Increasing Rates of Dementia at Time of Declining Mortality From Stroke

Svetlana Ukraintseva, PhD; Frank Sloan, PhD; Konstantin Arbeev, PhD; Anatoly Yashin, PhD

Background and Purpose—Stroke is associated with increased risk of dementia. There has been a decline in mortality from stroke among persons 65 and older in recent decades in the US. It is not clear, however, how this process has affected incidence of various dementias.

Methods—We evaluated over time changes in stroke admission rates and survival, and in rates of newly diagnosed dementias (Alzheimer disease, senile, and cerebrovascular disease–related dementia) in persons with and without stroke aged 65 and over, using Medicare inpatient records, 1984 to 2001, linked to the National Long-Term Care Survey (about 380 000 person-years totally).

Results—Age-adjusted stroke rate increased from 0.0066 to 0.008 (P<0.08) from 1984–1990 to 1991–2001. One-year survival after stroke improved from 53% in 1984 to 1990 to 65% in 1991 to 1996 (P<0.0001). Age-standardized rate of diagnosed dementias increased from 0.0062 in 1984 to 1990 to 0.0095 in 1991 to 2000 (P<0.001). Among stroke patients the rate rose from 0.043 to 0.080. The relative increase in risk was largest for cerebrovascular disease–related dementia (3.68). For senile dementia, the increase was small and not significant. Rates of dementia among persons without stroke rose mainly attributable to Alzheimer disease.

Conclusions—Mortality from stroke declined mainly because of declining stroke case-fatality. In parallel, the rate of diagnosed dementia increased. The increase was larger for persons with stroke compared with stroke-free population. Improved survival from stroke may contribute to this trend. Other contributing factors may include better diagnostics, an increased propensity to make the diagnosis, and increasing dementia risk attributable to factors other than stroke. (Stroke. 2006;37:1155-1159.)

Key Words: Alzheimer disease ■ dementia ■ epidemiology ■ stroke ■ survival

Stroke is associated with an excess risk of dementia. Epidemiological studies suggest a several-fold increased incidence of various dementias after stroke.1–4 About 700 000 persons in the US experienced a new or recurrent stroke during 2002.5 The large number of strokes, taken in combination with the association of stroke and dementia onset, implies that stroke-related dementia is a major public health issue.

Since the 1980s, there has been an almost 2-fold decline in mortality from stroke among persons aged 65 and older in the US.6 This decline could have occurred from a decline in stroke incidence, or case-fatality rates, or both. Only a few studies have documented changes over time in stroke incidence and patients’ survival, and recent trends are not quite clear. A decline in stroke incidence rate has been recorded in several European countries.7–10 There are limited data demonstrating a similar decline among Americans aged 70 years and older, in particular before the 1990s.11–12 Case-fatality rate from stroke declined from 12% to 7% to 8% in the US, during in-hospital stay among patients aged 65 and over between 1982 to 1996.13 A modest improvement in poststroke survival from 1985 to 1989 was observed in a study using Medicare hospital claim records.14 Some European studies have recorded declining case-fatality rates for stroke (at least in women).10,15 In several other European studies, case-fatality did not change significantly over time, so that authors have attributed the decline in stroke mortality to a reduction in the incidence rather than in the case-fatality rate.9,11

Although decreasing stroke incidence per se should reduce the number of new cases of dementia, the effect of improved survival from stroke is less clear. On the one hand, some factors associated with improved survival (eg, better differential diagnostics of hemorrhagic and ischemic stroke or better treatment of stroke consequences) could potentially reduce the risk of poststroke dementia. On the other hand, improved survival from stroke could increase the proportion of stroke survivors with more severe brain injury (who would have died previously), which might cause an increase in dementia risks after stroke.

In this article, we examine the age patterns and time trends in stroke rates during 1984 to 2001, survival after the stroke,
and the rates of newly diagnosed dementias (developed after stroke as well as in stroke-free population), using data from Medicare Part A inpatient claims linked to the National Long-Term Care Survey (NLTCs) participants. We address the following question: How did the declining trend in mortality from stroke affect rates of various diagnosed dementias in the US elderly in recent decades?

**Materials and Methods**

**Subjects**

The NLTCs is a survey designed to measure health status, functional limitations, disability, and the use of long-term care among the elderly Americans. It contains longitudinal and cross-sectional data on a nationally representative sample of 41,947 US elderly persons (from Medicare enrollees) who were aged ≥65 years at enrollment. The surveys were conducted in 1982, 1984, 1989, 1994, and 1999, with 17,000 to 20,000 age-eligible survivors at each of 5 rounds. At the time of each new survey, a cohort sample of about 5000 persons passing their 65th birthday in the prior 5 years was added to the surviving sample to replace the deaths occurring since the prior survey and to ensure that the new sample was representative of the entire elderly population aged 65 and over in the respective year. In total, there are 17,250 males (41%), 24,673 females (59%), 38,011 whites (91%), 3,152 blacks (8%) and 784 persons of other race (2%) in all 5 waves of the NLTCs.

