# Predictors of 30-Day Readmission Following Inpatient Rehabilitation for Patients at High Risk for Hospital Readmission

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[Fisher SR, Graham JE, Krishnan S, Ottenbacher KJ. Predictors of 30-day readmission following inpatient rehabilitation for patients at high risk for hospital readmission. *Phys Ther.* 2016;96:62–70.]



Published Ahead of Print: September 10, 2015
Accepted: September 7, 2015
Submitted: January 20, 2015

**Background.** The proposed Centers for Medicare & Medicaid Services (CMS) 30-day readmission risk standardization models for inpatient rehabilitation facilities establish readmission risk for patients at admission based on a limited set of core variables. Considering functional recovery during the rehabilitation stay may help clinicians further stratify patient groups at high risk for hospital readmission.

**Objective.** The purpose of this study was to identify variables in the full administrative medical record, particularly in regard to physical function, that could help clinicians further discriminate between patients who are and are not likely to be readmitted to an acute care hospital within 30 days of rehabilitation discharge.

**Design.** This study used an observational cohort with a 30-day follow-up of Medicare patients who were deconditioned and had medically complex diagnoses and who were receiving postacute inpatient rehabilitation in 2010 to 2011.

**Methods.** Patients in the highest risk quartile for readmission (N=25,908) were selected based on the CMS risk prediction model. Hierarchical generalized linear models were built to compare the relative effectiveness of motor functional status ratings in predicting 30-day readmission. Classification and regression tree analysis was used to create a hierarchical order among predictors based on variable importance in classifying patients based on readmission status.

**Results.** Approximately 34% of patients in the high-risk quartile were readmitted within 30 days. Functional outcomes and rehabilitation length of stay were the best predictors of 30-day rehospitalization. A 3-variable algorithm classified 4 clinical subgroups with readmission probabilities ranging from 28% to 75%.

**Limitations.** Although planned readmissions were accounted for in the outcome, potentially preventable readmissions were not distinguished from unpreventable readmissions.

**Conclusion.** For older patients who are deconditioned and have medically complex diagnoses admitted to postacute inpatient rehabilitation, information on functional status measures that are easily monitored by health care providers may improve plans for care transition and reduce the risk of hospital readmission.

The Centers for Medicare & Medicaid Services (CMS) adopted "all-cause unplanned acute care readmission for 30 days post discharge from inpatient rehabilitation facilities (IRFs)" as a quality measure in 2014.[1] After an initial reporting period, Medicare payments to IRFs will be reduced if their risk-standardized readmission rates are higher than expected. These calculated rates will be used for facility-level comparisons, public reporting, and reimbursement determinations. Risk-adjustment methods are needed to account for variations in patient case mix across providers. Models developed by CMS for risk adjustment at the level of the facility are not intended for use clinically at the individual patient level.

The proposed CMS standardization models for IRFs establish 30-day readmission risk for patients at admission based on a limited set of core variables.[2] Examples of risk-adjustment variables include demographic characteristics, principal diagnoses and length of stay from the immediately prior acute stay, types of surgery or procedure from the prior acute stay, and number of admissions and comorbidities from all acute stays in the year preceding the IRF admission.

Variables from the subsequent rehabilitation course (eg, discharge function and length of rehabilitation stay) are not included. Some known readmission risk factors (eg, race/ethnicity and social support) are purposely excluded. The goal of risk standardization as a facility-level quality metric is to aid unbiased hospital comparisons. Readmission risk assessment at the patient level is different. Here, the goal is to help target the delivery of resources and appropriate postdischarge interventions to those patients who could benefit the most.[3]

Patients who are deconditioned and have medically complex diagnoses have the highest 30-day readmission among the 6 largest rehabilitation impairment categories (RICs).[4] Rehabilitation impairment categories are clinically homogeneous diagnosis groupings that represent the primary reason for the rehabilitation stay. Patients in this RIC cover the spectrum of organ systems and medical conditions.[5] In general, they have medically complex conditions and have had prolonged, complicated hospital stays. The resultant debility has been labeled acute "hospital-associated deconditioning," which involves a distinct pathway of functional decline and decreased independence in activities of daily living.[6]

Although generalized deconditioning or complex medical conditions, or both, comprise about 12% of IRF admissions,[4] they are not considered 1 of the 13 core diagnostic categories of the Medicare 60% rule. The 60% rule limits the number and types of patients in IRFs who are not within the 13 categories.[7] Nevertheless, functional recovery for patients who are deconditioned is similar to that of patients with traditional rehabilitation diagnoses.[8] Considering the extent of functional recovery during the rehabilitation stay may help clinicians further stratify these patients based on likelihood of hospital readmission.

