Gender Differences in Stroke Incidence and Poststroke Disability in the Framingham Heart Study

Rodica E. Petrea, MD; Alexa S. Beiser, PhD; Sudha Seshadri, MD; Margaret Kelly-Hayes, RN, EdD; Carlos S. Kase, MD; Philip A. Wolf, MD

Background and Purpose—Stroke is emerging as a major public health problem for women, as it is for men. Controversy persists regarding gender differences in stroke incidence, severity, and poststroke disability.

Methods—Participants in the Framingham Original (n=5119; 2829 women) and Offspring (n=4957, 2565 women) cohorts who were 45 years and stroke-free were followed to first incident stroke. Gender-specific outcome measures were adjusted for the Framingham Stroke Risk Profile components.

Results—We observed 1136 incident strokes (638 in women) over 56 years of follow-up. Women were significantly (P<0.001) older (75.1 versus 71.1 years for men) at their first-ever stroke, had a higher stroke incidence above 85 years of age, lower at all other ages, and a higher lifetime risk of stroke at all ages. There was no significant difference in stroke subtype, stroke severity, and case fatality rates between genders. Women were significantly (P<0.01) more disabled before stroke and in the acute phase of stroke in dressing (59% versus 37%), grooming (57% versus 34%), and transfer from bed to chair (59% versus 35%). At 3 to 6 months poststroke women were more disabled, more likely to be single, and 3.5 times more likely to be institutionalized (P<0.01).

Conclusions—These results from the Framingham Heart Study (FHS) support the existence of gender-differences in stroke incidence, lifetime risk (LTR) of stroke, age at first stroke, poststroke disability, and institutionalization rates. Prestroke disability and sociodemographic factors may contribute to the high rate of institutionalization and poorer outcome observed in women. (Stroke. 2009;40:1032-1037.)

Key Words: gender ■ stroke ■ incidence ■ disability outcome

There are 780 000 new and recurrent strokes occurring each year in the United States, making stroke the major cause of disability, the third leading cause of death in the United States and the second cause of death worldwide in both men and women. Recent data shows that 60 000 more women than men have a stroke each year in the United States. The burden of stroke in women was often underestimated until the early 1980s, and after being once considered primarily a disease of men, stroke is currently emerging as a major public health problem for women as well.

Prior reports on the LTR of stroke based on the Framingham Study cohort estimated that 1 in 5 women and 1 in 6 men who reach age 55 free of stroke will develop a stroke during their remaining lifetime. Thus elderly women, the fastest growing segment of the American population, face an increased likelihood of stroke, a troubling statistic because this group may have in addition the greatest risk of disability after stroke.

There is increasing evidence of gender-specific differences in stroke symptoms, diagnosis, peri-procedural risk, treatment, and preventive interventions. For example, results from the Women’s Health Study and the Physician’s Health Study revealed that aspirin is an efficacious measure for primary stroke prevention in women but not in men. Surprisingly, the data on gender-specific rates of stroke incidence are still scarce, and controversies continue regarding differences in stroke mortality and poststroke disability outcomes.

The aim of our study was to explore gender-specific differences in stroke incidence, cumulative incidence, severity, and poststroke disability in the FHS, based on data from 56 years of prospective follow-up in a community-based sample.

Subjects and Methods

Study Population

The FHS is a longitudinal community-based cohort study which was initiated in 1948 with the enrollment of 5209 participants aged 28 to 62 years. In 1971 the offspring and the offspring spouses of the Original cohort participants were enrolled as the Offspring cohort. Since the study’s inception, participants have had serial examinations including standardized interviews, physician examinations, and...
laboratory testing. More details of the study design have been
detailed elsewhere.21
FHS participants who survived free of clinical stroke to age 45
constituted the study sample for this investigation. These 10 076
participants (5119 from the Original cohort and 4957 from the
Offspring cohort), 5394 of whom were women were followed for up
to 56 years through 2005 to the first-ever stroke. This sample was
used to estimate age-specific stroke incidence and remaining LTR of
stroke. Incident stroke cases (n=1136) were further investigated for
prestroke comorbidity and pre- and postdisability, stroke severity,
and case fatality rates.

