Original Contributions

Marked Increase of Stroke Incidence in Men Between 1972 and 1990 in Frederiksberg, Denmark

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Background and Purpose: Stroke incidence declined until the end of the 1970s in the United States, and the decline continued into the 1980s in Japan. The purpose of this study was to determine possible temporal changes of stroke incidence in a European community.

Methods: A prospective stroke registry was established in the community of Frederiksberg (population, approximately 90,000), Denmark, in the two periods 1972–1974 and 1989–1990. All patients suspected of stroke were clinically evaluated by a neurologist. Only patients with first-ever stroke were included. Complete case ascertainment was ensured by registration of both hospitalized and nonhospitalized patients. Death certificates were also scrutinized.

Results: A total of 927 patients with first-ever stroke was recorded. The annual stroke incidence rate per 1,000 increased by 18% from 2.6 in 1972–1974 to 3.1 in 1989–1990 (p<0.01). This increase was due solely to a 42% increase in men, in whom stroke incidence rose from 2.1 to 3.0 (p<0.0005). Incidence was unchanged in women at 3.0 and 3.1, respectively. The incidence rates from 1972–1974 were age and sex adjusted to the 1990 population. After adjustment to the Danish population, stroke incidence in Denmark was 2.0 for all, 2.3 for men, and 1.9 for women. In the second study period computed tomography or necropsy was performed in 85% of cases; 2.4/1,000 had cerebral infarction; 0.20/1,000 had intracerebral hemorrhage; and 0.02/1,000 had subarachnoid hemorrhage.

Conclusions: In a period when decline in stroke incidence has stopped in the United States and has continued in Japan, a marked increase of stroke incidence in Danish men was observed. (Stroke 1992;23:1701–1704)

Key Words • Denmark • epidemiology • incidence

Stroke incidence, in particular its variation in time, has been a subject of considerable interest not only for epidemiological purposes, but also for the planning of community health care facilities. Only a few investigators, however, have studied temporal changes in stroke incidence.

A continuous decline in stroke incidence was observed in women in Rochester, Minnesota, between 1945 and 1979. The decline in men lagged behind women and began 10 years later. A decline in stroke incidence was also seen between 1961 and 1976 in Hisayama, Japan; and in Ikawa, Japan, from 1964 to 1978. A European study (Finland) from this period, however, found no such decline in stroke incidence.

In the early 1980s the decline in stroke incidence apparently stopped. Increasing rates have even been found in Söderhamn, Sweden, in Stockholm, Sweden, and in Rochester, Minnesota. In Ikawa, Japan, however, the decline seems to have continued into the 1980s.

In the present study we examined possible temporal changes of stroke incidence in a Danish community by comparing stroke incidence between 1972 and 1990.

Patients and Methods

A stroke registry was established to record and evaluate prospectively all patients with cerebrovascular stroke in the municipality of Frederiksberg, Denmark. Study design fulfilled criteria for the "ideal" stroke incidence study as defined by Malmgren et al. Registration was carried out similarly in two different periods. The first survey, performed from January 1, 1972, to December 31, 1974, has previously been published in part. Data on first-ever stroke, however, were not published. The second survey period was started on April 1, 1989, and ended on March 31, 1990.

Study Area and Population

The municipality of Frederiksberg is well suited for combined clinical and epidemiological studies. The area totals 8.7 km², is situated within Greater Copenhagen, and is a mainly residential district with a high proportion of elderly people in the higher income brackets. According to official statistics, the average population was 97,543 during the first study period and 85,611 during the second. Sex ratio was unchanged between...
the study periods. Specific demographic data are presented in Table 1. There is easy and free access to medical care with 45 general practitioners serving the population, and there is only one hospital (Frederiksberg Hospital), to which all patients with stroke requiring admission are referred.

**Case Ascertainment**

The case-finding methods were similar in the two survey periods. All patients suspected of stroke and admitted to the hospital were clinically evaluated and registered by a neurologist. Complete case ascertainment was ensured by informing all general practitioners in the district about the study; they were also regularly asked to send all nonhospitalized patients suspected of stroke to the registry outpatient clinic. Clinical evaluation and registration of these patients were also performed by a neurologist. Finally, we scrutinized all death certificates to obtain information about fatal strokes occurring outside the hospital; supplementary clinical data were obtained from certifying doctors and nursing home records. Only patients with positive diagnostic criteria were included.

**Diagnostic Criteria**

The diagnosis of stroke was based on the clinical evaluation only, as defined by the World Health Organization. All strokes were registered during the two study periods, but only cases of first-ever stroke were used for calculation of stroke incidence.

**Classification of Stroke Subtype**

During the second study period, computed tomographic (CT) scan was performed in 74% of all patients; postmortem examination was performed in 11% of the patients. However, this was only done with the purpose of subtyping stroke, as the diagnosis of stroke was based only on clinical evaluation. Cerebral infarction was diagnosed if CT or necropsy showed no sign of intracranial hemorrhage. If CT showed neither infarction nor hemorrhage, the stroke subtype was classified as cerebral infarction and CT was usually not repeated; intracerebral hemorrhage was diagnosed if the above-mentioned examinations revealed intracerebral hemorrhage; subarachnoid hemorrhage was diagnosed if CT showed subarachnoid hemorrhage or if the cerebrospinal fluid was macroscopically hemorrhagic in patients lacking gross neurological deficits.