For this research, we studied patients within the CMS RIC that encompasses deconditioning and medically complex diagnoses and identified those at highest risk based on the proposed 30-day readmission risk standardization model. We were interested in answering the following 2 questions: (1) Were there other variables within the full administrative medical record, particularly in regard to physical function, that could help clinicians further discriminate likelihood of readmission within this high-risk group? and (2) Which of these factors should a clinician consider most when determining risk of readmission; in other words, what is the predictive hierarchy among risk factors?

# Method

## Data Source and Study Population

Data were extracted from the 100% Medicare files from CMS. Our university has an active data use agreement with CMS. We linked functional status information from the Inpatient Rehabilitation Facility-Patient Assessment Instrument (IRF-PAI) file with claims data in the Medicare Provider Analysis and Review (MedPAR) file for patients discharged from inpatient rehabilitation between January 1, 2010, and November 30, 2011. Prior to selecting the study sample (see below), individual 30-day all-cause unplanned readmission risks were calculated for the entire inpatient rehabilitation population and stratified by quartile; calculations were based on the risk prediction model in the current CMS Hospital-Wide All-Cause Unplanned Readmission Measure.[9] Our target sample was Medicare fee-for-service beneficiaries admitted to rehabilitation for generalized deconditioning or complex medical conditions, or both, so we then selected patients in RIC 20[10] from the larger population.

The initial RIC 20 sample included 87,577 patients. Exclusion criteria were enrollment in a Medicare Advantage plan (n=10,422; Medicare Advantage plans are not required to submit individual claims to CMS), no acute care hospital stay within 30 days of the acute hospitalization precipitating the IRF admission (n=3,779), another inpatient rehabilitation stay within the previous 30 days (n=4,792), admitted for a reason other than initial rehabilitation (n=4,329), length of rehabilitation stay greater than 30 days (n=632), died within 30 days of discharge (n=4,909), and missing data (n=1,588). The final sample from which those at highest risk for readmission were drawn included 62,426 patients. The total number excluded is less than the sum of the individual exclusion parameters, as some patients met more than one criterion.

## Variables

**Unplanned hospital readmission.** An unplanned hospital readmission was coded if there was a claim from a short-term or critical access hospital within 30 days of rehabilitation discharge. Patients who were unexpectedly readmitted to acute care directly from an IRF were counted as readmissions. Planned readmissions were identified using the methodology described in the Hospital-Wide All-Cause Unplanned Readmission Measure.[9] Planned readmissions include occurrences such as admission to an acute hospital for scheduled organ transplant, maintenance chemotherapy, or a procedure scheduled at the time of the index admission.

**Sociodemographics.** Sociodemographic characteristics included age at rehabilitation admission (continuous and categories: ≤74, 75–84, ≥85 years), sex, race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, and other), and prehospital living status (living alone versus with family or friends or with a paid attendant). These variables were extracted from the rehabilitation assessment data (IRF-PAI) and beneficiary summary files.

**Functional status.** We used the Functional Independence Measure (FIM)[5,11] admission and discharge motor function ratings (continuous) for functional status. Function status items are administered by physical therapists or occupational therapists at admission and within 36 hours of discharge as part of the IRF-PAI. The motor function subscale includes 13 activities, such as walking, transferring from bed to chair, bathing, dressing, and toileting. Each motor item is assigned to 1 of 7 levels of function, ranging from total assistance with a helper (level 1) to complete independence with no helper (level 7). The higher the score, the more independent the patient is in performing the task associated with that item. The motor subscale rating ranges from 13 to 91.

We also created a continuous FIM motor scale change variable by subtracting admission motor scale ratings from discharge motor scale ratings. The minimal clinically important change in the FIM motor scale score has not been determined for patients who are deconditioned and have medically complex diagnoses. Beninato et al,[12] however, found a rating of 17 to represent clinically important change for patients with stroke undergoing inpatient rehabilitation. The FIM has been widely studied and found to have adequate psychometric properties.[13]

**Clinical variables.** Clinical variables studied included length of rehabilitation stay in days (continuous); length of stay of the preceding acute hospitalization in days (continuous), number of prior acute hospitalizations in the year preceding the index rehabilitation admission, and whether the patient was discharged from the IRF against medical advice (yes/no). We included the FIM cognition scale rating at admission as an overall measure of cognitive function. The continuous cognition scale ratings range from 5 to 35 and include communication and social cognition domains.