A subset of stroke cases was closely followed for disability as part
of a separate study of the precursors and outcomes of stroke (PE: PA
Wolf). Participants diagnosed with a stroke, alive, living in the
geographic area, and able to participate in a disability evaluation in
the acute phase of stroke and at 3 to 6 months poststroke were
included in the disability assessment. This assessment was per-
formed on 594 stroke cases (364 women) in the acute phase of stroke
and on 205 stroke cases (120 women) in the chronic phase of stroke,
at 3 to 6 months poststroke.

Written informed consent was obtained from all participants. The
consent form and the study design were approved by the Institutional
Review Board of Boston University Medical Center.

Methods
Details of our protocol for stroke surveillance, diagnosis and type of
stroke, assessment of stroke severity, and disability after stroke have
been published previously.4,13
Stroke was clinically defined as a sudden onset of a focal
neurological deficit of a presumed vascular etiology and lasting more
than 24 hours. The surveillance for new stroke events involved
screening at consecutive cohort examinations, including a medical
history that specifically enquired about stroke symptoms and a
physical examination. Persons with suspected stroke underwent
evaluation by a study stroke neurologist. There was also ongoing
daily monitoring of local hospital admissions and emergency room
visits, tracking of records for interim hospitalizations, questioning of
participants for stroke symptoms in annual telephone health updates,
and referrals from ancillary study examinations including those from
an ongoing study of brain MRI in all eligible participants from the
Original and Offspring cohorts.

The diagnosis of stroke and stroke subtype was based on prees-
tablished criteria that included clinical, laboratory and noninvasive
imaging and vascular studies, cardiac evaluations, and information
from autopsy studies, when available. Potential stroke cases were
reviewed and adjudicated by a physician review panel of 3 investi-
gators (with a minimum of 2 neurologists).

All ischemic and hemorrhagic strokes were included. Ischemic
strokes were classified as atherothrombotic brain infarctions (ABI)
or cardioembolic infarctions (CE). Hemorrhagic strokes were classi-
cified as intracerebral hemorrhages (ICH) or subarachnoid hemor-
rhages (SH). Stroke severity was defined according to the neurolog-
ical deficits identified on examination during the acute phase of
stroke and was further classified into 4 categories: none (no deficit),
mild (deficit present in visual, motor, sensory, or language domains
but without functional impairment), moderate (deficit requiring
assistance in 1 of the domains mentioned above), and severe (deficit
requiring assistance in at least 2 of the domains). Case fatality rates
were defined as the percentage of patients with stroke who died
within 30, 90, and 180 days from the onset of stroke.

Disability Assessment
Disability assessment was performed prestroke as part of the ongoing
Framingham cycle examinations (done within the 5 years preceeding
the stroke) and poststroke (as part of a larger poststroke assessment
battery) in the acute phase and at 3 to 6 months, on a subset of cases
as described above. We defined physical disability using modified
Katz activities of daily living (ADL) scale.22 This scale has been
used in other large population-based studies with high test-retest
reliability.23 24 The assessment included 5 domains of activity which
were eating, dressing, grooming, transfer from bed to chair, and

Table 1. Gender-Specific Stroke Incidence by 10-Year Periods
of Time

<table>
<thead>
<tr>
<th>Age (Years)</th>
<th>No. of Strokes</th>
<th>Incidence/1000PY</th>
<th>No. of Strokes</th>
<th>Incidence/1000PY</th>
</tr>
</thead>
<tbody>
<tr>
<td>45 to 54</td>
<td>34</td>
<td>0.82</td>
<td>41</td>
<td>1.16</td>
</tr>
<tr>
<td>55 to 64</td>
<td>76</td>
<td>1.76</td>
<td>93</td>
<td>2.58</td>
</tr>
<tr>
<td>65 to 74</td>
<td>161</td>
<td>5.04</td>
<td>182</td>
<td>7.59</td>
</tr>
<tr>
<td>75 to 84</td>
<td>226</td>
<td>12.09</td>
<td>145</td>
<td>13.40</td>
</tr>
<tr>
<td>85 to 94</td>
<td>128</td>
<td>21.57</td>
<td>34</td>
<td>15.51</td>
</tr>
<tr>
<td>Crude</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>625</td>
<td>4.42</td>
<td>495</td>
<td>4.56</td>
</tr>
<tr>
<td>Age-adjusted</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4.07</td>
<td></td>
<td>4.96</td>
<td></td>
</tr>
</tbody>
</table>

walking. Information about institutionalization was obtained pre-
stroke and at the time of disability evaluation in the acute and 3-
to 6-month assessment.

