change of Mortality from Various Causes Between 1969 and 1979 in Finnish Subjects Aged 45–74

<table>
<thead>
<tr>
<th>Causes</th>
<th>Death rates*</th>
<th>Relative decline over 10 years (in %)</th>
<th>Observed values of death rates</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1969–79 Mean ± SD</td>
<td>Slopet</td>
<td>1952</td>
</tr>
<tr>
<td>All causes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>males (M)</td>
<td>25.47 ± 1.57</td>
<td>0.45</td>
<td>18</td>
</tr>
<tr>
<td>females (F)</td>
<td>11.04 ± 1.29</td>
<td>0.38</td>
<td>35</td>
</tr>
<tr>
<td>(M + F)/2</td>
<td>18.25 ± 1.42</td>
<td>0.42</td>
<td>23</td>
</tr>
<tr>
<td>All cardiovascular diseases</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>males</td>
<td>14.03 ± 0.82</td>
<td>0.23</td>
<td>16</td>
</tr>
<tr>
<td>females</td>
<td>5.82 ± 0.87</td>
<td>0.25</td>
<td>44</td>
</tr>
<tr>
<td>(M + F)/2</td>
<td>9.93 ± 0.83</td>
<td>0.24</td>
<td>24</td>
</tr>
<tr>
<td>Cerebrovascular disease</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>males</td>
<td>2.24 ± 0.31</td>
<td>0.09</td>
<td>39</td>
</tr>
<tr>
<td>females</td>
<td>1.64 ± 0.36</td>
<td>0.11</td>
<td>64</td>
</tr>
<tr>
<td>(M + F)/2</td>
<td>1.94 ± 0.33</td>
<td>0.10</td>
<td>49</td>
</tr>
<tr>
<td>All cancer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>males</td>
<td>5.69 ± 0.23</td>
<td>0.06</td>
<td>11</td>
</tr>
<tr>
<td>females</td>
<td>2.82 ± 0.07</td>
<td>0.02</td>
<td>6</td>
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<tr>
<td>(M + F)/2</td>
<td>4.26 ± 0.14</td>
<td>0.04</td>
<td>9</td>
</tr>
<tr>
<td>Stomach cancer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>males</td>
<td>0.77 ± 0.12</td>
<td>0.03</td>
<td>44</td>
</tr>
<tr>
<td>females</td>
<td>0.35 ± 0.06</td>
<td>0.02</td>
<td>46</td>
</tr>
<tr>
<td>(M + F)/2</td>
<td>0.56 ± 0.09</td>
<td>0.03</td>
<td>45</td>
</tr>
</tbody>
</table>

*Death rates are per thousand.
†All decreases are significant at the p < 0.001 level.

The analysis of the trends in subcategories of CVA mortality (figure 3) in Finland showed marked differences between intracerebral haemorrhage and thrombotic stroke (cerebral thrombosis and cerebral embolism). In 1963 the mortality rate for intracerebral

cancers by 11% and 6% and the mortality from all causes by 18% and 35%, respectively.

Figure 1 shows the smoothed mortality trends for CVA in ten countries for males and figure 2 for females. In 1969 the adjusted rates of both males and females in Finland were much higher than in the other countries. A significant declining trend was found in all countries and in both sexes. The decline was close to linear but started levelling off gradually after 1976 in both sexes in most countries. The relative decrease in Finland from 1969 to 1979 was the steepest in females and the fourth steepest of all countries in males. In 1979, the highest adjusted rates both in males and females were found in Austria.

The analysis of the trends in subcategories of CVA mortality (figure 3) in Finland showed marked differences between intracerebral haemorrhage and thrombotic stroke (cerebral thrombosis and cerebral embolism). In 1963 the mortality rate for intracerebral
haemorrhage was slightly higher and the decline between the years 1963 and 1979 much steeper (74%; \( p < 0.001 \)) than that for thrombotic stroke which also decreased significantly (9%; \( p < 0.001 \)).

Figure 4 presents smoothed mortality trends from 1969 on for SC in the ten countries studied for males and figure 5 for females. In the early fifteens the adjusted mortality rates for males and females in Finland were second highest after Austria. However, the steeper decline in stomach cancer mortality rates in Finland resulted in these rates becoming lower than the West German ones (1970). A significant declining trend in SC mortality was observed in all ten countries and for both sexes. Finland showed the second steepest relative decrease over 10 years after Norway. Also in SC mortality the declining trend in Finland seemed to start levelling off since 1976. In 1978, SC mortality rates were highest in Austria and FRG, Finland still ranking third well above the other countries that were studied.

In addition, we also computed slopes of the regression lines of the logarithmic death rates which highly significantly correlated with the linear ones (\( r = 0.997 \)). This validates the method used for calculating trends. Plotting the mortality rates on a logarithmic scale showed a similar levelling off as on a linear one.

The stroke-stomach cancer relationship in Finland is shown in figure 6 for the period 1952–79. The observations are means of males and females aged 45–74. Three periods may be discerned: 1952–58, 1959–68 and 1969–79. From figure 6 it is clear that misclassification of stroke and/or stomach cancer may explain the random distribution of the observations in the 1950's. From 1959 on a rapid decline in SC mortality may be observed, while CVA mortality remained constant. The third period starts around 1970: SC mortality continued decreasing as before whereas CVA mortality started declining much faster.

