Preventable Readmissions Within 30 Days of Ischemic Stroke Among Medicare Beneficiaries

Judith H. Lichtman, PhD; Erica C. Leifheit-Limson, PhD; Sara B. Jones, MPH; Yun Wang, PhD; Larry B. Goldstein, MD

Background and Purpose—The Centers for Medicare and Medicaid Services proposes to use 30-day hospital readmissions after ischemic stroke as part of the Hospital Inpatient Quality Reporting Program for payment determination beginning in 2016. The proportion of poststroke readmissions that is potentially preventable is unknown.

Methods—Thirty-day readmissions for all Medicare fee-for-service beneficiaries aged ≥65 years discharged alive with a primary diagnosis of ischemic stroke (International Classification of Diseases, Ninth Revision, Clinical Modification 433, 434, 436) between December 2005 and November 2006 were analyzed. Preventable readmissions were identified based on 14 Prevention Quality Indicators developed for use with administrative data by the US Agency for Healthcare Research and Quality. National, hospital-level, and regional preventable readmission rates were estimated. Random-effects logistic regression was also used to determine patient-level factors associated with preventable readmissions.

Results—Among 307,887 ischemic stroke discharges, 44,379 (14.4%) were readmitted within 30 days; 5,322 (1.7% of all discharges) were the result of a preventable cause (eg, pneumonia), and 39,057 (12.7%) were for other reasons (eg, cancer). In multivariate analysis, older age and cardiovascular-related comorbid conditions were strong predictors of preventable readmissions. Preventable readmission rates were highest in the Southeast, Mid-Atlantic, and US territories and lowest in the Mountain and Pacific regions.

Conclusions—On the basis of Agency for Healthcare Research and Quality Prevention Quality Indicators, we found that a small proportion of readmissions after ischemic stroke were classified as preventable. Although other causes of readmissions not reflected in the Agency for Healthcare Research and Quality measures could also be avoidable, hospital-level programs intended to reduce all-cause readmissions and costs should target high-risk patients. (Stroke. 2013;44:00-00.)

Key Words: outcome assessment (health care) ■ patient readmission

Stroke is common, costly, and potentially devastating. There are an estimated 6.8 million stroke survivors in the United States, with ≈795,000 new and recurrent strokes identified annually.1 Stroke is one of the 10 highest contributors to Medicare costs, and among the elderly, is a leading cause of hospitalization. Reducing readmission rates is a goal of national healthcare reform.2,3 Risk-standardized readmission rates after hospital discharge are publically reported by the Centers for Medicare and Medicaid Services (CMS) and are being used as an indicator of the quality and efficiency of hospital-level care for cardiovascular conditions and pneumonia.2,4 Although high readmission rates may, in part, reflect unresolved problems at discharge or the quality of immediate posthospital care, they may also reflect a more chronically ill population, social or economic issues, or a combination of these factors.5 With the passage of the Patient Protection and Affordable Care Act, CMS is holding hospitals accountable for excessive readmission rates by assessing financial penalties on the basis of their performance using risk-adjusted measures (ie, reduced reimbursements to hospitals with readmission rates in excess of their expected rate). In 2013, nearly three-quarters of hospitals in the United States (US) were subject to such penalties.5 CMS proposes to use a hospital-level 30-day risk-standardized all-cause readmission measure for ischemic stroke in the Hospital Inpatient Quality Reporting Program for payment determination beginning in 2016.6 Hospitals caring for patients with stroke will be faced with the challenges of meeting this performance goal to avoid payment reductions. An underlying premise of the program is that readmissions can be reduced by improving quality of care during the acute hospitalization, discharge planning, and care transitions. However, studies of non–stroke-specific conditions show that...
a small subset of readmissions is potentially preventable and that many of the causes of readmissions may be outside of a hospital’s control, raising concern about using all-cause readmission metrics.7–9 Comparable studies have not been conducted for patients hospitalized with stroke. Our primary aim was to estimate national rates of preventable readmissions after ischemic stroke using widely available, evidence-based measures developed by the US Agency for Healthcare Research and Quality (AHRQ; eg, unrecognized aspiration pneumonia, urinary tract infections, and uncontrolled diabetes mellitus, which might have been addressed during the initial hospitalization). We hypothesized that a small proportion of readmissions within 30 days after discharge for ischemic stroke would be preventable according to the AHRQ measures. Because there are hospital-level differences in 30-day all-cause readmissions after ischemic stroke10,11 and geographic differences in readmissions for recurrent stroke,12,13 we also hypothesized that preventable readmission rates would vary among hospitals and across geographic regions. As a secondary aim, we identified patient characteristics associated with increased risk of 30-day readmission for a preventable condition after discharge for ischemic stroke.

