Trends in Survival and Recovery From Stroke
Evidence From the National Long-Term Care Survey/Medicare Data

Anatoli Yashin, ScD; Igor Akushevich, PhD; Svetlana Ukrainseva, PhD; Lucy Akushevich, MS; Konstantin Arbeev, PhD; Alexander Kulminski, PhD

Background and Purpose—Improvements in recovery rates may contribute to an increase in healthy life expectancy. It is unclear, however, whether such changes take place because health researchers traditionally deal with changes in incidence and survival from diseases. The purpose of this study was to test for the presence of time trends in the recovery rate from stroke.

Methods—We compared age patterns of recovery rates from stroke evaluated in 2 subcohorts represented in the National Long-Term Care Survey data linked with the Medicare service use files.

Results—We found a statistically significant increase in recovery rate between 1994 and 1999 for females but not for males.

Conclusions—Time trends in recovery rate from stroke exist and can be detected from available data. The roles of influential factors and causes of sex difference in recovery improvement deserve further studies. (Stroke. 2010;41:563-565.)

Key Words: recovery trends ■ sensitivity analyses ■ healthy life span ■ compression of morbidity ■ survival after stroke

Despite the noticeable decline in mortality from stroke between 1981 and 2004, the causes of this decline remain controversial.1-5 Earlier, we found that survival from stroke significantly improved while the incidence rate almost did not change between 1984 and 2001 among the US elderly.4,5 A recent study6 provided evidence that long-term outcome after first ischemic stroke depends on the quality of treatment and subsequent rehabilitation, indicating that under appropriate conditions, functional recovery from stroke is possible. Improvements in recovery from disease would contribute to increasing the quality of life for stroke victims by increasing their healthy life span. At the population level, the progress in recovery would reduce disease burden and contribute to public health improvement. To our knowledge, no studies of temporal changes in the recovery rate from stroke have been performed so far. In this article, we introduce a working definition of recovery from stroke, evaluate time trends in recovery rates, and investigate the sensitivity of findings to different factors, including variable definitions of recovery and incidence rates and age and comorbidity structures in compared cohorts from Medicare files linked with the National Long-Term Care Survey (NLTCS) data.

Data and Methods
The NLTCS file contains longitudinal and cross-sectional data on a nationally representative sample of ~49 000 US elderly persons age 65+ years. All NLTCS records are linked to Medicare data for 1982 to 2005 to allow for tracking mortality, morbidity, and health maintenance organization (HMO) enrollment/disenrollment. Individual medical histories of stroke, including information on life span, were reconstructed from Medicare files linked with the NLTCS data, from records containing respective ICD-9 codes (431.xx, 433.x1, 434.x1, and 436.xx), and ages at onset of stroke and subsequent recovery were identified. Then, 2 cohorts of patients having the disease onset between 1994 to 1996 and 1999 to 2001 were formed to investigate time trends in recovery rates. Patients in these 2 cohorts were followed up until death or the recovery event. An individual was considered to be in recovery (or sustained remission) if he/she did not have a Medicare record containing the respective ICD code(s) during 1 year after the last inpatient or outpatient visit related to this disease. Age at death that happened before recovery and ages of the last available data (at the end of 2005) were treated as censoring variables for the recovery time.

Survival and not-yet-recovery (ie, the analog of survival function constructed for recovery events) functions were calculated with the Kaplan–Meier approach. The difference between survival functions in the 2 subcohorts was tested with the log-rank test.

Results
The analyses revealed statistically significant improvement in the recovery rate between 1994 and 1999 for females but not for males. The Figure (left) shows the graphs of the 2 not-yet-recovery functions constructed from 2 recovery rates evaluated for patients with stroke in the 2 (1994 to 1996 and 1999 to 2001) subcohorts for males and females. This Figure shows that the respective recovery rate is higher for the 1999 to 2001 subcohort than for the 1994 to 1996 subcohort. The total numbers of subjects in each subcohort, the percentages of recovery and censored events, and the median values with respective 95% CIs are shown in the tables below the graphs.
The survival functions after stroke (where the occurrences of recovery were treated as censoring times) for the same subcohorts did not reveal substantial changes during the 5-year period for each sex (right panel of the Figure). Together with the results shown in the left panel of the Figure, these indicate that progress in coping with the disease was mainly due to changes in recovery from this disease in females.

Sensitivity Analyses
To test the sensitivity of our findings to different factors capable of affecting trends in recovery rate, we repeated our calculations with (1) several different operational definitions of recovery and incidence rates; (2) explicit representation of observed heterogeneity effects stratifying individuals on age, comorbidity (Charlson index\textsuperscript{7}), or disability (the numbers of self-reported activities of daily living/instrumental activities of daily living); and (3) other approaches to censoring strategies, selection of individuals, and study design effects. The results of the analyses, presented in the Table for both sexes, indicate that positive trends in the recovery rate from stroke took place in all cases independent of the definition of such rates. One source of bias in findings could be partial coverage by an HMO, which may reduce the number of stroke diagnoses in Medicare records. In our calculations, this source of uncertainty could be important because the fraction of coverage by an HMO is different for the 2 considered time periods. Therefore, in 1994, the fraction of person-months additionally covered by an HMO was at the level of 3% to 5%, whereas in 1999 the fraction exceeded 15%.