**Comorbidity tier.** We used the CMS comorbidity tier system as a measure of comorbid burden. Comorbidity tiers are classified based on their anticipated impact on service utilization and functional recovery during the inpatient rehabilitation stay.[14] The most costly comorbidities are ranked in 3 cost tiers: tier 1 (highest reimbursement) to tier 3 (lowest reimbursement). In 2012, there were 8 comorbid conditions in tier 1, 11 in tier 2, and 924 in tier 3. The fourth category is no tier comorbidity (no additional reimbursement).[15] An example of a tier 1 comorbidity is dialysis. An example of a tier 3 comorbidity is diabetes. Patients are assigned to the tier with the highest level of reimbursement if more than one comorbidity is present.

## Data Analysis

After selection of the target sample (see Data Source and Study Population section), we stratified patient characteristics and the 30-day readmission outcome by the original predicted readmission risk quartiles. Patients with generalized deconditioning or complex medical conditions, or both, have the highest unadjusted readmission rates,[4] so they are disproportionately represented in the higher-risk quartiles derived from the comprehensive model. Univariate comparisons among the 4 risk groups were performed with analysis of variance or chi-square tests, as appropriate. Patients in the highest risk quartile were then selected and their characteristics stratified by actual unplanned rehospitalization status (yes/no). Between group differences were assessed by *t* tests or chi-square tests. All subsequent analyses were limited to the highest risk quartile group.

Hierarchical generalized linear models with a logit link were used to re-estimate risks within the preidentified high-risk group using additional demographic and clinical variables not included in the provider-level risk standardization model. Hierarchical models allow control for the clustering of patients within facilities.[9] Three separate models were built to compare the relative effectiveness of admission FIM motor scale ratings, discharge FIM motor scale ratings, and change in FIM motor scale ratings in predicting 30-day unplanned admission within this high-risk group. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated for 5-point intervals on each of the continuous FIM motor scale ratings for better clinical interpretation. All 3 models controlled for age, sex, race/ethnicity, prior living situation, prior acute hospitalizations, acute hospital length of stay, rehabilitation length of stay, discharged against medical advice, comorbidity tier, and admission FIM cognition scale rating. The estimates were converted to probabilities and plotted by the different motor scale scores for visual analysis.

Classification and regression tree (CART) analysis[16] was used to create a hierarchical order among the predictors based on variable importance in classifying patients who were readmitted versus were not readmitted within 30 days of rehabilitation discharge. In CART analyses, interactions are evaluated recursively rather than simultaneously, as in linear regression. This process results in a classification rule and is represented as a tree; it has been shown to be a clinically useful means of understanding complex relationships among factors, classifying patient risk, and developing guidelines in other clinical contexts.[17–19] All 10 covariates and the 3 motor scales were entered into the CART model.

Lastly, we compared calibration and discrimination characteristics of the 5 different multivariable models used in our study: the proposed CMS risk standardization model; the 3 comprehensive models that focused on admission FIM motor scale ratings, discharge FIM motor scale ratings, and change in FIM motor scale ratings; and a final parsimonious model with the 3 variables that defined the terminal nodes of the CART analysis. Calibration was assessed by including risk scores from the multivariable models as the only predictor in the 5 separate

**Table 1.**
Demographic and Clinical Characteristics of Patients in RIC 20 Stratified by 30-Day Readmission Risk Quartiles[a]