As a comparison the same CVA-SC relationship was plotted in figure 7 for the average of seven western countries: USA, Norway, Sweden, Denmark, England and Wales, the Netherlands and West Germany. Belgium was excluded because CVA mortality was considerably misclassified as arterial mortality before 1968, and therefore might have influenced the “averaged” observations.2 Again three periods are observed, although somewhat less clear: influence of misclassification before 1957, a simultaneously linear decrease of CVA and SC mortality between 1958 and 1972, and a steeper one from 1973 on.

In figure 8 a cross-country comparison between SC and CVA mortality is made for 30 countries for the average of males and females aged 45–74. Each observation is the average of all the observations over the period 1968–75. The regression is calculated over 30 countries. A significant positive relationship between SC and CVA mortality is observed.
Smoothed Trends of Stomach Cancer

Figure 4. Smoothed trends in adjusted stomach cancer mortality in males, aged 45–74 years in ten countries between 1969 and 1978–81. The changes estimated in per cent over ten years are as follows: N (-46), SF (-44), DK (-42), B (-39), A (-38), FRG (-37), USA (-34), S (-33), NL (-30) and EW (-25). All p < 0.007.

Discussion

Stomach cancer and stroke mortality were found to behave in a similar way over time and between countries. Finland does not seem to be an exception to this phenomenon. During the most recent period (1969–79) stroke mortality decreased in Finland much faster than stomach cancer mortality, especially for females. This steeper decline is most probably due to introducing mass drug treatment of hypertension. The same phenomenon as in Finland has been observed in several other countries. In Finland the National Social Insurance Institution decided to reimburse antihypertensive drug treatment completely in chronic hypertension from 1970 on. This caused a major change in the policy of antihypertensive treatment.

Other data support as well the effect of anti-hypertensive drug therapy on stroke mortality. Epidemiological studies in Finland have shown that high blood pressure is the utmost important risk factor for stroke. Evaluation of hypertension control programs in Finland has shown that the impact of the programs has been greater among females than males. For instance in North Karelia the proportion of hypertensives among middle-aged women reduced during 1972–77 from 30% to 15% but among men only from 26% to 19%. Of course, anti-hypertensive drug therapy reduces the risk of cerebral stroke only among treated persons and, therefore, its overall effect on the population attributable risk is limited. It may be possible that in Finland the improvement of drug therapy has reached its maximal benefit approximately in the mid 70’s and therefore, the declining trend in stroke mortality is levelling off. However, time is still too short to draw final conclusions on overall benefits of antihypertensive drug therapy on mortality.

Another matter that may bias the observation on disease trends is the validity of reporting cause-specific deaths. Although Finland is one of the countries where vital statistics have existed for a long period, that does not remove this problem. Reporting of deaths according to the ICD 8th revision started in Finland in 1969. However, if the change in coding would be the only reason for deviation from the previous trend, one might not expect linear changes in cause-specific mortality trends but abrupt changes during one or two years.

One should also consider the possibility that the reported change in the saturated fat intake in Finland may have influenced the blood pressure levels, as...
shown in a recent experiment, as well as the development of thrombotic lesions. Hence it is possible that the rapid reduction in CVA mortality is a result of the combined effect of better treatment and dietary changes.

The working hypothesis that salt is the linking factor in the stroke-stomach cancer relationship was presented in 1965 and has been tested since then. In Finland the first reliable studies on salt intake were carried out in the 70's. The results of those studies indicate that salt intake in Finland is very high, even much higher than that reported from representative population samples from any other western country, except Portugal. This fits well into the salt hypothesis for the pathogenesis of stroke and stomach cancer when comparing the mortality rates between several western countries which seem to have lower mortality rates for these diseases than Finland are compared.

Compared with the stomach cancer and stroke death rates of e.g. Belgium, the Finnish rates in 1979 are approximately at the same level than those in Belgium 10 years ago. This is the case for both sexes. In 1966 the average daily salt intake in Belgium was 15 g NaCl in the middle-aged population and similar salt intake levels were detected in Finland in 1979.

Further support to the salt hypothesis was obtained by correlating stomach cancer rates and 24-hour urinary sodium excretion between countries. In 19 observations from ten countries the cross-country correlation between sodium excretion and stomach cancer mortality is reasonably high (r = 0.79). The findings from epidemiological studies on sodium excretion fits this hypothesis well.

In Finland, epidemiological research has been carried out to find the factors related to the high stroke rates and to find clues for primary prevention. Much publicity has been given to the development of hypertension control programs, and also recently, to salt and fat intake and their control. A special study in Finland on feasibility and effects of salt intake reduction in the community was established and its future results may provide additional information for the salt hypothesis in stroke and stomach cancer mortality.

Whelton and Goldblatt recently suggested in their cross-national analysis on stroke and stomach cancer that it is unlikely that there is a common factor such as salt predisposing for these diseases. However, the methodology in their study was based on the assumption that all underlying causes of death have been duly reported in the death certificates, an assumption which has no clear support in Finland. Often only the main cause of death is reported and there is no evidence that stroke patients would have been referred for tests for possible stomach cancer. Our analysis, as well as that of Joossens and Whelton and Goldblatt attempt to seek for etiologic factors of these diseases. We fully agree with Whelton and Goldblatt's comment that the
situation could be considerably clarified if information pertaining to the incidence of stomach cancer in hypertensive or stroke registry patients would be made available to researchers. Another argument against the Whelton-Goldblatt hypothesis is that susceptibility to stroke and stomach cancer could be differently distributable in the population even assuming a common environmental factor. The data base of the North Karelia Project could provide conditions for the research work which might bring some further answers to these questions, because in addition to the national cancer registry, a stroke registry and a hypertension register have existed in North Karelia since 1972.

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Trends in stomach cancer and stroke in Finland. Comparison to northwest Europe and USA.

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