Note that the definition of recovery index used in this article does not take into account some important factors affecting the recovery rate, such as rehabilitation therapy. These details, however, were not among the goals of this study, which was focused on detecting the presence of positive trends in the recovery from stroke. An important property of our results is that they are robust to changes in definitions of recovery or incidence events, as well as to many other potential confounders. Note that the estimate of an increase in healthy life span would be more sensitive to the definitions of incidence and recovery events.

Conclusions
Time trends in the recovery rate from stroke exist and can be detected from available data. The detected sex difference in such trends may partly be caused by different attitudes toward the use of health care services in males and females,\textsuperscript{8} as well as a small time difference between compared subcohorts. Note that sex differences are also documented in stroke incidence and case fatality.\textsuperscript{8} More studies are needed to evaluate the changes in the quality of life in poststroke individuals.
Sources of Funding
This study was supported by NIA/NIH grants R01AG027019, R01AG028259, and R01AG032319. The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIA or NIH.

Disclosures
None.

References

Table. Results of Sensitivity Analysis

<table>
<thead>
<tr>
<th>Females</th>
<th>Median, y</th>
<th>Males</th>
<th>Median, y</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base calculation</td>
<td>261,206 0.0009 0.64 0.29</td>
<td>142,115 0.8132 0.39 0.17</td>
<td></td>
</tr>
</tbody>
</table>

Approaches to identification of recovery events
- Time to recovery (1.5 y): 237,192 0.0049 1.05 0.36 135,109 0.9988 0.69 0.41
- Time to recovery (0.5 y): 286,223 0.0043 0.34 0.21 155,129 0.9686 0.24 0.17
- Alzheimer disease and dementia: 261,206 0.0178 0.61 0.41 142,115 0.4345 0.69 0.42

Approaches to identification of incident cases
- All Medicare sources used: 286,221 0.0013 0.64 0.31 159,125 0.6977 0.39 0.24
- Keeping not only primary diagnoses: 323,269 0.0009 0.49 0.24 182,145 0.8476 0.36 0.09
- No requirement of second visit: 523,416 0.0111 0.09 0.05 276,242 0.4220 0.05 0.01
- Acceptable lag of prediagnosis=0.5 y: 261,206 0.0009 0.64 0.29 146,117 0.8363 0.39 0.20
- Only 436 ICD-9 code included: 228,182 0.0017 0.61 0.25 123,90 0.8276 0.39 0.24
- Exclude hemorrhagic (ie, 431) stroke: 258,202 0.0016 0.62 0.29 141,109 0.7406 0.39 0.25
- Only hemorrhagic (ie, 431) stroke: 13,14 0.5680 0.016 0.063 10,12 0.1711 0.227 0.027
- Include ICDs 430–432: 261,206 0.0178 0.61 0.41 142,115 0.4345 0.69 0.42
- Exclude not completely covered: 229,188 0.0041 0.61 0.27 136,108 0.5108 0.39 0.14

Factors of observed heterogeneity
- 65<age<72: 56,43 0.0140 0.61 0.21 31,31 0.4543 0.25 0.32
- 73<age<84: 139,110 0.0096 0.72 0.30 95,66 0.8493 0.39 0.20
- 85<age: 66,53 0.4828 0.61 0.24 16,18 0.3374 0.15 0.09
- Charlson Index=0: 107,77 0.0522 0.61 0.24 55,36 0.9565 0.18 0.23
- 1<Charlson Index<3: 120,95 0.0232 0.76 0.36 66,56 0.7897 0.46 0.14
- Charlson Index<4: 34,34 0.1317 0.61 0.25 21,23 0.8836 0.79 0.25
- Disability group=1: 143,128 0.0007 0.60 0.24 97,87 0.4733 0.39 0.13
- Disability group=2: 47,27 0.0504 1.01 0.21 22,13 0.4767 0.13 0.28
- Disability group=3: 71,51 0.9775 0.80 0.90 23,15 0.5246 1.32 1.49

Censoring strategies
- Cases of death are recovery cases: 261,206 0.0059 0.50 0.25 142,115 0.4704 0.39 0.16
- Cases of death are never recovered: 346,278 0.0478 2.61 0.93 194,154 0.5400 1.20 1.17

Enrollment from Medicare and coverage by HMO
- All covered by HMO are included: 284,215 0.0125 0.61 0.33 149,124 0.8593 0.37 0.17
- Fraction of HMO enrollment<0.3: 264,209 0.0015 0.62 0.31 145,118 0.9811 0.39 0.17

Study design effect
Using NLTCs weights: 472,524,427 500 0.62 0.31 270,628,255 493 0.39 0.13

N94 and N99 show the size of the cohorts of respective years.

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*Stroke*. 2010;41:563-565; originally published online January 21, 2010; doi: 10.1161/STROKEAHA.109.572339

*Stroke* is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
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Print ISSN: 0039-2499. Online ISSN: 1524-4628

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