Each NLTCs participant is linked to Medicare records, containing information on Part A and B claims. Part A refers to the Medicare insurance program that covers inpatient hospital care, posthospital skilled nursing care, home health services, and hospice care for aged and disabled individuals who meet the eligibility requirements. Part B pays for physicians’ services, outpatient hospital care, durable medical equipment, and some medical services that are not covered by Part A (for more information see: http://www.medicare.gov/; http://www.cms.hhs.gov/). Diagnostic information was not available on Part B records until 1991. The quality of information for Part A inpatient (IP) claims was sufficient for the entire study period (1984–2001). That is, only 0.18% of IP records contained missing data on ICD-9-CM diagnostic codes in 1984, and <0.1% of records contained the missing data in the other years. Hence, in our study we only used IP claims to obtain the information on diagnoses assigned to the NLTCs participants during hospital stay. In total, about 380,000 person-years were represented in our data (supplemental Tables I and II, available online at http://stroke.ahajournals.org).

We did not use sample weights in our analyses. The weights were available for the years 1982, 1984, 1989, 1994, and 1999. However, the weights were not available for the years between the surveys. In our study, we had to calculate the rates of Medicare diagnoses for each of the years between 1984 and 2001. Therefore, for consistency of estimates through the entire study interval (1984–2001), we did not use sample weights and calculated nonweighted rates for each study year.

**Diagnoses of Stroke and Dementia**

We used the ICD-9-CM diagnostic codes (downloaded from ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Publications/ICD9-CM/2003). The history of changes in ICD-9-CM codes was tracked to evaluate possible influences on the analyses of data using “Conversion Table of New ICD-9-CM Codes, October 2004” (downloaded from http://www.cdc.gov/nchs/data/icd9/iccdcm05.pdf). There was only 1 change in ICD-9-CM codes that could affect our analyses. The code 438.0 (Cerebrovascular disease–related cognitive deficit) was introduced on 10/01/1997. Before then, this diagnosis was represented by a combination of 2 codes: 294.9 & 438. Two individuals in our database had such a combination before 10/01/1997. They were counted as diagnosed with cerebrovascular disease–related dementia (CBVD) and were included in calculations of respective rates.

The stroke sample consisted of persons with a principal ICD-9-CM diagnosis of stroke (436), acute intracranial hemorrhage (431), or iatrogenic cerebrovascular infarction or hemorrhage/postoperative stroke (997.02). We considered 3 groups of individuals with newly diagnosed dementia, according to the ICD-9-CM codes: (1) Alzheimer disease (AD)-331.0 (Alzheimer disease) or 290.1 (Presenile dementia) codes; (2) CBVD-290.4 (Vascular dementia: multi-infarct, arteriosclerotic dementia) or 438.0 (cerebrovascular disease–related cognitive deficit) codes; and (3) Senile Dementia-290.0, 290.2, 290.3, 290.4, 290.8, 290.9, 331.2, or 310.1 codes. The latter group represents various cases of senility with mental deterioration. We computed dementia rates for these groups defining them to be mutually exclusive diagnoses. That is, if the person had an AD, she or he was assigned to the AD group, regardless of possible presence of other dementia diagnoses. Individuals diagnosed with both CBVD and senile dementias were classified as having CBVD. Finally, persons diagnosed with senile dementia alone (ie, without AD or CBVD) were placed in the senile dementia category. Thus, in respective calculations of dementia rates, a person was counted only once. We separated diagnoses of AD and CBVD from the rest of dementias (“senile”) aiming to reduce the heterogeneity in the AD and CBVD groups rather than to specify senile dementias as a homogeneous diagnosis.

**Statistical Analyses**

We evaluated rates of occurrence of first stroke and newly diagnosed dementia after stroke—by beneficiary age, and survival after stroke—by duration since the stroke onset. The date of a disease onset was the first date after the admission for which an IP claim was found. Rates of dementia after stroke were calculated for 1 year after the first admission for stroke. Persons with dementia diagnosis assigned before stroke event were excluded from the analyses of dementia risks after the stroke. We also calculated rates of dementia per year for persons without stroke. Confidence intervals for the rates and significance of differences between the rates at different ages were evaluated using standard asymptotic formulae for the binomial probabilities. To compute age-standardized rates, we used data on 1999 US 65 and over population stratified by age in 5-year intervals and by gender from the US Bureau of the Census data, (http://www.census.gov), assessed August 1, 2005.