Statistical Analysis
We calculated gender-specific annual stroke incidence per 1000
person-years within 10-year age groups and overall, and used direct
standardization to estimate gender-specific age-adjusted stroke inci-
dence. We compared stroke incidence in men and women within age
groups and overall using Poisson regression.

Gender-specific estimates of remaining LTR of stroke were calcu-
lated using a survival analytic technique adjusting for the competing risk
of death (described in detail elsewhere),23 25 26 Seshadri et al3 esti-
mated the remaining LTR of stroke in stroke-free men and women at
the index age of 45; we updated those results here using slightly
longer follow-up.

Estimates of age-specific stroke incidence and remaining LTR of
stroke were calculated using participants aged 45 to 94 only; persons
remaining free of stroke provided information until the date when
they were last interviewed or examined to determine whether they
suffered a stroke, until they died or reached age 95 years, or until
December 2005.

Gender-specific crude prevalence of prestroke comorbidity and
disability and stroke outcomes are presented, with comparisons made
using age-adjusted logistic regression. Stroke outcomes were addi-
tionally adjusted for prestroke disability and the components of the
Framingham Stroke Risk Profile27: systolic blood pressure (SBP),
antihypertensive treatment, atrial fibrillation (AF), current smoking,
prevalent cardiovascular disease (CVD), and diabetes mellitus (DM).

Results
Gender-Specific Stroke Incidence and LTR
of Stroke
We observed a total of 1136 strokes (638 in women) during the
56-year follow-up period. Of these, 1117 incident strokes
(625 in women) that occurred between ages 45 to 94 constituted
the basis for the incidence and LTR analyses. Gender-specific stroke incidence by 10-year age group is
shown in Table 1 with a graphic representation displayed in
Figure 1. We found that stroke incidence increased with each
decade of life in both women and men. Among those aged 45
to 84, stroke incidence was higher in men than in women
(P<0.001). The gender effect reversed in the oldest group,
with stroke incidence higher in women than in men among
those aged 85 to 94. However, the number of cases in this age
group was small and the difference did not reach statistical
significance (P=0.087).
The remaining LTR of stroke for individuals who survive stroke-free to age 45 was estimated as 1 in 6 for men and 1 in 5 for women (Figure 2). A similar pattern to that seen in the age-specific incidence analyses is noticed again with the mortality-adjusted cumulative incidence higher in men until age 85; beyond age 85 the LTR of stroke curve for women surpassed the rate for men. Age and gender-specific 10-, 20-, 30-, 40- year, and LTR (through age 95) estimates for incident stroke are shown in supplemental Table I, available online at http://stroke.ahajournals.org.

Subtypes of All Incident Strokes
Table 2 presents data on subtypes of all incident strokes. Less than 1% of strokes remained unspecified, and there was no significant difference between women and men with regard to stroke subtype.

Gender-Specific Disability and Institutionalization Rates
The pre and poststroke disability and institutionalization rates were calculated in the acute phase of stroke on all incident strokes included in the disability assessment. In those who survived and attended a 3- to 6-month poststroke visit, gender-specific disability and institutionalization rates were obtained in the acute phase of stroke and at 3 to 6 months poststroke, as shown in Table 4.