| Variable | Total | Risk Quartile | | | | *P* |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | |
| No. of patients | 62,426 | 3,019 | 12,972 | 20,527 | 25,908 | |
| Age (y), % | | | | | | <.001 |
| <75 | 37.4 | 41.2 | 34.2 | 34.1 | 41.2 | |
| 75–84 | 37.9 | 35.6 | 38.6 | 38.4 | 37.4 | |
| 85+ | 24.7 | 23.2 | 27.2 | 27.4 | 21.4 | |
| $\bar{X}$±SD | 76.5±11.0 | 75.4±12.0 | 77.2±11.0 | 77.4±10.8 | 75.6±11.0 | <.001 |
| Sex, % | | | | | | <.001 |
| Women | 55.4 | 68.7 | 63.6 | 55.9 | 49.2 | |
| Men | 44.6 | 31.3 | 36.4 | 44.1 | 50.8 | |
| Race/ethnicity, % | | | | | | <.001 |
| Non-Hispanic white | 83.2 | 87.3 | 85.9 | 84.2 | 80.6 | |
| Non-Hispanic black | 10.5 | 7.3 | 8.5 | 10.1 | 12.3 | |
| Hispanic | 4.4 | 3.8 | 3.7 | 3.9 | 5.1 | |
| Other | 1.9 | 1.6 | 1.9 | 1.8 | 2.0 | |
| Prior living situation, % | | | | | | <.001 |
| Family/friends | 64.8 | 51.9 | 57.4 | 63.4 | 71.1 | |
| Paid/other | 1.1 | 0.8 | 0.8 | 1.0 | 1.2 | |
| Alone | 34.1 | 47.3 | 41.8 | 35.5 | 27.7 | |
| Acute hospital length of stay (d), $\bar{X}$±SD | 9.9±9.0 | 5.1±3.1 | 6.5±4.4 | 8.5±6.0 | 13.2±11.7 | <.001 |
| Prior acute hospitalizations, $\bar{X}$±SD | 2.2±1.6 | 1.2±0.4 | 1.4±0.7 | 1.8±1.0 | 3.0±2.0 | <.001 |
| Rehabilitation length of stay, $\bar{X}$±SD | 12.0±4.9 | 8.7±3.4 | 10.6±4.1 | 11.9±4.6 | 13.2±5.2 | <.001 |
| Discharged against medical advice, % | | | | | | .036 |
| No | 99.8 | 99.8 | 99.8 | 99.8 | 99.7 | |
| Yes | 0.2 | 0.2 | 0.2 | 0.2 | 0.3 | |
| Tier comorbidity, % | | | | | | <.001 |
| No tier | 44.9 | 73.1 | 61.9 | 47.6 | 31.0 | |
| Tier 3 | 36.3 | 22.8 | 29.8 | 38.3 | 39.4 | |
| Tier 2 | 11.6 | 3.9 | 7.2 | 10.4 | 15.5 | |
| Tier 1 | 7.3 | 0.1 | 1.1 | 3.7 | 14.1 | |
| Admission FIM cognition scale ratings, $\bar{X}$±SD | 24.4±6.4 | 28.3±4.8 | 26.1±5.5 | 24.5±6.2 | 23.1±6.6 | <.001 |
| Admission FIM motor scale ratings, $\bar{X}$±SD | 39.0±11.1 | 53.4±6.7 | 45.3±8.5 | 29.4±10.0 | 33.9±10.4 | <.001 |
| Discharge FIM motor scale ratings, $\bar{X}$±SD | 61.5±14.5 | 72.9±8.6 | 67.4±11.1 | 62.4±13.4 | 56.5±15.4 | <.001 |
| Change in FIM motor scale ratings, $\bar{X}$±SD | 22.5±11.8 | 19.5±8.2 | 22.1±10.2 | 23.0±11.5 | 22.6±12.9 | <.001 |
| Readmitted, % | | | | | | <.001 |
| No | 74.7 | 90.6 | 83.9 | 77.3 | 66.2 | |
| Yes | 25.3 | 9.4 | 16.1 | 22.7 | 33.8 | |

[a] For risk quartiles, patients in the entire inpatient rehabilitation population were classified into individual 30-day all-cause unplanned readmission risk quartiles based on the risk prediction model in the current Centers for Medicare & Medicaid Services Hospital-Wide All-Cause Unplanned Readmission Measure. Patients in rehabilitation impairment category (RIC) 20 were disproportionately represented in the higher-risk quartiles derived from the comprehensive model because they had the highest readmission risk among all RICs. FIM=Functional Independence Measure.