**Results**

There was slight increase in age-adjusted rates of stroke appearance from 1984–1990 to 1991–2001 (from 0.0066 to 0.008; P = 0.08). Changes in the rate by age are shown in

**Figure 1.** Age-specific rate (±SE) of first stroke diagnosis at different years.
Figure 1. Survival at 1 year after first diagnosed stroke increased significantly ($P<0.0001$) from 53% to 65% from 1984–1990 to 1991–1996 (Figure 2). The change in 1-year survival accounted for almost all the improvement in survival through 5 years after stroke. Mortality among stroke survivors remained very high; however, during 1991 to 1996, by 5 years after admission for stroke, about 65% had died. Note that the survival functions were limited by 1996 (not 2001) because we needed 5-year follow-up after the stroke onset to calculate these functions.

Age-adjusted rates of newly diagnosed dementia in the entire NLTCS sample rose from 0.0062 to 0.0095 ($P<0.001$) from 1984–1990 to 1991–2000 (Table). Age-specific (non-standardized) rates for different types of dementia increased over time in the entire sample as well (Figure 3). The most substantial absolute increase in the rates was observed for AD (Figure 3a). Increases in CBVD and senile dementia were less pronounced (Figure 3b and 3c).

Overall risk of dementia was much higher (up to 10 times) during 1 year after stroke as compared with stroke-free population (Table; Figure 4). This excess in risk was statistically significant (at 0.05 level) for all ages during 1991 to 2000, and for ages between 70 and 90 during 1984 to 1990.

Age-adjusted rates of poststroke dementia increased from 0.043 during 1984 to 1990 to 0.080 during 1991 to 2000 (Table). The greatest (almost 4-fold) relative increase was observed for CBVD developing after stroke (95% CI [1.83, 7.41]; Table 1). For persons who did not have a stroke, the overall rate of dementia has also increased (from 0.0061 in 1984 to 1990 to 0.0084 in 1991 to 2000; $P=0.024$), although the relative increase was less substantial than for stroke patients (1.38 and 1.87, respectively; Table). Rates of dementia among the elderly without stroke rose largely attributable to increases in rates of AD (Table). There were comparable relative increases in the rates of AD among stroke patients and in stroke-free population during the study period (1.64 and 1.55, respectively). For senile dementia alone, the increases in rates from 1984–1990 to 1991–2000 were small and statistically not significantly different in individuals with and without stroke (the relative increase was 1.1 and 1.19, respectively; Table).

**Discussion**

Our study demonstrated that stroke rates did not change significantly over time, whereas the risk of dementia after stroke substantially increased. The CBVD accounted for almost all the relative increase in dementia risks among individuals with stroke (Table). The improved survival from stroke might contribute to this trend. The improved survival

<table>
<thead>
<tr>
<th>Disease/Year</th>
<th>Rate</th>
<th>SE</th>
<th>Rate</th>
<th>SE</th>
<th>Rate</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stroke, 1 y</td>
<td>Nonstroke</td>
<td>Entire Sample</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. AD</td>
<td>0.0174</td>
<td>0.0099</td>
<td>0.0027</td>
<td>0.0004</td>
<td>0.0026</td>
<td>0.0004</td>
</tr>
<tr>
<td>1991–2000</td>
<td>0.0285</td>
<td>0.0105</td>
<td>0.0041</td>
<td>0.0004</td>
<td>0.0045</td>
<td>0.0004</td>
</tr>
<tr>
<td>RI*</td>
<td>1.64</td>
<td>(0.95, 2.82)</td>
<td>1.55</td>
<td>(1.37, 1.75)</td>
<td>1.72</td>
<td>(1.53, 1.93)</td>
</tr>
<tr>
<td>2. CBVD (not AD)</td>
<td>0.0084</td>
<td>0.0070</td>
<td>0.0008</td>
<td>0.0003</td>
<td>0.0009</td>
<td>0.0003</td>
</tr>
<tr>
<td>1991–2000</td>
<td>0.0310</td>
<td>0.0113</td>
<td>0.0010</td>
<td>0.0002</td>
<td>0.0015</td>
<td>0.0002</td>
</tr>
<tr>
<td>RI</td>
<td>3.68</td>
<td>(1.83, 7.41)</td>
<td>1.26</td>
<td>(1.0, 1.58)</td>
<td>1.63</td>
<td>(1.33, 1.98)</td>
</tr>
<tr>
<td>3. Senile dementia (not AD and not CBVD)</td>
<td>0.0183</td>
<td>0.0083</td>
<td>0.0031</td>
<td>0.0004</td>
<td>0.0033</td>
<td>0.0004</td>
</tr>
<tr>
<td>1991–2000</td>
<td>0.0133</td>
<td>0.0120</td>
<td>0.0026</td>
<td>0.0006</td>
<td>0.0026</td>
<td>0.0005</td>
</tr>
<tr>
<td>RI</td>
<td>1.1</td>
<td>(0.61, 1.99)</td>
<td>1.19</td>
<td>(1.05, 1.36)</td>
<td>1.25</td>
<td>(1.1, 1.41)</td>
</tr>
<tr>
<td>4. All dementias (AD + CBVD + senile)</td>
<td>0.0166</td>
<td>0.0102</td>
<td>0.0026</td>
<td>0.0006</td>
<td>0.0026</td>
<td>0.0005</td>
</tr>
<tr>
<td>1991–2000</td>
<td>0.0133</td>
<td>0.0083</td>
<td>0.0031</td>
<td>0.0004</td>
<td>0.0033</td>
<td>0.0004</td>
</tr>
<tr>
<td>RI</td>
<td>1.1</td>
<td>(0.61, 1.99)</td>
<td>1.19</td>
<td>(1.05, 1.36)</td>
<td>1.25</td>
<td>(1.1, 1.41)</td>
</tr>
</tbody>
</table>