Methods

Study Population

The study included all Medicare fee-for-service beneficiaries aged ≥65 years hospitalized with a principal discharge diagnosis of ischemic stroke (International Classification of Diseases, Ninth Revision, Clinical Modification [ICD-9-CM] codes 433, 434, 436) from December 1, 2005, to November 30, 2006. Data were obtained from the Medicare Provider Analysis and Review files and included demographic information, primary and secondary discharge diagnosis codes, and procedure codes for each hospitalization. To ensure complete claims history and readmission information, only patients with ≥12 continuous months of Medicare fee-for-service enrollment before and 1 month after the index hospitalization were included in analyses.2,3,6,10,11,14 Beneficiaries aged <65 years were excluded because these patients do not represent typical Medicare patients. We further excluded patients who died during the index admission, were discharged from nonacute care facilities, were transferred to another acute care facility, left the hospital against medical advice (because providers would not have had the opportunity to deliver intended care), or were discharged within 1 day of admission (because they were unlikely to have had an ischemic stroke). We randomly selected 1 ischemic stroke hospitalization for patients with multiple ischemic stroke admissions during this time period (each discharge represents a unique individual).

Medicare data were protected through a data use agreement with CMS. The Yale Human Investigation Committee approved an exemption for the use of CMS data for research analyses and publication.

Patient and Regional Characteristics

To adjust for differences in case-mix, preexisting comorbidities were identified using the principal and secondary discharge codes from claims submitted in the year before the index hospitalization and from claims from the index admission for conditions that would not represent an acute stroke complication (ie, conditions that would not reflect stroke-related quality of care; eg, hypertension or diabetes mellitus). The >15 000 ICD-9-CM codes were grouped into clinically coherent categories using the Hierarchical Condition Categories, a system developed by physician and statistical consultants under contract to CMS.13 Candidate covariates for risk prediction models were considered based on previous models for 30-day readmission after ischemic stroke.10,11 Geographic region was categorized into 9 regions (New England, Mid-Atlantic, South Atlantic, East North Central, East South Central, West North Central, West South Central, Mountain, and Pacific) and territories (Puerto Rico and Virgin Islands) defined by the US Census. We also evaluated geographic patterns according to hospital referral region (HRR), a classification system developed to represent regions of healthcare service use in which the majority of residents both live and receive health care.14 There were 306 HRRs in 2006.

Outcomes

Preventable readmissions were defined according to the AHRQ Prevention Quality Indicators (PQIs).17 The PQIs are a set of evidence-based measures, developed and maintained by AHRQ, that use hospital inpatient administrative data to identify avoidable hospitalizations for ambulatory care sensitive conditions. The PQIs are part of the AHRQ Quality Indicators software modules and are publicly available (qualityindicators.ahrq.gov). The 14 individual PQI measures are endorsed by the National Quality Forum and are widely used to assess quality of care.14–22 The PQIs include common ambulatory care sensitive conditions, many of which (eg, pneumonia and urinary tract infection) are often cited as reasons for readmission after stroke.10,14,26 Our analyses of preventable readmissions included PQIs relevant to patients aged ≥65 years: chronic lung condition indicators (chronic obstructive pulmonary disease and adult asthma), diabetes mellitus–related indicators (diabetes mellitus, short-term complications; diabetes mellitus, long-term complications; and uncontrolled diabetes mellitus), cardiovascular-related indicators (hypertension; congestive heart failure; and angina without procedure), and acute condition indicators (dehydration; bacterial pneumonia; and urinary tract infection).

Only the first readmission was considered for analyses of cases in which the index stroke discharge was followed by ≥1 readmission within 30 days. Consistent with prior 30-day risk-standardized readmission measures for ischemic stroke, we excluded readmissions for procedures that may represent planned continuation of treatment after discharge unless ICD-9-CM 433.x1 or 434.x1 (acute ischemic stroke) was listed as the principal discharge diagnosis for the readmission.10 Planned readmissions were determined a priori and included carotid endarterectomy, carotid stenting, percutaneous carotid or vertebral artery stenting, intracranial stenting, patent foramen ovale closure, cardiac ablation procedures, aortic or mitral valve replacement, and cranioplasty.

