Stroke in 85-Year-Olds
Prevalence, Incidence, Risk Factors, and Relation to Mortality and Dementia

Martin Liebetrau, MD; Bertil Steen, MD, PhD; Ingmar Skoog, MD, PhD

Background and Purpose—Stroke and dementia are major health problems in the elderly. We examined the prevalence and incidence of stroke and their relation to dementia in a representative sample of 494 subjects 85 years of age from Gothenburg, Sweden, who were followed up to 88 years of age.

Methods—Information on stroke was obtained from an inpatient hospital linkage system, death certificates, self-reports, and key informants. Dementia was defined according to the Diagnostic and Statistical Manual of Mental Disorders, third revision.

Results—The prevalence of stroke at 85 years of age was 18.8% (self-reports, 10.7%; key informants, 13.2%; register data, 13.0%). The incidence of stroke between 85 and 88 years of age was 57.2/1000 person-years (men, 32.5/1000 person-years; women, 66.9/1000 person-years; self-reported, 30.8/1000 person-years; key informants, 38.5/1000 person-years; register data, 45.4/1000 person-years). Female sex (risk ratio [RR], 2.1; 95% confidence interval [CI], 1.0 to 4.8) and higher systolic blood pressure (per 10 mm Hg: RR, 1.14; 95% CI, 1.02 to 1.28) were associated with higher incidence of stroke. Baseline stroke was related to increased mortality in women and higher prevalence but not incidence of dementia. There was an association between incidence strokes and incidence dementia between 85 and 88 years of age (RR, 3.8; 95% CI, 2.2 to 6.7).

Conclusions—One fifth of 85-year-olds had stroke, and half of those were demented. In this age, it is important to use several sources of information to detect stroke because of the high number of demented. High blood pressure increases stroke risk also in the very old, which is important in relation to prevention.

Key Words: aged, 80 and older ■ brain ischemia ■ dementia ■ epidemiology ■ follow-up studies ■ Sweden

The frequency of stroke and dementia increases with age; thus, these disorders have become major health problems in Western societies because of increasing numbers of elderly. Frequency of stroke in elderly populations has generally been derived from self-reports or hospital registry data. These sources of information may underestimate the occurrence of stroke in the very old because dementia is common in this age and because demented individuals may not provide reliable information or be admitted to hospital for their stroke.

Dementia is common after stroke, and both dementia and stroke contribute to disability in old age. Stroke increases the risk of dementia ~9 times. However, the relation between stroke and dementia is complex. It has been suggested that stroke-free individuals with cognitive dysfunction or mild dementia are at increased risk for stroke. Thus, the direction of the association between stroke and dementia is not clear. Available data regarding the association between stroke and dementia are derived mainly from clinic-based studies, and there are few studies among the very old.

Established risk factors for stroke include old age, male sex, cardiovascular disease, hypertension, diabetes, hypercholesterolemia, alcohol consumption, and smoking. It is not clear whether these risk factors are important also in the very old.

The primary aim of this study was to estimate the occurrence (prevalence and incidence), risk factors, and mortality rate for stroke in 85-year-olds using information from self-reports, key informants, a hospital record linkage system, and death certificates as part of the Longitudinal Gerontologic and Geriatric Population Studies (H70) in Gothenburg, Sweden. The second aim was to study the cross-sectional and longitudinal relationship between stroke and dementia in 85-year-olds.

Subjects and Methods

Subjects
All 85-year-olds born between July 1, 1901, and June 30, 1902, and registered for census purposes in Gothenburg, Sweden, were invited to take part in a health survey. People living in the community and

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at institutions were included. Every second person was systematically selected for a neuropsychiatric examination, and 494 accepted (response rate, 63%; 144 men, 350 women). The study has been described in detail previously. Nonparticipants and participants did not differ regarding sex, marital status, mortality to 88 years of age, and registration as a psychiatric outpatient or inpatient in Gothenburg. Demographic factors are described in Table 1. Informed consent was obtained from all participants and/or their relatives. The study was approved by the Ethics Committee for Medical Research at Göteborg University in Gothenburg.