A diagnosis of unspecified stroke was given to patients who underwent only clinical examination (15%).

**Statistical Methods**

The incidence figures from the first study period were age and sex adjusted to the 1990 population by the indirect method when total rates for the study periods were compared. This method was also used to calculate incidence rates in the Danish 1990 population. The $\chi^2$ test was used to test for differences between two groups.

The study was approved by the Ethics Committee of Frederiksberg and Copenhagen.

**Results**

A total of 927 first-ever strokes was recorded, 665 in the first 3-year period (1972–1974) and 262 in the second 1-year period (1989–1990). In addition, 249 recurrent strokes were recorded (Table 2). In both periods 12% of all cases were not hospitalized.

The mean age of men with first-ever stroke was 69.8 years in 1972–1974 and 72.3 years in 1989–1990. The mean age of women was 75.6 years in 1972–1974 and 77.4 years in 1989–1990.

**Incidence of Stroke**


Stroke incidence rose significantly by 18% from 2.6 per 1,000 in 1972–1974 to 3.1 per 1,000 in 1989–1990 ($p<0.01$). This increase was due solely to a 42% increase in men, in whom stroke incidence rose from 2.1 to 3.0 ($p<0.0005$) (Table 4). The increase for men appeared almost exclusively in the group aged 65–84 years, where stroke incidence increased by 66% ($p<0.0005$). The numbers for other age groups were too small, however, to conclude that the rise was limited to the group aged 65–84 years. The incidence for women was unchanged, at 3.0 in 1972–1974 and 3.1 in 1989–1990 (Table 5).

When 1989–1990 rates were adjusted to the age distribution and sex distribution in the 1990 Danish population, the resulting annual first-ever stroke incidence in Denmark was 2.0 per 1,000 for all, 2.3 for men, and 1.9 for women.

**Incidence Rates for First-Ever Stroke in Frederiksberg, Denmark**

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>0–54</td>
<td>30</td>
<td>0.16</td>
<td>12</td>
<td>0.21</td>
<td>1.3</td>
<td>NS</td>
</tr>
<tr>
<td>55–64</td>
<td>122</td>
<td>2.71</td>
<td>26</td>
<td>3.06</td>
<td>1.1</td>
<td>NS</td>
</tr>
<tr>
<td>65–74</td>
<td>194</td>
<td>4.92</td>
<td>72</td>
<td>7.02</td>
<td>1.4</td>
<td>&lt;0.005</td>
</tr>
<tr>
<td>75–84</td>
<td>235</td>
<td>11.22</td>
<td>106</td>
<td>13.10</td>
<td>1.2</td>
<td>NS</td>
</tr>
<tr>
<td>≥85</td>
<td>84</td>
<td>17.45</td>
<td>46</td>
<td>16.00</td>
<td>0.9</td>
<td>NS</td>
</tr>
</tbody>
</table>

Total incidence is expressed as number per 1,000 per year.

Age-adjusted to 1990 population.
TABLE 4. First-Ever Stroke Incidence Rates for Men in Frederiksberg, Denmark

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>1972–1974 No.</th>
<th>Rate</th>
<th>1989–1990 No.</th>
<th>Rate</th>
<th>Rate ratio</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–54</td>
<td>17</td>
<td>0.19</td>
<td>7</td>
<td>0.25</td>
<td>1.3</td>
<td>NS</td>
</tr>
<tr>
<td>55–64</td>
<td>77</td>
<td>4.09</td>
<td>13</td>
<td>3.53</td>
<td>0.9</td>
<td>NS</td>
</tr>
<tr>
<td>65–74</td>
<td>89</td>
<td>6.18</td>
<td>47</td>
<td>11.90</td>
<td>1.9</td>
<td>&lt;0.0005</td>
</tr>
<tr>
<td>75–84</td>
<td>72</td>
<td>11.15</td>
<td>38</td>
<td>15.72</td>
<td>1.4</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>≥85</td>
<td>25</td>
<td>20.52</td>
<td>11</td>
<td>20.37</td>
<td>1.0</td>
<td>NS</td>
</tr>
<tr>
<td>Total</td>
<td>280</td>
<td>2.12*</td>
<td>116</td>
<td>3.00</td>
<td>1.4</td>
<td>&lt;0.0005</td>
</tr>
</tbody>
</table>

Rate is expressed as number per 1,000 per year.
*Age-adjusted to 1990 population.

Stroke Subtype

In 85% of cases, first-ever stroke in 1989–1990, a CT scan (74%) or a postmortem examination (11%) was performed. The total incidence rates of different types of stroke were as follows: cerebral infarction, 2.39; intracerebral hemorrhage, 0.20; subarachnoid hemorrhage, 0.02; and unspecified stroke, 0.44 (Table 6).