In a sample of 276 women and 182 men, we observed that before stroke women were significantly more disabled as assessed by the Katz ADL scale (16% versus 6%, OR = 2.31, P<0.05) and 4 times more likely to be dependent in their living situation (27% versus 6%, OR = 4.03, P<0.001). In the acute phase of stroke, women were also significantly more disabled than men (P<0.01) in eating (42% versus 26%, OR = 1.56), dressing (59% versus 37%, OR = 1.91), grooming (57% versus 34%, OR = 2.01), and transfer from bed to chair (59% versus 35%, OR = 2.16). After adjusting for all the

Table 2. Subtypes of All Incident Strokes

<table>
<thead>
<tr>
<th></th>
<th>All Strokes</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Women</td>
<td>Men</td>
</tr>
<tr>
<td>No. incident</td>
<td>638</td>
<td>498</td>
</tr>
<tr>
<td>ABI</td>
<td>367 (58%)</td>
<td>310 (62%)</td>
</tr>
<tr>
<td>CE</td>
<td>170 (27%)</td>
<td>116 (23%)</td>
</tr>
<tr>
<td>SH</td>
<td>33 (5%)</td>
<td>21 (4%)</td>
</tr>
<tr>
<td>ICH</td>
<td>59 (9%)</td>
<td>46 (9%)</td>
</tr>
</tbody>
</table>

ABI indicates atherothrombotic brain infarctions; CE, cardioembolic infarctions; SH, subarachnoid hemorrhage; ICH, intracerebral hemorrhage.

Table 3. Comorbidities, Age, Stroke Severity at First-Ever Stroke, and Case Fatality Rates at 30, 90, and 180 Days Among Participants Who Attended an Exam Within 5 Years Before Stroke

<table>
<thead>
<tr>
<th></th>
<th>Women</th>
<th>Men</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. incident</td>
<td>519</td>
<td>413</td>
</tr>
<tr>
<td>Prestroke morbidity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>25%</td>
<td>28%</td>
</tr>
<tr>
<td>Cardiovascular disease</td>
<td>34%</td>
<td>39%</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td>16%</td>
<td>14%</td>
</tr>
<tr>
<td>Systolic blood pressure, mm Hg</td>
<td>155±27</td>
<td>149±25</td>
</tr>
<tr>
<td>Antihypertensive treatment</td>
<td>49%</td>
<td>41%</td>
</tr>
<tr>
<td>Smoking</td>
<td>22%</td>
<td>28%</td>
</tr>
<tr>
<td>Cancer*</td>
<td>16%</td>
<td>18%</td>
</tr>
<tr>
<td>Age at stroke,** y</td>
<td>75±11</td>
<td>71±10</td>
</tr>
<tr>
<td>Stroke severity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fatal/severe</td>
<td>29%</td>
<td>21%</td>
</tr>
<tr>
<td>Death in 30 days</td>
<td>21%</td>
<td>15%</td>
</tr>
<tr>
<td>Death in 90 days</td>
<td>27%</td>
<td>20%</td>
</tr>
<tr>
<td>Death in 180 days</td>
<td>30%</td>
<td>23%</td>
</tr>
</tbody>
</table>

*Age-adjusted P<0.01; **P<0.001.
components of the Framingham Stroke Risk Profile\textsuperscript{27} (SBP, antihypertensive treatment, AF, current smoking, prevalent CVD, and DM) and for the prestroke disability, women were still significantly more disabled than men \((P<0.01)\) in dressing \((\text{OR}=1.87)\), grooming \((\text{OR}=2.11)\), and transfer from bed to chair \((\text{OR}=2.37)\).

In a subsample of 106 women and 77 men who survived the acute phase of stroke and attended the 3- to 6-month poststroke visit, women were again almost 4 times more likely to be dependent in their living situation before stroke \((22\% \text{ versus } 5\%, \text{ OR}=3.71)\), married at the time of the acute stroke \((22\% \text{ versus } 74\%, \text{ OR}=2.26)\), and reached statistical significance only for grooming \((44\% \text{ versus } 22\%, \text{ OR}=2.26, P<0.01)\) in the acute phase and for transfer from bed to chair \((32\% \text{ versus } 13\%, \text{ OR}=2.37, P<0.05)\) at 3 to 6 months poststroke evaluation. However, this trend reached statistical significance only for grooming \((44\% \text{ versus } 22\%, \text{ OR}=2.26, P<0.05)\) in the acute phase and for transfer from bed to chair \((32\% \text{ versus } 13\%, \text{ OR}=2.37, P<0.05)\) at 3 to 6 months poststroke. At 3 to 6 months poststroke, women were 3.5 times more likely to be institutionalized than men \((35\% \text{ versus } 10\%, \text{ OR}=3.50, P<0.01)\).