Methods
The study included nurse home visits, physical examinations by geriatricians (including assessment of physical disorders), neuropsychiatric examinations, key informant interviews, and laboratory tests, including ECG, chest x-ray, and an extensive biochemical evaluation. Casual blood pressure was measured in the right arm in the seated position after 5 minutes’ rest with a mercury manometer. Systolic (SBP) and diastolic (DBP) blood pressures were registered to the nearest 5 mm Hg. The neuropsychiatric examination included 131 questions (eg, about social factors, psychiatric symptoms, and stroke), 65 cognitive measures (eg, regarding memory, language, visuospatial ability), and 60 observed variables (psychiatric symptoms, neurological symptoms). The key informant telephone interview was performed by a neuropsychiatrist for 380 participants at 85 years of age and included 370 questions about cognitive and psychiatric symptoms and stroke symptoms. Both examinations were semistructured, allowing clarifying questions; eg, in the questions about history of stroke, several synonyms of stroke were given to the participant.

Diagnostic Procedures
Stroke
Information on stroke was derived from 3 different sources of information: self-reported, key informant, and hospital linkage system. Participants and key informants (eg, spouse or child) were interviewed by a neuropsychiatrist regarding occurrence of stroke. Participants were also interviewed by a geriatrician who examined focal signs indicating previous stroke. The interviews included questions about sudden onset of focal symptoms or acute aphasia and admission to hospital because of stroke. All side notes and answers to these questions were examined by a stroke neurologist and a neuropsychiatrist. Only stroke patients with a definite history of acute focal symptoms (hemiparesis or acute aphasia) were included. Stroke was self-reported in 98 patients at 85 years of age, but only 53 of those were accepted. Key informants reported 88 cases of stroke at age 85, but only 50 were accepted.

Hospital Linkage System
Since 1978, all hospital admissions in Sweden have been registered in a computerized hospital linkage system and classified according to the International Classification of Diseases, ninth edition (ICD-9; codes 430 to 438 for stroke). According to previous studies, 94% of registered strokes are correctly classified. In addition, strokes were identified by death certificates.

Dementia
A diagnosis of dementia and its severity was made according to the Diagnostic and Statistical Manual of Mental Disorders, third revision, as previously described.

Incidence
Among 401 stroke-free individuals at 85 years of age, 104 died and 62 refused a follow-up examination at 88 years of age. Information on new strokes during follow-up on all 401 individuals was derived from the hospital record linkage system and death certificates; data on dementia came from medical records from psychiatric and geriatric institutions and outpatient departments in Gothenburg and were examined by a neuropsychiatrist. Information on incidence of dementia and first-ever stroke between 85 and 88 years of age was also obtained from self-reports (n = 235) and key informant interviews (n = 190) at 88 years of age.

Calculation of incidence was based on person-years at risk and computed as subjects affected in the interval divided by sum of person-years at risk. For those considered nondiseased (no dementia, no stroke), the risk time was calculated as time to death or 36 months. For incidence cases of stroke or dementia, risk time was calculated as the time from examination at 85 years of age to the date of onset of the disease. In cases of missing information about onset, the assumption was made that onset occurred in the middle of the follow-up period, and risk time was calculated as time between the examinations divided by 2. In the subanalysis of stroke incidence when only information from self-reports or key informants was considered, the risk time for nondiseased was calculated as the time between the 2 examinations.

Statistical Methods
The associations between stroke and dementia at 85 years of age and between stroke and 3-year mortality were tested for significance with Fisher’s exact test, and odds ratios (ORs) were calculated with logistic regression analyses. These were first calculated with univariate logistic regression analyses, followed by stepwise logistic regression.

Cox proportional-hazards regression analyses were used to calculate the hazard ratios for factors related to the incidence and risk time of stroke and the relation between baseline stroke and the incidence

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**TABLE 1. Demographic Factors in 85-Year-Olds**

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female sex</td>
<td>351</td>
<td>71.1</td>
</tr>
<tr>
<td>High education</td>
<td>113</td>
<td>25.1</td>
</tr>
<tr>
<td>Hypertension</td>
<td>213</td>
<td>43.7</td>
</tr>
<tr>
<td>Hypercholesterolemia</td>
<td>92</td>
<td>21.6</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>38</td>
<td>7.9</td>
</tr>
<tr>
<td>Smoker</td>
<td>35</td>
<td>7.4</td>
</tr>
<tr>
<td>Overweight</td>
<td>155</td>
<td>45.7</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td>50</td>
<td>11.9</td>
</tr>
<tr>
<td>Myocardial infarction</td>
<td>54</td>
<td>11.5</td>
</tr>
<tr>
<td>3-y Mortality</td>
<td>161</td>
<td>32.6</td>
</tr>
</tbody>
</table>