Statistical Analysis

We used the Wilcoxon rank-sum test to compare patient characteristics between the readmitted and admission-free groups and for comparisons stratified by region. We used Kaplan–Meier methods to estimate the observed all-cause and preventable readmission rates within 30 days of the index hospital discharge, censoring for deaths. We developed a random-effects logistic regression model with Markov Chain Monte Carlo simulations to identify patient characteristics associated with preventable readmissions. Posterior probabilities for each covariate were estimated on the basis of the proportion of simulations in which the covariate was significantly associated with the outcome in the logistic model using c=0.05 to determine significance. Variables selected for the final risk-adjusted model had posterior probabilities >0.85 (or <0.15 for covariates with estimates <1.0). The c-statistic was used to assess model discrimination. We used Cox proportional hazards regression to estimate the hazard ratio of each selected variable associated with preventable readmissions. We then used a mixed logistic model with hospital-specific random intercepts to calculate hospital-level 30-day risk-standardized preventable readmission rates, using variables selected from the initial logistic model. This approach simultaneously models 2 levels (patient and hospital) to account for variation in patient outcomes within and between hospitals. Using the hospital-level risk-standardized rates, we fitted the mixed model with region-specific random intercepts to obtain risk-standardized preventable readmission rates for the 9 Census regions.
and US territories. Similarly, we fitted the mixed model with HRR-specific random intercepts to obtain HRR-specific risk-standardized preventable readmission rates. We then classified each HRR into 3 mutually exclusive groups: significantly higher, same as, and significantly lower than the national average. Analyses were conducted using SAS version 9.3 (SAS Institute Inc, Cary, NC). Statistical testing was 2-sided at a significance level of \( \alpha=0.05 \).

**Results**

The study included 307,887 discharges for ischemic stroke among Medicare fee-for-service beneficiaries. Of these, 44,379 (14.4%) were followed up by a readmission within 30 days (5322 [1.7% of all discharges] resulted in a 30-day readmission for conditions categorized as preventable and 39,057 [12.7%] were for other reasons); 11.9% of all readmissions were for a preventable cause. Patients readmitted for a preventable cause were more likely to be women, older, and of black race than patients not readmitted or readmitted for other conditions (Table 1). They also had an increased prevalence of cardiovascular-related comorbid conditions, including congestive heart failure, myocardial infarction, diabetes mellitus, and renal failure. Patients with a preventable readmission had a longer length of stay for the index stroke and were more likely to be discharged to a skilled nursing or intermediate care facility. Patient-level proportional hazards analyses confirmed that older age, female sex, and having comorbid conditions often associated with stroke or cardiovascular disease were associated with an increased likelihood of being readmitted for a preventable reason (Table 2).

Hospitals had a median of 2 preventable readmissions within 30 days (interquartile range, 1–4) and a median of 21 all-cause readmissions (interquartile range, 11–35). The distribution of hospital-level 30-day risk-standardized preventable readmission rates varied across hospitals (Figure 1). Compared with the national average (1.7%), patient-level rates of preventable readmissions were classified into 3 mutually exclusive groups: significantly higher, same as, and significantly lower than the national average. Analyses were conducted using SAS version 9.3 (SAS Institute Inc, Cary, NC). Statistical testing was 2-sided at a significance level of \( \alpha=0.05 \).

**Table 1. Characteristics of Medicare Fee-for-Service Beneficiaries Discharged Alive After Hospitalization for Ischemic Stroke by 30-Day Readmission Status**