\section*{Discussion}

In our community-based longitudinal study, we observed that women develop a first-ever stroke an average of 5 years later than men, that they have an overall higher LTR of stroke because of their greater life-expectancy, and that their pre-stroke and poststroke disability and institutionalization rates were significantly higher. At the same time, we did not observe a significant difference in the stroke severity or case fatality rates between women and men. Because women have a greater life expectancy advantage, a stroke occurring later in life at a time when a women’s health and ability to function independently are already compromised, compounds the disability observed in stroke survivors.

The biological and social explanations for these observations require further study. Since sex differences in stroke began to be recognized, the particular influence of estrogen and testosterone on the endothelium and the vascular system, the role of risk factors unique to women such as the use of oral contraceptives, hormone replacement therapy, and pregnancy, systemic delays in the recognition, and insufficient treatment of conventional stroke risk factors in women have all been considered as probable explanations. Efforts to discuss the possible role of these different factors have been hampered by the paucity of data on gender-differences in age-specific stroke incidence, as was recently outlined by Reeves et al.\textsuperscript{28} The inherent difficulties in conducting long-term longitudinal follow-up cohort incidence studies and the persistent misperception that stroke is a rarer disease in women may in part be responsible for the paucity of available data. Systematic data gathering on stroke incidence in women has largely occurred only in the past 2 to 3 decades.\textsuperscript{29} Hence, our current data, which are gathered over 56 years of follow-up in the Framingham Heart Study, are unique. We observed a trend toward a higher incidence of first ever stroke in women than in men after age 85 years, and a lower risk at all other ages. Although the stroke incidence in both genders has shown a trend toward an increase with each decade of life, the main burden of stroke was seen in participants between 65 and 85 years of age. Our observation of a trend toward a higher incidence of stroke in women older than 85 years of age, even though it did not reach statistical significance \((P=0.087)\), likely as a result of the small number of participants in this age group, is concordant with results from the Oxford Vascular Study,\textsuperscript{30} which showed a higher incidence of stroke for women aged 85 years and older and

\section*{Table 4. ADL Modified Katz Disability Scale and Rate of Institutionalization in the Acute Phase of Stroke and at 3 or 6 Months Poststroke}

<table>
<thead>
<tr>
<th></th>
<th>Acute Phase of Stroke</th>
<th>3 to 6 Months Poststroke</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Women</td>
<td>Men</td>
</tr>
<tr>
<td>No. incident strokes</td>
<td>276</td>
<td>182</td>
</tr>
<tr>
<td>Prestroke dependent living</td>
<td>27%</td>
<td>6%</td>
</tr>
<tr>
<td>Prestroke Katz ADL scale (1+ dependent)</td>
<td>16%</td>
<td>6%</td>
</tr>
<tr>
<td>Age at stroke</td>
<td>81±9</td>
<td>75±9</td>
</tr>
<tr>
<td>Married</td>
<td>22%</td>
<td>74%</td>
</tr>
<tr>
<td>Poststroke institutionalization</td>
<td>86%</td>
<td>81%</td>
</tr>
<tr>
<td>Poststroke disability</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Domain of activity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eating</td>
<td>42%</td>
<td>26%</td>
</tr>
<tr>
<td>Dressing</td>
<td>59%</td>
<td>37%</td>
</tr>
<tr>
<td>Grooming</td>
<td>57%</td>
<td>34%</td>
</tr>
<tr>
<td>Transfer bed to chair</td>
<td>59%</td>
<td>35%</td>
</tr>
<tr>
<td>Walking</td>
<td>64%</td>
<td>48%</td>
</tr>
</tbody>
</table>

\*\(P<0.05\); \**\(P<0.01\); \***\(P<0.001\).
with a Swedish study, which also found an increased incidence of stroke in women aged 75 years or more. Data from the Rotterdam Study, another population-based study, with a mean follow-up time of 6 years, found that, although stroke incidence increases with age in both sexes, it remained higher in men than in women over the entire age range studied. However, the Rotterdam estimates are based on only 28 events occurring at or after age 85, whereas the current Framingham estimates are based on data from 162 events in persons aged 85 or above.