**TABLE 2. Prevalence of Stroke in 85-year-Olds According to Different Sources of Information**

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Men</th>
<th>Women</th>
<th>All information</th>
<th>Self-reports</th>
<th>Key informants</th>
<th>Linkage system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prevalence, %</td>
<td>(95% CI)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All information</td>
<td>16.8</td>
<td>11.3</td>
<td>24.1</td>
<td>19.7 (15.7–24.3)</td>
<td>7.7 (4.1–13.7)</td>
<td>9.5 (4.9–17.2)</td>
<td>10.5 (6.2–17.0)</td>
</tr>
<tr>
<td>Self-reports</td>
<td>12.0</td>
<td>8.9</td>
<td>15.9</td>
<td>12.0 (8.9–15.9)</td>
<td>7.7 (4.1–13.7)</td>
<td>9.5 (4.9–17.2)</td>
<td>10.5 (6.2–17.0)</td>
</tr>
<tr>
<td>Key informants</td>
<td>14.5</td>
<td>10.7</td>
<td>19.4</td>
<td>14.5 (10.7–19.4)</td>
<td>12.0 (8.9–15.9)</td>
<td>14.5 (10.7–19.4)</td>
<td>14.5 (10.7–19.4)</td>
</tr>
<tr>
<td>Linkage system</td>
<td>14.0</td>
<td>10.6</td>
<td>18.1</td>
<td>14.0 (10.6–18.1)</td>
<td>12.0 (8.9–15.9)</td>
<td>14.0 (10.6–18.1)</td>
<td>14.0 (10.6–18.1)</td>
</tr>
</tbody>
</table>

*Stroke cases/those with information
and risk time of dementia. Because the significance of the parameters in the Cox regression models is based on large sample approximations, we also compared the incidence risk using risk time information with a nonparametric method. Risks were calculated as the number of incidence cases divided by the number of observational years; the confidence interval (CI) for the risk ratio (RR) was then calculated with the conditional binomial method; and the significance of the RR was calculated with the binomial test for comparing 2 Poisson rates.

Agreement between different sources of information was tested with $\kappa$ statistics. Two-tailed tests were used in all analyses at a significance level of $P<0.05$. We chose not to correct for multiple comparisons in the analyses because doing so may give rise to false-negative results.13

Results

Prevalence of Stroke at 85 Years of Age

A history of stroke was identified by self-reports in 10.7% (53 of 494), by key informants in 13.2% (50 of 380), and by the hospital linkage system in 13.0% (64 of 494). Overall, the prevalence of stroke was 18.8% (n=93; Table 2). The hospital linkage system thus identified 68.8% of all cases. According to register data and key informants, 51 had 1 stroke, 16 had 2 strokes, 6 had 3 strokes, and 13 had ≥4 strokes. Seven had no information on number of strokes. The diagnosis of stroke was based on 1 source of information in 31.2% (n=29), from 2 sources in 43.0% (n=40), and from 3 sources in 25.8% (n=24). Those with a diagnosis according to register data and key informants had a diagnosis according to self-report or key informants in 66% (Table 3).

Incidence of Stroke Between 85 and 88 Years of Age

Among 85-year-olds without stroke (n=401), 56 individuals had their first-ever stroke between 85 and 88 years of age (self-reports in 19 cases; key informants in 19 cases; hospital linkage system and death certificates in 45 cases, of whom 21 had no follow-up examination or key informant interview; death certificates in 6 cases). The stroke incidence was 30.8/1000 person-years from self-reports, 38.5/1000 person-years from informants, and 45.4/1000 person-years from hospital linkage system or death certificates (Table 4). Overall, the incidence of first-ever strokes was 57.2/1000 person-years (32.5/1000 person-years in men, 66.9/1000 person-years in women). Only 237 persons had information regarding stroke from key informants or self-report, mainly because of death before 88 years of age. Among 24 who had stroke according to register data and information from self-report or key informants, 16 had stroke according to self-report or key informants. Among the 27 who had stroke according to self-report or key informants, 16 were confirmed by the hospital linkage system.

Risk Factors at 85 Years of Age in Relation to Incidence of Stroke

Among traditional risk factors for stroke (sex, treated hypertension, SBP, DBP, diabetes mellitus, cholesterol, over-

