Hospital Readmission in Persons With Stroke Following Postacute Inpatient Rehabilitation

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Background. Readmission is an important quality indicator following acute care hospitalization. We examined factors associated with hospital readmission in persons with stroke following postacute inpatient rehabilitation.

Methods. Prospective cohort study including 674 persons with stroke who received rehabilitation at 11 facilities located in eight states and the District of Columbia. Measures included hospital readmission within 3 months of discharge, sociodemographic characteristics, length of stay, primary payment source, comorbidities, stroke type, standardized assessments of motor and cognitive function, depressive symptoms, and social support.

Results. Mean age was 71.5 years (SD = 10.5). Twenty-five percent of patients reported high depressive symptoms. Overall, 18% (n = 122) of the sample was rehospitalized. Univariate analyses showed that people who were rehospitalized were more likely (p < .05) to be non-Hispanic white, married, demonstrate less functional independence at discharge, experience longer lengths of stay in rehabilitation, and report more depressive symptoms and lower social support. In the fully adjusted multivariable hierarchical generalized linear model, motor functional status (OR = 0.98, 95% CI 0.96–0.99), depressive symptoms (OR = 1.80, 95% CI 1.06–3.05), and social support (OR = 2.28, 95% CI 1.29–4.03) remained statistically significant. In addition, a minority-by-depressive symptoms interaction term also reached statistical significance.

Conclusion. Functional status, depressive symptoms, and social support were important predictors of hospital readmission. These variables are not included in most administrative data sets. Future research to develop useful risk-adjustment models for rehospitalization following postacute inpatient rehabilitation services should include large diverse samples and explore practical sources for additional meaningful information.

Key Words: Outcomes—Quality indicators—Disability—Postacute.

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The majority of patients who experience a stroke are older than 65 years of age and have at least one comorbid condition making them a high risk for hospital readmission (1–3). Previous studies of hospital readmission for persons with stroke have focused on hospital readmission following acute care hospitalization. A systematic review of 16 studies examining hospital readmission following acute care in persons with stroke concluded that the “current literature provides little guidance for the development of risk-standardized models suitable for the public reporting of hospital-level readmission performance” ([4], p. 2525).

More than 30% of persons with a stroke receive postacute inpatient rehabilitation services (5). Previous studies of hospital readmission for persons with stroke receiving inpatient rehabilitation are limited by small samples of patients, usually from one facility (4,6,7) and by the fact that they were conducted prior to the introduction of the Centers for Medicare and Medicaid Services prospective payment for postacute inpatient rehabilitation in 2002 (8).

We examined sociodemographic factors and clinical variables associated with hospital readmission in a sample of patients with stroke who received postacute inpatient rehabilitation. Our goal was to evaluate risk factors related to all-cause hospital readmission (2) by identifying demographic, clinical, and environmental factors that could be potentially useful in programs to reduce readmission.

Methods

Source of Data

We examined data from the Stroke Underserved Populations Recovery database (9), an observational study of persons with first time stroke who received postacute rehabilitation.
from 2005 through 2006. Eleven U.S. rehabilitation facilities from California, Florida, Illinois, Iowa, Kentucky, New Jersey, New York (two facilities), Texas (two facilities), and Washington, DC participated. Bed size ranged from 12 to 155 (median = 78). All facilities except for one were accredited by The Joint Commission and the Commission on Accreditation of Rehabilitation Facilities.

Data Collection

Sociodemographic and clinical measures were collected within 72 hours of discharge and at 3 months postdischarge. Discharge interviews were completed by trained nursing staff at the rehabilitation facility familiar with the patient. Postdischarge information was collected by trained nurse investigators using telephone interview. Discharge and follow-up interviews were conducted in Spanish or English based on patient preference. The nurse interviewers received 8–12 hours of training in the standardized interview protocol and were credentialed in the use of the Functional Independence Measure instrument by the Uniform Data System in Medical Rehabilitation. Previous studies have documented the reliability and concurrent validity of collecting clinical information, including functional status using telephone interview by trained nurses (10,11).

Study Population

Eligible patients were admitted between 2005 and 2006 with a diagnosis of first time stroke (ICD-9 codes 430–438), aged 50 years or older, and a length of stay of 50 days or less. Patients were screened for cognitive appropriateness by nursing staff regarding their ability to respond to basic questions about orientation to person, place, and time; 970 met the screening criteria. Patients discharged to an acute hospital (n = 61) were excluded from further analyses. At 3-month follow-up, 18 participants had died, 19 refused to participate in the interview, 27 could not be contacted, and 171 did not have complete information on study variables to participate in the interview, 296 excluded patients were more likely to be minorities, report more depressive symptoms, and demonstrate slightly lower motor and cognitive functioning at discharge from inpatient rehabilitation. No other variables differed significantly (p < .05) between groups. Institutional review board approval was obtained from the University and participating hospitals or rehabilitation centers.