<table>
<thead>
<tr>
<th>Patient Characteristic</th>
<th>Preventable Readmission</th>
<th>Other Readmission</th>
<th>No Readmission</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients discharged alive</td>
<td>5322</td>
<td>39,057</td>
<td>263,508</td>
</tr>
<tr>
<td>Age, y; mean±SD</td>
<td>79.5±7.7</td>
<td>78.6±7.6</td>
<td>78.2±7.7</td>
</tr>
<tr>
<td>65–74</td>
<td>28.3</td>
<td>32.1</td>
<td>34.4</td>
</tr>
<tr>
<td>75–84</td>
<td>44.8</td>
<td>44.6</td>
<td>43.1</td>
</tr>
<tr>
<td>≥85</td>
<td>26.9</td>
<td>23.3</td>
<td>22.5</td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>16.9</td>
<td>12.6</td>
<td>9.5</td>
</tr>
<tr>
<td>Other</td>
<td>5.2</td>
<td>5.2</td>
<td>4.5</td>
</tr>
<tr>
<td>White</td>
<td>77.9</td>
<td>82.2</td>
<td>86.0</td>
</tr>
<tr>
<td>Women</td>
<td>59.1</td>
<td>53.8</td>
<td>55.0</td>
</tr>
<tr>
<td>Comorbid conditions and medical history</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Congestive heart failure</td>
<td>33.5</td>
<td>19.3</td>
<td>14.8</td>
</tr>
<tr>
<td>Myocardial infarction</td>
<td>2.3</td>
<td>1.5</td>
<td>1.0</td>
</tr>
<tr>
<td>Peripheral vascular disease</td>
<td>11.3</td>
<td>12.0</td>
<td>10.6</td>
</tr>
<tr>
<td>Unstable angina</td>
<td>0.9</td>
<td>0.7</td>
<td>0.5</td>
</tr>
<tr>
<td>Atherosclerosis</td>
<td>33.8</td>
<td>31.2</td>
<td>30.6</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>35.8</td>
<td>29.7</td>
<td>27.9</td>
</tr>
<tr>
<td>Cerebrovascular disease</td>
<td>30.3</td>
<td>33.3</td>
<td>38.0</td>
</tr>
<tr>
<td>Protein-calorie malnutrition</td>
<td>3.2</td>
<td>3.1</td>
<td>1.6</td>
</tr>
<tr>
<td>Renal failure</td>
<td>17.4</td>
<td>10.1</td>
<td>6.1</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>8.1</td>
<td>7.9</td>
<td>4.7</td>
</tr>
<tr>
<td>Dementia</td>
<td>13.1</td>
<td>12.8</td>
<td>11.8</td>
</tr>
<tr>
<td>Anemia</td>
<td>12.4</td>
<td>11.1</td>
<td>8.3</td>
</tr>
<tr>
<td>Discharge disposition</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Home</td>
<td>31.2</td>
<td>36.2</td>
<td>46.4</td>
</tr>
<tr>
<td>Home care</td>
<td>14.9</td>
<td>12.5</td>
<td>11.1</td>
</tr>
<tr>
<td>Skilled nursing/intermediate care facility</td>
<td>34.7</td>
<td>30.7</td>
<td>21.6</td>
</tr>
<tr>
<td>Rehabilitation</td>
<td>14.9</td>
<td>15.9</td>
<td>14.1</td>
</tr>
<tr>
<td>Other†</td>
<td>4.3</td>
<td>4.7</td>
<td>6.9</td>
</tr>
<tr>
<td>Length of stay, d; mean±SD</td>
<td>6.3±6.1</td>
<td>5.9±5.8</td>
<td>4.4±4.3</td>
</tr>
</tbody>
</table>

* \( p<0.001 \) for all differences in characteristics across readmission groups.
† Includes approved swing bed, inpatient care, long-term care facility, and others.
readmissions were significantly higher in the Mid-Atlantic, East South Central, and US territories and lower in the West North Central, Mountain, and Pacific regions (Figure 2A). The variation across regions persisted in risk-standardized analyses, with considerable hospital-level variation between and within regions (Figure 2B). There was also regional variation in rates across the 306 HRRs (Figure 3). A total of 41 HRRs (13.4%) had risk-standardized preventable readmission rates that were significantly higher than the national average, accounting for 23% of total stroke discharges. In comparison, 28 HRRs (9.2%) had risk-standardized rates that were significantly lower than the national average, accounting for 8.2% of total stroke discharges.

### Discussion

We found that a small proportion of discharges after ischemic stroke resulted in a preventable readmission within 30 days according to AHRQ PQI criteria, but rates varied across the country. Several patient characteristics were associated with an increased risk of a preventable readmission. The results have implications for national healthcare policies that focus on all-cause readmissions as a strategy for improving quality of care and reducing costs.

A preventable readmission suggests that it could have been avoided by better care during the index hospitalization, improvements in discharge planning and follow-up care, or better transitions between inpatient and outpatient healthcare teams. If readmissions are to be used as an indicator of quality of care, it is important to differentiate preventable readmissions from those that may not be preventable. Our study found that 1.7% of hospital discharges for ischemic stroke resulted in readmissions for preventable conditions, and these readmissions occurred more frequently among individuals of advanced age, women, and those with a history of comorbid cardiovascular conditions. Our results suggest that targeting these high-risk patients for more intensive transition-of-care programs may help reduce readmissions.

A prospective cohort study that reviewed all urgent readmissions within 6 months after discharge at 11 hospitals found that <20% of urgent readmissions were potentially avoidable.9 Similarly, a systematic review identifying 34 studies of general, non–stroke-specific populations found a median proportion of 27% of readmissions were avoidable, but there was considerable heterogeneity among the reports (range, 5%–79%).8 Our finding that 11.9% of all readmissions after ischemic stroke were preventable according to the AHRQ PQIs is at the lower end of this range. In this prior systematic review, it was also noted that studies using administrative data tended to report higher proportions of avoidable readmissions than studies using medical record review or other methods.8 Accordingly, the small proportion of preventable readmissions in our Medicare claims data may represent an overestimate as compared with data derived from medical records.