*RI indicates relative increase (95% CIs in parentheses) in the rate of various dementias from 1984–1990 to 1991–2000.
could favor an increase in the proportion of people with more severe brain damage who otherwise would have died in the past. Such persons might be more predisposed to dementia.

The small relative increase in rates of senile dementia over time (Table) suggests that no major environmental changes occurred that might have affected rates of dementia for this group (representing mixed cases of elderly mental deterioration that are not AD or CBVD). Expanding use of brain protective medications among the elderly during recent decades suggests that there may even be protective factors against dementia in population. Relevant studies are, however, limited and do not allow to draw reliable conclusions about this potential influence.

The similarity of the relative increases in rates of AD among persons with and without stroke (Table) suggests that factors other than survival from stroke contributed to the change in rates of AD over time. Possible factors include improved diagnostic procedures for AD, increasing popularity of the diagnosis, and an increase in AD risk in elderly individuals in an association with some other disorders. Relative contributions of these factors in increased rates of AD are, however, not clear.

Comparisons With Other Studies
Comparing our findings with those of previous studies is complicated by differences in follow-up periods, variations among countries, and in observational periods. Our analyses show that the chances of an elderly person being admitted for a stroke did not change significantly from 1984–1990 to 1991–2001, whereas the probability of surviving a year after admission for stroke substantially increased from 1984–1990 to 1991–1996. In an earlier (1994) Medicare claims study, stroke incidence declined 9.5% from 1985 to 1989, and then increased 3.3% to 1991. The authors, however, used a broader list of ICD-9-CM codes that included chronic cerebrovascular disorders as well. Survival after stroke based on the US studies improved between 1982 and 1996 that is in accordance with our data. Similar to others, our study showed substantial (several-fold) excess in risk of dementia among stroke patients compared with stroke-free population. The general increase in diagnosed AD has been reported previously, and it is also shown in present study. Because the higher rates of AD onset were not limited to persons after stroke in our study, there are clearly general factors accounting for the increased rates of the diagnosis.

Strengths and Limitations
Our study has several strengths. Time trends for different kinds of dementia after stroke were evaluated for the first time and compared with the trends in dementia onset in a nonstroke population. This allowed us to evaluate the relative contribution of the different kinds of mental impairment to the increased risk of overall dementia and suggest factors responsible for observed trends. Another important strength is
the study’s national scope of the data, which is representative of the US elderly.

We also acknowledge several study limitations. First, we measured rates of dementia from diagnoses reported in Medicare claims. There is likely to be variation in the criteria and clinical evidence used by physicians to make a dementia diagnosis which affects clinical decision making, e.g., treatment of acute myocardial infarction and personal health care expenditures more generally. Second, limiting the study to Medicare Part A inpatient claims plausibly led to an underestimate of rates of diagnosed dementia. However, the study objective was to measure time trends in the rates of diagnosed dementia rather than to estimate “true” incidence. To determine the trends reliably, we limited our analysis to the IP records. Third, all study participants were Medicare beneficiaries, and a selection bias could have arisen because of the differential access to the Medicare system according to race, socio-economic status, education, and income. Finally, there may have also been differential underreporting (e.g., severe stroke patients are more likely to be readmitted and thus could more likely be identified as having dementia than those with milder strokes).

**Summary**

Mortality from stroke declined mainly because of declining stroke case-fatality. At the same time, rates of diagnosed dementia increased appreciably from 1984–1990 to 1991–2000. The relative increase was larger for persons with stroke compared with stroke-free population (Table). Improved survival from stroke might contribute to this difference in trends. The increase in risk of dementia in stroke-free population was largely attributable to AD (Table).

The increasing trend in dementia recorded in Medicare claims data may have occurred for several reasons, including a true increase in underlying risk or an increase in case identification or diagnosis popularity. More studies are needed to identify actual reasons for the increasing rates of diagnosed dementia in the US elderly.

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