Cerebral infarction was diagnosed in 91% of the patients in whom a CT scan or a postmortem examination was performed; 8% had intracerebral hemorrhage, and 1% had subarachnoid hemorrhage.

Discussion

We found a marked increase in stroke incidence between 1972 and 1990, whereas the incidence for women remained unchanged. The increase was observed in the groups aged 65–74 years and 75–84 years, but the numbers for other age groups were too small to conclude that the rise was limited to the group aged 65–84 years. Age- and sex-specific incidence rates from 1989–1990 were comparable to rates found in other stroke studies in the 1980s, namely Auckland,11 Rochester,10 and Oxfordshire.14 Further, the increase in stroke incidence found in men must be explained by an alteration in either risk factors or in the nature of stroke itself.

Improved survival due to better medical treatment in patients with coronary heart disease, i.e., thrombolytic agents and angiotensin converting enzyme inhibitors, might lead to an increase of stroke incidence. Because CHD is more common in men than in women, a rise in stroke incidence only in men could appear. It seems unlikely, however, that this treatment, which has only been used routinely in Denmark since the late 1980s, should already have caused this marked increase in stroke incidence in men.

More strokes as a complication of an increase in coronary artery surgery and carotid artery surgery in patients with transient ischemic attack or asymptomatic carotid stenosis would indeed increase stroke incidence, but no strokes were recorded in relation to either coronary or carotid surgery.

In Rochester a rise in stroke incidence in the early 1980s was largely explained by the introduction of the CT scan.10 However, in our study an increase based on a difference in stroke diagnosis between the two survey periods would be expected to occur in both men and women. Furthermore, the diagnosis in our study was based solely on clinical evaluation (in accordance with the World Health Organization definition). Therefore, the introduction of the CT scan between study periods cannot explain the rise of stroke incidence found in men.

A change in case-finding methods toward a more aggressive approach in the second study period could have produced an artificial rise in stroke incidence. However, the study was designed with a similar case-finding system in the two periods. The fact that stroke incidence in women was unchanged also speaks against an altered case-finding system in the second period. Finally, a possible difference in degree of hospitalization between 1972 and 1990 could theoretically have changed incidence figures, but the degree of cases registered outside the hospital was unchanged.

The increasing incidence found in men therefore implies a real change in stroke incidence. This is supported by a study from Stockholm, Sweden, in which stroke incidence in men in Stockholm increased significantly by 17% between 1974 and 1981, while the incidence for women was unchanged. A direct comparison is not possible because the Swedish study was retrospective and included only hospitalized cases.

In a study from Söderhamn, Sweden, stroke incidence increased in women but not in men. The study population was, however, relatively small (30,736), and the interval between its study periods was only 5 years (1978–1983). A recent Danish study found no difference in stroke incidence between 1976 and 1988.15 This result is not directly comparable with the present study. It was based on a small cohort (15,499) with few elderly people; the cases were registered retrospectively through the National Hospital Discharge Register and included only hospitalized cases.

The increased stroke incidence in men must be explained by an alteration in either risk factors or in the nature of stroke itself. As it is beyond the scope of our study, we have no explanation for this increase. The study measures a period in which treatment for hypertension has increased. This effort has not made a measurable impact on stroke incidence in this study.
However, increased treatment of hypertension may have been beneficial in some stroke subtypes. But because the first study period was before the introduction of the CT scan, which was the single criterion we used for typing the stroke, it was not possible to compare rates of stroke subtypes between the two periods. The incidence rates for stroke subtypes found in the second period (1989–1990) were comparable to rates found in Oxfordshire,14 Lausanne,16 and Dijon.17

Previously, stroke incidence has changed at different times for men and for women. The decrease in stroke incidence observed in Rochester between 1945 and 1979 appeared 10 years later in men than in women.4 Thus, an increased stroke incidence in men might point toward a future increased stroke incidence in women.

### References


### Table 6. Incidence Rates for Types of First-Ever Stroke in Frederiksberg, Denmark, 1989–1990

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Cerebral infarction</th>
<th>Intracerebral hemorrhage</th>
<th>Subarachnoid hemorrhage</th>
<th>Unspecified stroke</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>Rate</td>
<td>No.</td>
<td>Rate</td>
</tr>
<tr>
<td>0–54</td>
<td>11</td>
<td>0.20</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>55–64</td>
<td>21</td>
<td>2.47</td>
<td>3</td>
<td>0.35</td>
</tr>
<tr>
<td>65–74</td>
<td>64</td>
<td>6.24</td>
<td>5</td>
<td>0.49</td>
</tr>
<tr>
<td>75–84</td>
<td>77</td>
<td>9.52</td>
<td>8</td>
<td>0.99</td>
</tr>
<tr>
<td>≥85</td>
<td>32</td>
<td>11.11</td>
<td>1</td>
<td>0.35</td>
</tr>
<tr>
<td>Total</td>
<td>205</td>
<td>2.39</td>
<td>17</td>
<td>0.20</td>
</tr>
</tbody>
</table>

Rate is expressed as number per 1,000 per year.
Marked increase of stroke incidence in men between 1972 and 1990 in Frederiksberg, Denmark.

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