Measures

We identified patient factors and clinical variables related to hospital readmission based on clinical experience, systematic reviews of the relevant research literature (4), and clinical practice guidelines.

Dependent variable.—Rehospitalization within 3 months of discharge from inpatient rehabilitation was the primary outcome measure. At 3-month follow-up, participants were asked if they had been rehospitalized since their discharge. Response categories were “none,” “medical/surgical,” “rehabilitation,” or “both.” Rehospitalization was dichotomized into no/yes for analyses.

Independent variables.—Sociodemographic characteristics included age (continuous), gender, race/ethnicity (non-Hispanic white, minority), education (<12 years, ≥12 years), and marital status (married, not married). Clinical measures included a summary comorbidity scale (0, 1–3, > 3) (12), length of rehabilitation stay (days), stroke type (ischemic, hemorrhagic, other), body involvement (right, left, or bilateral), primary payment source (Medicare, Medicaid, or commercial insurance/other), and living status at discharge (alone, with others).

Functional status was assessed by the Inpatient Rehabilitation Facilities–Patient Assessment Instrument (13). The Inpatient Rehabilitation Facilities–Patient Assessment Instrument was developed by the Centers for Medicare and Medicaid Services to determine eligibility for prospective payment and includes 54 items used to assign rehabilitation patients to case-mix groups. The case-mix group determines prospective reimbursement by the Centers for Medicare and Medicaid Services (14,15). The functional status items in the Inpatient Rehabilitation Facilities–Patient Assessment Instrument are from the Functional Independence Measure and include 18 items covering 6 domains: self-care, sphincter control, transfer, locomotion, communication, and social cognition (16). Items are scored on a 7-point scale, ranging from complete dependence (level 1) to complete independence (level 7) with a potential total score range of 18–126. Functional status ratings can be grouped into Motor and Cognition domains. The Functional Independence Measure items were administered by trained personnel within 36 hours of both admission and discharge. Functional Independence Measure ratings were used as a continuous variable in all analyses. The reliability, validity, and responsiveness of the functional status items have been widely investigated with intraclass correlation coefficients consistently more than .85 (16,17).

The 20-item Center for Epidemiologic Studies-Depression (CES-D) scale (18) was used to determine depressive symptoms at discharge. Responses were rated on a 4-point scale and ranged from 0 (rarely or none of the time) to 3 (most of the time). Summing the responses creates a rating from 0 to 60, with ratings of 16 or more suggestive of clinical depression (19). The CES-D was coded as low (<16) and high (≥16) depressive symptoms. The reliability and validity of the CES-D have been established (18,20,21).

Social support was measured by the 11-item Duke–University of North Carolina Functional Social Support Index (22) designed to identify persons at risk of isolation. Each item is rated on a 5-point Likert scale. Scores range from 0 to 55,
with higher scores indicating more social support. We created three levels for social support (low = 0–48, medium = 49–54, and high = 55) (22). The reliability and responsiveness of the questionnaire have been established (19,22).

**Data Analysis**
Discharge sociodemographic and clinical measures were stratified by hospital readmission status and examined using descriptive statistics. Differences among continuous variables were evaluated by t tests, and chi-square tests were used for categorical measures.

Patients within different rehabilitation facilities represent clustered samples. To address the issue of patients nested within the same facility, we used a multistep hierarchical generalized linear model (23,24) to estimate the odds of rehospitalization. Step 1 included basic sociodemographic factors: age, sex, minority status, education level, and primary payment source. Step 2 added clinical and functional status variables, including length of stay, number of comorbidities, stroke type, body involvement, motor and cognition functional ratings, and CES-D scores. Step 3 added indicators of social support, including marital status, living situation, and Duke Social Support scale. We also tested interaction terms for minority status and gender and both minority status and gender with the following factors: CES-D, Duke Social Support, and motor and cognition functional ratings. The Minority × CES-D term was the only one that reached statistical significance and was included in Step 4. Testing was two-sided using p < .05 for all models. Regression diagnostics indicated no significant outliers or collinearity among continuous variables (25). Analyses were performed using SAS version 9.2 (SAS Institute, Inc., Cary, NC) and HLM version 6.0 (Scientific Software International, Inc).