Towfighi et al. used data from the National Health and Nutrition Examination Surveys (NHANES), reported a midlife stroke surge among women in the United States; between the ages of 45 and 54 women were twice as likely as men to have had a stroke. The higher prevalence was largely explained by an increase in stroke incidence among women aged 45 to 54, a finding also supported by the Rochester Community Study and the Swedish Hospital Discharge Register. In our study we did not observe such a “midlife” increase in risk among women, but the number of events we observed in this age group was small.

The higher stroke incidence in elderly women (above age 85) that we observed has been supported by other studies. However, in addition to age and the common stroke risk factors, social isolation and loss of a spouse (which is more common among elderly women than men), could, as already shown by other studies, negatively affect overall health, and appears to account for the increased risk of institutionalization in our study.

The LTR of stroke in our study was higher in women than in men, consistent with our prior observations. The longer life expectancy in women is most likely responsible for this finding, but a higher incidence of stroke in women at older ages could be an additional explanation.

Our study did not find a significant gender-specific difference in stroke severity and case fatality rates at 30, 90, or 180 days. This is concordant with data from the Rotterdam study. However, higher case fatality rates were seen in women in almost all populations studied as part of the WHO MONICA Project as well as in the International Stroke Trial. Along with death, disability and institutionalization are the most feared and devastating poststroke outcomes. Our current study explored short-term follow up disability outcomes at 3 to 6 months after stroke and observed a trend toward women being more disabled than men, and the rates of institutionalization significantly higher for women, almost 4 times as high as for men. The most intriguing finding was that although men had at the time of the stroke a higher prevalence of cardiovascular disease and cancer, women were more disabled in their ADLs and they were half as likely to be living independently even before stroke. Men were also almost 3 times more likely to be married at the time of their stroke as opposed to women, who were more likely to be widowed or unmarried and to be living alone. These results are concordant with other disability studies, including previous data from the FHS.

Prestroke disability along with social isolation and lack of social support might prevent women from having the same recovery outcomes as men. Nevertheless, these findings differ from the findings of the few existing studies that evaluate long term survival and functional status after stroke. One of these studies, a prior publication from the Framingham study, noted that women who survived for more than 20 years after a stroke retained good functional abilities although they had a greater mortality than age- and sex-matched control subjects. The difference between our current and prior observations may lie in the selective mortality of the most disabled women who sustained a stroke. In the prior study the average age at first stroke was only 56 years versus a mean age of over 75 years in the current sample.

The 2001 World Health Organization International Classification of Functioning, Disability, and Health highlights the role of environmental and personal factors in the disablement process. The importance of age, family, and social factors as a risk factor for institutionalization, one of the most dreaded consequences of stroke, cannot be underestimated.

Limitations and Strengths
Our study was restricted to an ethnically homogenous sample, white of European descent, which limits the generalizability of our results. Its strengths are the availability of more than 5 decades of meticulously collected, prospective, follow-up data from the large community-based longitudinal Framingham cohort, the use of consistent standardized definitions, the ongoing stroke surveillance, the continuity of follow-up with the same investigators over more than 3 decades (M.K.H., C.S.K., P.A.W.), and the serial disability assessments.

Public Health Significance
Results from the FHS and other studies supporting the presence of gender-differences in stroke incidence, lifetime risk of stroke, age at first stroke, poststroke disability, and institutionalization rates could influence new gender-specific stroke prevention and rehabilitation strategies, targeting women for enrollment in clinical stroke prevention trials. In regard to elderly women our data suggest a need for increased social support. A better understanding of social and medical factors explaining gender-specific disability related issues in people living with stroke could help reduce stroke-related declines in quality of life and increases in living costs in the rapidly aging populations, especially of the United States and Western Europe.

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Disclosures
None.

References


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