### Table 4. Incidence of First-Ever Stroke Between 85 and 88 Years of Age in Relation to Dementia at 85 Years of Age

<table>
<thead>
<tr>
<th></th>
<th>Stroke Events, n</th>
<th>Stroke per 1000 Person-Years (95% CI)</th>
<th>RR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>56</td>
<td>979.2</td>
<td>57.2 (43.9–74.1)</td>
</tr>
<tr>
<td>Women</td>
<td>47</td>
<td>702.3</td>
<td>66.9 (50.1–88.7)</td>
</tr>
<tr>
<td>Men</td>
<td>9</td>
<td>276.8</td>
<td>32.5 (15.9–62.9)</td>
</tr>
<tr>
<td>Nondemented</td>
<td>43</td>
<td>777.6</td>
<td>55.3 (40.8–74.4)</td>
</tr>
<tr>
<td>Women</td>
<td>35</td>
<td>556.5</td>
<td>62.9 (44.7–87.1)</td>
</tr>
<tr>
<td>Men</td>
<td>8</td>
<td>221.1</td>
<td>36.2 (16.9–72.7)</td>
</tr>
<tr>
<td>Demented</td>
<td>13</td>
<td>201.5</td>
<td>64.5 (36.2–110.0)</td>
</tr>
<tr>
<td>Women</td>
<td>12</td>
<td>145.9</td>
<td>82.3 (45.1–142.3)</td>
</tr>
<tr>
<td>Men</td>
<td>1</td>
<td>55.7</td>
<td>18.0 (9.9–108.2)</td>
</tr>
</tbody>
</table>

*Compared with nondemented.
TABLE 5. Three-Year Mortality in 85-Year-Olds in Relation to Stroke

<table>
<thead>
<tr>
<th></th>
<th>Men (RR (95% CI) for Death in Those With Stroke)</th>
<th>Women (RR (95% CI) for Death in Those With Stroke)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stroke %</td>
<td>% n 95% CI</td>
<td>% n 95% CI</td>
</tr>
<tr>
<td>All</td>
<td>52.2 36/69 39.9–64.2</td>
<td>52.2 36/69 39.9–64.2</td>
</tr>
<tr>
<td>Demented</td>
<td>64.3 27/42 48.0–78.0</td>
<td>64.3 27/42 48.0–78.0</td>
</tr>
<tr>
<td>Nondemented</td>
<td>33.3 9/27 17.2–54.0</td>
<td>33.3 9/27 17.2–54.0</td>
</tr>
</tbody>
</table>

weight, smoking, atrial fibrillation, myocardial infarction, and alcohol consumption), only SBP (RR, 1.14; 95% CI, 1.02 to 1.28) and female sex (RR, 2.1; 95% CI, 1.0 to 4.8) were related to an increased risk of stroke.

Dementia in Relation to Stroke

The prevalence of dementia was 57.0% in 85-year-olds with stroke and 23.5% in those without (OR, 4.3; 95% CI, 2.7 to 6.9). The result was similar in men (45.8% versus 23.5%; OR, 2.8; 95% CI, 1.1 to 6.8) and in women (60.9% versus 23.5%; OR, 5.1; 95% CI, 2.9 to 8.9) and among those identified by self-reports or informants (60.6% versus 24.6%; OR, 4.7; 95% CI, 2.8 to 8.0) and those identified by the hospital linkage system (56.3% versus 25.8%; OR, 3.7; 95% CI, 2.2 to 6.3).

Stroke was more common in those with more severe dementia. Compared with the nondemented, the OR for stroke was 2.8 (95% CI, 1.3 to 6.1) among those with mild dementia, 3.5 (95% CI, 1.8 to 6.9) among those with moderate dementia, and 6.9 (95% CI, 3.7 to 12.8) among those with severe dementia.

Demented and nondemented 85-year-olds without stroke had a similar incidence of first-ever stroke between 85 and 88 years of age (Table 4). The incidence of first-ever strokes did not differ on the basis of dementia severity (mild, moderate, severe). The incidence of dementia between 85 and 88 years of age was similar in those with and without stroke at 85 years of age (87.1 versus 85.5/1000 person-years; RR, 0.98; 95% CI, 0.4 to 2.2).

In individuals without stroke or dementia at baseline (n=282), 39 developed stroke and 56 developed dementia between 85 and 88 years of age. Nineteen developed both dementia and stroke; i.e., 49% of incidence stroke cases developed dementia (OR, 3.8; 95% CI, 2.2 to 6.7). Dementia occurred before stroke in 9 patients and after stroke in 10 patients.

Mortality

Information on date of death was available from the census register in Gothenburg, which monitors all deaths in the region. History of stroke at 85 years of age was related to an increased 3-year mortality in women but not in men (Table 5). Stroke was associated with higher mortality in both demented and nondemented women.

Discussion

We examined the prevalence and incidence of stroke in a representative sample of 85-year-olds living in Gothenburg, Sweden, using 3 sources of information: self-reports, key informants, and register data. Information on stroke from only 1 source was obtained from 31% at 85 years of age and from 46% of the incidence cases with examination at 88 years of age, suggesting that it is necessary to use several sources of information to avoid underestimation of stroke in the very elderly.