**RESULTS**
Sociodemographic and clinical characteristics stratified by hospital readmission status are presented in Table 1. Approximately 18% of patients were rehospitalized during the 3-months following discharge from inpatient rehabilitation. In unadjusted analyses, persons in the rehospitalized group were more likely (p < .05) to be non-Hispanic white and married, to demonstrate less functional independence at discharge, to experience longer lengths of stay in rehabilitation, and to report more depressive symptoms and lower social support compared with those not rehospitalized.

Table 2 displays the results from the four-step hierarchical generalized linear model with hospital readmission status as the dependent variable. In the fully adjusted model, high depressive symptoms (CES-D ≥ 16) and lower Duke Social Support ratings (<55) were associated with higher odds of rehospitalization. Conversely, both higher motor and cognition functioning as well as the minority-by-depressive symptoms interaction term were associated with lower odds of rehospitalization.

Unadjusted rehospitalization rates by minority status and CES-D scores are shown in Figure 1. Figure 2 shows the predicted rehospitalization rates for these subgroups based on the fully adjusted model (Step 4 in Table 2). A greater number of depressive symptoms was positively associated with hospital readmission in non-Hispanic white patients and negatively associated with hospital readmission in minority patients. In addition, controlling for sociodemographic and other clinical characteristics reduced the magnitude of the association in non-Hispanic whites and increased the magnitude in minorities. To further explore the interaction, we examined the pattern of scores for the CES-D subscales across the non-Hispanic white and minority groups and found no statistically significant differences (data not shown).

**DISCUSSION**
The study goal was to better understand the factors associated with hospital readmission in persons who receive postacute inpatient rehabilitation following a stroke. Overall, we found that persons with better motor and cognitive abilities...
Previous studies examining readmission for persons with stroke (4, 26) and other impairments (27) have found measures of functional status are consistently related to hospital readmission and mortality (28). Duke Social Support ratings were strongly related to readmission. The odds of persons in the lowest level of social support being rehospitalized were more than two times greater than for persons in the highest level of support. In addition, the effects of perceived social support on risk of readmission were less likely to be rehospitalized, whereas those reporting more depressive symptoms and/or lower levels of social support were more likely to be rehospitalized. In addition, the effects of depressive symptoms on risk of rehospitalization were different for non-Hispanic whites and minorities.

Stroke can adversely affect both motor and cognitive abilities. Our findings reiterate the importance of functional status on a person’s long-term health and independence. Previous studies examining readmission for persons with stroke (4,26) and other impairments (27), have found measures of functional status are consistently related to hospital readmission and mortality (28).

Duke Social Support ratings were strongly related to readmission. The odds of persons in the lowest level of social support being rehospitalized were more than two times greater than for persons in the highest level of support. In addition, the effects of depressive symptoms on risk of readmission were different for non-Hispanic whites and minorities.