Concern has been raised about the predictive capacity of models that calculate risk-standardized readmission rates for hospital comparison purposes. A systematic review found that among 26 models (several of which are currently being applied in clinical, research, and policy settings), most were poor predictors of readmissions.77 Approximately half of the models reviewed calculated risk-standardized readmission rates for hospital comparison purposes, and the other half were clinical models that identify high-risk patients for

![Figure 1. Distribution of hospital-level 30-day risk-standardized preventable readmission rates. The line bisecting the box and whisker plot above the distribution represents the median/50th percentile, the upper boundary of the box represents the 75th percentile, and the lower boundary represents the 25th percentile. The whiskers are set at the 5th and 95th percentiles, with circles representing outlying hospitals.](http://stroke.ahajournals.org/doi/fig/1)
whom transitional care interventions might be appropriate. The discriminative capacity of our model ($c=0.67$) is considered modest (suggesting reasonable predictive ability), but it is higher than those reported for all-cause readmission for other conditions using Medicare administrative data (range, 0.55–0.63). However, none of the studies included in the review were restricted to stroke.27

We found regional heterogeneity in the rates of preventable readmissions, with higher rates in the Southeast and Mid-Atlantic, that is, the stroke belt, and US territories. Rates were lower in the Mountain and Pacific regions. Reasons for these variations are likely multifactorial and could include patient-level factors (eg, medication compliance, socioeconomic status, and availability of resources) and system-level factors (eg, poor/inadequate care transitions, discharge planning, and physician follow-up after discharge). Other contributing factors may include hospital bed availability, composition of a hospital’s patient population, or resources of the surrounding community.28 A prior study did not find a difference in 30-day readmissions between critical access hospitals treating patients with ischemic stroke and other acute care hospitals, but it focused on all-cause rather than preventable readmissions.11 However, hospitals are not responsible for the socioeconomic status of the communities in which they are situated or the composition of their patient populations. These types of issues can only be addressed through support of programs that provide resources for community health and outpatient care.

One limitation of this analysis is that the classification of preventable readmissions based on AHRQ PQIs relies exclusively on administrative data and, therefore, may not completely identify all readmissions for unavoidable reasons (ie, not identify all relevant comorbid conditions or consider

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**Figure 2.** Thirty-day preventable readmission rates by US census regions and territories. **A**, Patient-level observed 30-day preventable readmission rates, with the reference line representing the national average observed preventable readmission rate of 1.7%. **B**, Hospital-level distribution of 30-day risk-standardized preventable readmission rates, with the reference line representing the national average risk-standardized preventable readmission rate of 1.7%. *Region-specific risk-standardized rate significantly higher than national average. †Region-specific risk-standardized rate significantly lower than national average. CI indicates confidence interval; EN, East North; ES, East South; WN, West North; and WS, West South.
other patient or clinician factors that might contribute to readmissions). Moreover, the AHRQ PQIs may not reflect all potentially preventable conditions related to the index stroke hospitalization. Future studies are needed to explore further causes of preventable readmissions for patients with ischemic stroke, as well as directly compare readmission rates based on chart abstraction with those based on administrative data. Stroke severity, an important predictor of mortality, is not available in claims data. Although available studies have not shown a similar independent association between stroke severity and readmissions, the possibility of such a relationship cannot be excluded. Functional dependence and social factors, such as marital status and living situation, may influence readmission rates but are unavailable in Medicare data. Because our model development was limited to beneficiaries aged ≥65 years, the results may not be applicable to those without Medicare fee-for-service coverage or to patients with stroke aged <65 years (however, the majority of strokes occur in patients ≥65 years of age). CMS claims data are not available for Medicare managed care enrollees that represent ≈19% of Medicare beneficiaries. Our data are from 2006; however, there have not been marked changes in readmission rates after ischemic stroke since this time. Finally, there may be regional differences in the threshold for admitting patients according to emergency department protocols, hospital bed availability, or coding practices that may explain some of the geographic heterogeneity in readmission rates.

Conclusions
We found that 14.4% of patients discharged after ischemic stroke were readmitted within 30 days, and 11.9% of these readmissions were avoidable according to AHRQ PQI measures. Identification of high-risk patients may allow targeting of specific interventions. Efforts to reduce 30-day all-cause readmission rates after ischemic stroke primarily focused on hospital-level care, however, may have limited effect because the number of potentially preventable readmissions based on AHRQ measures is small, the reasons for readmissions are diverse, and many may be beyond a hospital’s control. Future studies should assess the effect of community-level interventions to minimize potentially avoidable hospitalizations.

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