**Table 2.**
Demographic and Clinical Characteristics of the Highest Risk Quartile Stratified by Actual Readmission Status[a]

| Variable | Total | Rehospitalized | | P |
|---|---|---|---|---|
| | | No | Yes | |
| No. of patients | 25,908 | 17,162 | 8,746 | |
| Age (y), % | | | | <.001 |
| <75 | 41.2 | 39.2 | 45.1 | |
| 75–84 | 37.4 | 37.9 | 36.6 | |
| 85+ | 21.4 | 22.9 | 18.3 | |
| $\bar{X}$±SD | 75.6±11.0 | 76.1±10.8 | 74.5±11.4 | <.001 |
| Sex, % | | | | .099 |
| Women | 49.2 | 48.9 | 50.0 | |
| Men | 50.8 | 51.1 | 50.0 | |
| Race/ethnicity, % | | | | <.001 |
| Non-Hispanic white | 80.6 | 81.5 | 78.8 | |
| Non-Hispanic black | 12.3 | 11.7 | 13.6 | |
| Hispanic | 5.1 | 4.9 | 5.5 | |
| Other | 2.0 | 1.9 | 2.1 | |
| Prior living situation, % | | | | .066 |
| Family/friends | 71.1 | 70.6 | 72.0 | |
| Paid/other | 1.2 | 1.2 | 1.2 | |
| Alone | 27.7 | 28.1 | 26.8 | |
| Prior acute hospitalizations, $\bar{X}$±SD | 3.0±2.0 | 2.9±1.9 | 3.4±2.3 | <.001 |
| Acute hospital length of stay (d), $\bar{X}$±SD | 13.2±11.7 | 12.9±11.2 | 13.9±12.5 | <.001 |
| Rehabilitation length of stay (d), $\bar{X}$±SD | 13.2±5.2 | 13.8±5.0 | 12.2±5.5 | <.001 |
| Discharged against medical advice, % | | | | .250 |
| No | 99.7 | 99.7 | 99.8 | |
| Yes | 0.3 | 0.3 | 0.2 | |
| Tier comorbidity, % | | | | <.001 |
| No tier | 31.0 | 32.3 | 28.5 | |
| Tier 3 | 39.4 | 39.6 | 39.2 | |
| Tier 2 | 15.5 | 15.4 | 15.7 | |
| Tier 1 | 14.1 | 12.8 | 16.6 | |
| Admission FIM cognition scale ratings, $\bar{X}$±SD | 23.1±6.7 | 22.9±6.7 | 23.3±6.7 | <.001 |
| Admission FIM motor scale ratings, $\bar{X}$±SD | 33.9±10.4 | 33.9±10.4 | 33.7±10.6 | .156 |
| Discharge FIM motor scale ratings, $\bar{X}$±SD | 56.5±15.4 | 59.0±14.3 | 51.6±16.4 | <.001 |
| Change in FIM motor scale ratings, $\bar{X}$±SD | 22.6±12.9 | 25.0±12.1 | 17.9±13.2 | <.001 |

[a] FIM=Functional Independence Measure.

logistic regression models, with 30-day unplanned rehospitalization as the outcome. Well-calibrated models should have an intercept ($\alpha$) close to 0 and a slope ($\beta$) close to 1.[20] Discrimination was assessed by calculating areas under the curve (AUCs, or C-statistics) from receiver operating characteristic curves and by stratifying observed 30-day rehospitalization rates by predicted risk quintiles from each model. C-statistics can range from 0.5 (no discrimination) to 1.0 (perfect discrimination).[21] The risk quintiles should show step-wise increases in observed readmission rates, with broad discrimination between high and low quintiles.

## Role of the Funding Source

This study was funded, in part, by grants from the National Institutes of Health (R24 HD065702, R24 HS022134, R01

**Table 3.**
Hierarchical Generalized Linear Models Regressing Admission and Discharge FIM Motor Scale Ratings to Change in Discharge FIM Motor Scale Ratings on 30-Day Readmission (Yes/No), Adjusting for Demographic Clinical Characteristics[a]

| Variable | Model 1 | | | Model 2 | | | Model 3 | | |
|---|---|---|---|---|---|---|---|---|---|
| | OR | 95% CI | | OR | 95% CI | | OR | 95% CI | |
| Admission FIM motor scale ratings | 0.890 | 0.876 | 0.904 | | | | | | |
| Discharge FIM motor scale ratings | | | | 0.829 | 0.821 | 0.837 | | | |
| Change in FIM motor scale ratings | | | | | | | 0.805 | 0.796 | 0.815 |

[a] Adjustment for age, sex, race/ethnicity, prior living situation, prior acute hospitalizations, acute hospital length of stay, rehabilitation length of stay, discharged against medical advice, comorbidity tier, and admission Functional Independence Measure (FIM) cognition rating. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated for 5-point intervals on the FIM motor scale ratings.