### Table 2. Results of Four-Step Hierarchical Generalized Linear Model

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<th>Step 1</th>
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<td>Age, y</td>
<td>0.99 0.97–1.02</td>
<td>0.98 0.96–1.01</td>
<td>0.99 0.96–1.02</td>
<td>0.99 0.96–1.02</td>
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<td>Female</td>
<td>0.72 0.48–1.07</td>
<td>0.70 0.46–1.07</td>
<td>0.75 0.48–1.18</td>
<td>0.76 0.48–1.19</td>
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<td>Minority</td>
<td>0.55 0.32–0.96</td>
<td>0.54 0.30–0.96</td>
<td>0.56 0.31–1.01</td>
<td>0.88 0.46–1.69</td>
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<td>Less than high School education</td>
<td>0.83 0.50–1.39</td>
<td>0.78 0.45–1.34</td>
<td>0.75 0.43–1.32</td>
<td>0.72 0.41–1.27</td>
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<td>Medicare</td>
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<tr>
<td>Medicaid</td>
<td>0.47 0.14–1.64</td>
<td>0.39 0.11–1.40</td>
<td>0.47 0.13–1.71</td>
<td>0.55 0.15–2.03</td>
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<td>Private insurance/other</td>
<td>0.71 0.39–1.30</td>
<td>0.76 0.40–1.45</td>
<td>0.80 0.42–1.54</td>
<td>0.78 0.41–1.50</td>
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<td>Length of stay, d</td>
<td>1.00 0.98–1.03</td>
<td>1.00 0.98–1.03</td>
<td>1.00 0.98–1.03</td>
<td>1.00 0.98–1.03</td>
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<td>Number of comorbid conditions</td>
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<td>1–3 conditions</td>
<td>0.73 0.18–2.88</td>
<td>0.59 0.15–2.39</td>
<td>0.53 0.13–2.19</td>
<td>0.68 0.16–2.90</td>
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<td>4+ conditions</td>
<td>0.93 0.23–3.77</td>
<td>0.76 0.18–3.15</td>
<td>0.68 0.16–2.90</td>
<td>0.68 0.16–2.90</td>
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<td>Ischemic stroke</td>
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<td>Hemorrhagic</td>
<td>1.08 0.59–1.95</td>
<td>1.10 0.60–2.01</td>
<td>1.10 0.60–2.01</td>
<td>1.10 0.60–2.01</td>
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<td>Other</td>
<td>0.88 0.43–1.80</td>
<td>0.84 0.40–1.76</td>
<td>0.82 0.39–1.72</td>
<td>0.82 0.39–1.72</td>
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<td>Left body impairment</td>
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<td>Right body impairment</td>
<td>0.79 0.40–1.27</td>
<td>0.81 0.50–1.32</td>
<td>0.81 0.50–1.32</td>
<td>0.81 0.50–1.32</td>
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<tr>
<td>Other impairment</td>
<td>0.80 0.43–1.47</td>
<td>0.74 0.40–1.38</td>
<td>0.77 0.41–1.44</td>
<td>0.77 0.41–1.44</td>
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<tr>
<td>FIM motor at discharge</td>
<td>0.98 0.96–0.99</td>
<td>0.98 0.96–0.99</td>
<td>0.98 0.96–0.99</td>
<td>0.98 0.96–0.99</td>
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<tr>
<td>FIM cognition at discharge</td>
<td>0.96 0.93–1.00</td>
<td>0.96 0.92–1.00</td>
<td>0.96 0.92–1.00</td>
<td>0.96 0.92–1.00</td>
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<tr>
<td>Depressed, CES-D ≥ 16</td>
<td>1.85 1.19–2.87</td>
<td>1.37 0.84–2.24</td>
<td>1.80 1.06–3.05</td>
<td>1.80 1.06–3.05</td>
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<tr>
<td>Not married</td>
<td>0.76 0.47–1.22</td>
<td>0.76 0.47–1.22</td>
<td>0.76 0.47–1.22</td>
<td>0.76 0.47–1.22</td>
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<tr>
<td>Living alone</td>
<td>0.85 0.28–2.58</td>
<td>0.85 0.28–2.58</td>
<td>0.88 0.29–2.72</td>
<td>0.88 0.29–2.72</td>
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<tr>
<td>Duke Social Support = 55</td>
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<td>Duke = 49–54</td>
<td>1.77 1.03–3.02</td>
<td>1.72 1.00–2.94</td>
<td>1.72 1.00–2.94</td>
<td>1.72 1.00–2.94</td>
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<tr>
<td>Duke = 15–48</td>
<td>2.26 1.28–3.98</td>
<td>2.28 1.29–4.03</td>
<td>2.28 1.29–4.03</td>
<td>2.28 1.29–4.03</td>
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<tr>
<td>Minority × Depressed</td>
<td>0.20 0.06–0.75</td>
<td>0.20 0.06–0.75</td>
<td>0.20 0.06–0.75</td>
<td>0.20 0.06–0.75</td>
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**Note:** The dependent variable is hospital readmission for persons with stroke who received postacute inpatient rehabilitation. All continuous variables were group (facility) mean centered for inclusion in the regression model. CES-D = Center for Epidemiologic Studies-Depression; FIM = Functional Independence Measure. Bolded values indicate statistical significance (p < .05).

Figure 1. Unadjusted rehospitalization rates by minority status and Center for Epidemiologic Studies-Depression scores.

Figure 2. Predicted rehospitalization rates by minority status and Center for Epidemiologic Studies-Depression scores based on the fully adjusted model shown in Table 2.
rehospitalization appear to be consistent across both gender and racial/ethnic categories as neither variable reached statistical significance when included in an interaction term with social support. It is also interesting to note that the addition of the three social support indicators in Step 3 of the regression model mediated the statistically significant effect of minority status on rehospitalization risk observed in Steps 1 and 2 (Table 2). These data raise questions regarding potential differences in degree, nature, and perception of social support between non-Hispanic whites and minorities.