Many studies have used self-reported data to obtain information on the prevalence of stroke. The accuracy of these data is high in middle-aged persons, but in old age, this method may be insufficient because of the high prevalence of dementia. Studies based on self-reports only may therefore underestimate the prevalence of stroke in older ages. Information from key informants may also underestimate stroke because informants may not always be aware of diseases in a relative. We also used an inpatient register, which has been widely used to study the prevalence of stroke. It has previously been reported that this register misses <10% of stroke patients in Sweden. However, in our sample, the hospital linkage system missed 31% of strokes at both baseline and follow-up. Hospitalization for stroke may be lower in the very old, which may underestimate the frequency of stroke in this age group. Other explanations for the finding that hospital registers missed cases of stroke in this study may be misclassification and misinformation from self-report or key informants and that mild strokes may not reach medical attention.

With all information, our prevalence of stroke (19%) is higher than in previous studies in the very old based on single source of information. Our prevalence from a single source of information (10% to 13%) is similar to studies in populations >85 years of age using only inpatient register data (12%) or self-reports (11.6% in men, 10.6% in women). To the best of our knowledge, no other study has used information from key informants to detect stroke.

In our study, the incidence of first-ever stroke between 85 and 88 years was 57/1000 person-years, which is higher than in other studies, partly because of our use of several sources of information. On the basis of register data, Thrift et al reported an incidence rate of 29/1000 person-years, and Iemolo et al reported 32/1000 person-years among individuals >85 years of age, which is lower than what we found for this source. One reason might be that we included death certificates in the register data, which raised the incidence rate from 39/1000 person-years to 45/1000 person-years. One large population-based study from Rotterdam found an incidence rate of 22/1000 person-years between 85 and 89 years of age. They obtained data mainly from an automated...
We found that higher SBP, but no other traditional stroke risk factor, was related to an increased incidence of stroke. Several studies have shown an association between high blood pressure and stroke in younger samples.11 Our finding that high SBP was related to an increased incidence of stroke suggests that it is important to treat hypertension in very old individuals, even if the risk of stroke associated with SBP is lower than in younger samples. However, the high incidence of stroke suggests that the number needed to treat may be lower than in younger age groups. The finding that stroke risk was slightly increased in women is contrary to what is reported for populations <80 years of age.11 It is possible that this was due to a survival effect or to women at risk for stroke having their stroke later in life than men.

Another sex difference was that only women experienced an increased mortality rate with stroke. The reason for this difference was mainly that men without stroke had a higher mortality rate than women without stroke because men and women with stroke showed a similar mortality rate.

We found that 57% of 85-year-olds with stroke had dementia. Our figures are higher than the 25% to 41% reported for younger hospitalized samples7,8,19 but similar to dementia. Our figures are higher than the 25% to 41% women with stroke showed a similar mortality rate. The reason for this association may be that individuals with mild dementia often have silent strokes. Our use of several sources of information led to detection of more strokes and thus to less undetected strokes in the demented group at baseline, which may be an explanation for the lack of association between dementia at baseline and stroke at follow-up.

Some methodological factors have to be considered. First, the validity of the different sources of information could be questioned. All information from self-reports and key informants was evaluated by a stroke neurologist and a neuropsychiatrist, and the criteria were rather strict, allowing only cases with a clear history of focal symptoms. Second, it is possible that we underestimated the prevalence of stroke because only 380 of 494 individuals had key informant interviews. However, most of the participants with missed key informant interviews were not demented (96%). Therefore, they may remember previous strokes better than demented participants. Third, information from the hospital linkage system may be questioned because diagnoses were made by many different physicians working under different circumstances; however, criteria for stroke had to be according to ICD-9. Fourth, the response rate was 63%, a fairly satisfactory response rate in this age group. Although a comparison between responders and nonresponders showed that the sample investigated was representative of its population base of 85-year-olds regarding a large number of factors, we cannot exclude the possibility that those who did not participate differed from participants. Fifth, we were not able to report on the various forms of stroke. However, in a population study like this one, it is difficult to determine the different stroke forms with certainty. According to the diagnosis from the hospital register, only very few strokes were hemorrhagic. Thus, the great majority of strokes were probably nonhemorrhagic.

In summary, we found that almost one fifth of 85-year-olds experienced stroke, and more than half of those with stroke had dementia. In this old age group, it is important to use several sources of information to detect stroke because of the high prevalence of demented participants and lower hospital admissions for stroke.

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### References


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