HD069443) and the National Institute on Disability, Independent Living and Rehabilitation Research (H133G140127).

## Results

The demographic and clinical characteristics of the target sample (N=62,426) stratified by 30-day readmission risk quartile based are provided in Table 1. The quartiles are based on the proposed CMS risk standardization model for the entire inpatient rehabilitation population. Overall, 25.3% of the initial sample were readmitted to an acute care hospital within 30 days of rehabilitation discharge. The highest risk quartile (n=25,908) was 8 times larger than the lowest risk quartile (n=3,019); 34% of the patients were readmitted within 30 days in the highest risk quartile versus 9% in the lowest risk quartile.

Three admission diagnoses comprised 87.1% of patients in the high risk quartile: debility (77.1%), disabling conditions/other (6.4%), and medically complex conditions/other (3.6%). Table 2 shows their demographic and clinical characteristics stratified by actual readmission status. The patients' mean age was 76.5 years (SD=11.0). Half were men (50.8%), and 80.6% were non-Hispanic white. Seventy-one percent were living with someone prior to their acute care hospitalization, and 27.7% lived alone. There was a mean of 3.0 acute hospitalizations (SD=2.0) in the previous year. Mean length of stay for the acute hospitalization preceding the rehabilitation stay was 13.2 days (SD=11.7). The mean rehabilitation length of stay was 13.2 days (SD=5.2). Sixty-nine percent of the patients had at least one CMS rehabilitation tier comorbidity. A very small percentage (0.3%, or approximately 777 people) were discharged from rehabilitation against medical advice. The mean admission FIM cognition scale rating for the sample was 23.1 (SD=6.7). The mean FIM motor scale ratings were 33.9 (SD=10.4) at admission and 56.5 (SD=15.4) at discharge. The mean changes in FIM motor scale ratings from admission to discharge was 22.6 (SD=12.9).

Patients who were readmitted did not significantly differ from those who were not readmitted based on sex, prior living

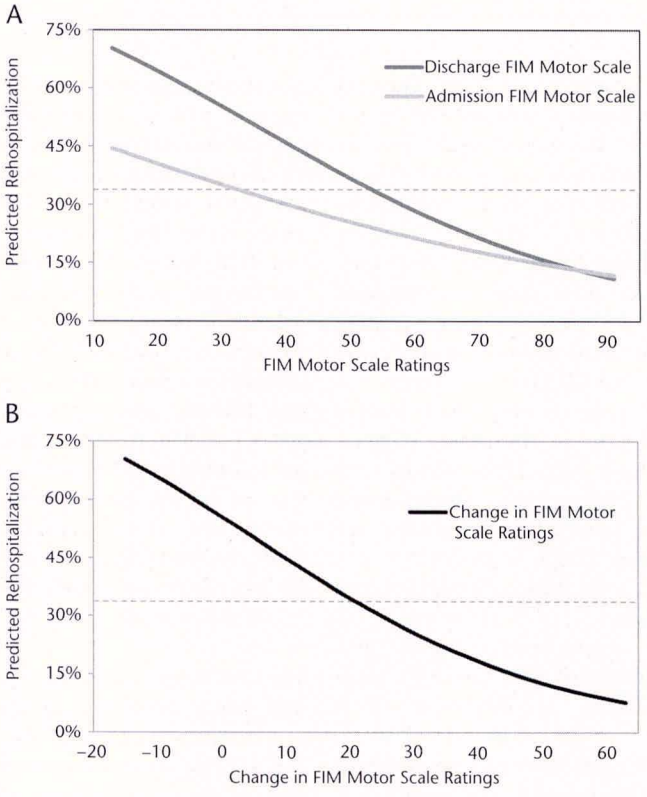


**Figure 1.**
Adjusted hospital readmission rates across each of the 3 Functional Independence Measure (FIM) motor scale rating distributions. Adjustment for age, sex, race/ethnicity, prior living situation, prior acute hospitalizations, acute hospital length of stay, rehabilitation length of stay, discharged against medical advice, comorbidity tier, and admission FIM cognition rating. The dashed horizontal line is the unadjusted readmission rate in this high-risk group: 33.8%.