Depressive symptoms (CES-D) were also significantly associated with hospital readmission. The odds of rehospitalization were 80% greater for persons with CES-D 16 or more compared with those with scores less than 16. Similar to the pattern for minority status described in the paragraph earlier, the addition of the social support variables mediated the significant association between depressive symptoms and rehospitalization risk (Step 3, Table 2). Previous studies suggest a positive association between social support and recovery from depression, but the mechanisms of this association are poorly understood (29). Nevertheless, inclusion of the minority-by-depressive symptoms interaction term in the final step reestablished the statistically significant relationship between depressive symptoms and hospital readmission.

The interaction term revealed an interesting finding. First, unlike in non-Hispanic whites, a greater burden of depressive symptoms among minority patients was associated with lower risk of rehospitalization. Second, controlling for differences in sociodemographic characteristics and clinical factors appears to diminish the positive relationship between depressive symptoms and readmission risk among non-Hispanic whites yet appears to enhance the negative relationship between depressive symptoms and readmission risk among minorities (see Figures 1 and 2). We examined whether the apparent opposing role of depressive symptoms in relation to rehospitalization between the non-Hispanic white and minority groups could be explained by differences in the CES-D sub-scale patterns, but there was no evidence of significant subscale differences. Previous investigators have also reported consistency in the CES-D factor structure across different racial and ethnic subgroups (30,31) and levels of SES (32). Exploring the apparent “contradictory” effects of depressive symptoms on risk of rehospitalization among minorities as well as the observation that controlling for other relevant risk factors partially explained the relationship in non-Hispanic whites versus unmasked the relationship in minorities are important topics for future research (33).

**Limitations**

The categorization of race/ethnicity as non-Hispanic white versus minority has several limitations. The persons in the minority category have different cultural, biological, and psychosocial experiences. A related problem is the role of socioeconomic status. We attempted to adjust for socioeconomic status by including variables such as Medicaid use and education level in our models. We realize, however, that these variables provide limited information regarding socioeconomic status.

Our sample size was more than 600 but not large enough to allow for a validation study on a subset of the original participants. Follow-up information is based on patient’s self-report, and we do not have medical record data on the reasons for readmission, the exact duration of hospital stay, or the treatments received. Research regarding the accuracy of self-reported hospital readmission is mixed (34–37), but appears to be satisfactory when obtained by trained interviewers. This was the case in our study. Self-reported responses may underestimate actual hospital readmission (37).

Readmission may also be underestimated due to failure to meet the inclusion criteria or missing data. We required that participants have complete data for the independent variables included in the hierarchical generalized linear model analysis. Two hundred and ninety-six potential participants did not meet the inclusion criteria or had incomplete or missing data. Two hundred and nineteen had information on rehospitalization. Twenty-one percent of those not included in the final analysis were rehospitalized compared with 18% in the final sample. This difference was not statistically significant.

We examined hospital readmission for persons with stroke who received services in an inpatient rehabilitation setting. Persons with a stroke may be discharged to postacute care settings other than inpatient medical rehabilitation facilities, including skilled nursing facilities, home health services, or outpatient rehabilitation. The factors that determine which postacute care services a person with stroke receives are complex and beyond the scope of our study. These factors may introduce a selection bias impacting who receives care in a specific postacute care venue. The factors determining postacute care services for persons with stroke and other impairments, for example, hip fracture, are of current research and policy interest in view of the plans to develop quality care indicators and bundled payment associated with the Affordable Care Act (38) and represent an important area for future research.

Study strengths include a diverse sample of persons with stroke across multiple states. We used established standardized measures of depressive symptoms (CES-D), social support (Duke Social Support Index) and functional status (Inpatient Rehabilitation Facilities–Patient Assessment Instrument). Standardized measures of depressive symptoms and social support are rarely used in studies examining readmission for persons with stroke. Another strength is the prospective nature of the data collection and the use of trained nurse investigators to collect discharge and follow-up information. The use of trained interviewers allowed us to verify variables such as gender and race/ethnicity by confirming medical record data with observation and in-person questions.
Summary/Conclusions

The Affordable Care Act mandates that inpatient rehabilitation facilities receiving Medicare payments submit data on quality indicators by 2014 (Federal Register, 76,151, August 5, 2011). Hospital readmission is high on the list of future candidates for IRF quality indicators (39). The Centers for Medicare and Medicaid Services and MedPAC (5) have noted the lack of research regarding hospital readmission following inpatient medical rehabilitation. Our findings begin to address this issue and indicate that functional status, depressive symptoms, and social support are important predictors of hospital readmission; however, these variables are not currently available in most administrative data sets. Additional research is needed to better understand factors associated with hospital readmission following inpatient rehabilitation and how these factors compare with readmission in other postacute care services. This information is necessary to develop meaningful quality indicators for postacute care.

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