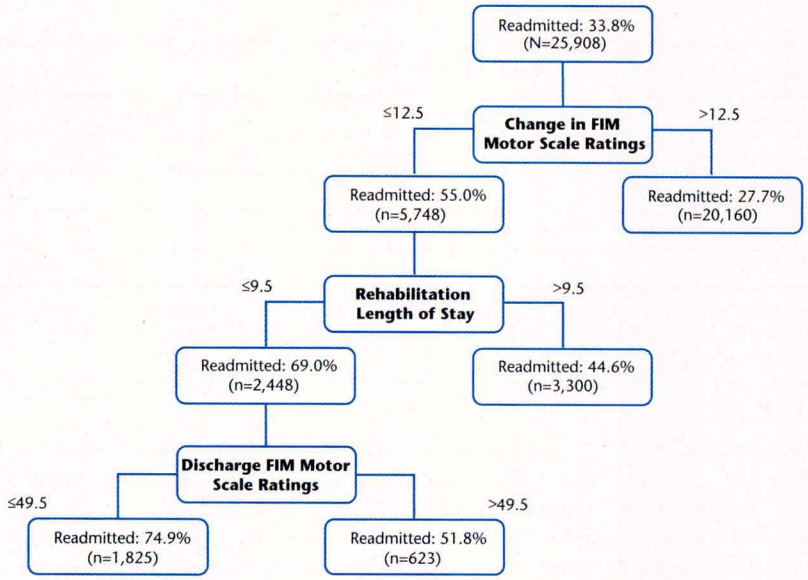


**Figure 2.**
Classification and regression tree (CART) analysis showing the predictive hierarchy of factors that best discriminated patients by readmission status. All study variables (see Tab. 2) were included in the CART model. Change in Functional Independence Measure (FIM) motor scale ratings, rehabilitation length of stay, and discharge FIM motor scale ratings were identified as the top 3 measures in terms of importance.

situation, discharge against medical advice, or mean admission FIM motor scale rating. Compared with patients who were not readmitted within 30 days, readmitted patients were significantly younger (mean age=76.1 years [SD=10.8] versus 74.5 years [SD=11.4], respectively), were more non-Hispanic white (18.5% versus 21.2%, respectively), had more previous acute hospitalizations ($\overline{X}$=2.9 [SD=1.9] versus 3.4 [SD=2.3], respectively), had longer lengths of stay in the acute hospital ($\overline{X}$=12.9 days [SD=11.2] versus 13.9 [SD=12.5], respectively), were more likely to be assigned a comorbidity tier (69.0% versus 71.5%, respectively), and had shorter rehabilitation lengths of stay ($\overline{X}$=13.8 days [SD=5.0] versus 12.2 [SD=5.5], respectively). Mean FIM motor scale ratings were lower for readmitted patients at discharge (59.0 [SD=14.3] versus 51.6 [SD=16.4], respectively) and showed less improvement from admission to discharge (25.0 [SD=12.1] versus 17.9 [SD=13.2], respectively).

Table 3 shows the results of the 3 hierarchical logistic regression models for the FIM motor scale ratings (admission, discharge, and admission to discharge change) after adjusting for patient and clinical characteristics. The OR and 95% CI values are for a 1-point change in each respective rating. The FIM motor scale rating change had the strongest association (OR=0.958; 95% CI=0.955, 0.960) among the 3 models; the larger the increase in motor ratings from admission to discharge, the lower the odds of readmission. Admission FIM motor scale ratings had the lowest effect (OR=0.977; 95% CI=0.974, 0.980). Race was no longer significantly associated with readmission in any of the 3 models. Figure 1 shows the adjusted probabilities for acute readmission calculated from the logistic regression models for each of the 3 FIM motor scale variables.

The CART results are shown in Figure 2. The tree is read like an algorithm. In order of importance, the best discriminators of readmission status were change in FIM motor scale ratings, rehabilitation length of stay, and discharge FIM motor scale rating. The CART procedure also identifies the cut-point within a particular predictor variable that best differentiates patients by readmission status. Among patients with a change rating of 12.5 points or less, 55% were readmitted. Among patients whose motor rating did not improve by at least 12.5 points, rehabilitation length of stay was the next best discriminator; 69% of patients with a rehabilitation stay of less than 9.5 days were readmitted. Among patients with a change in FIM motor scale ratings of 12.5 points or less and rehabilitation stay of 9.5 days or less, discharge FIM motor scale rating was the best predictor; 75% of patients with a discharge FIM motor scale rating of 49.5 or less were readmitted.

Calibration characteristics ($\alpha$, $\beta$) for the different models were: CMS ($\alpha$=0.14, $\beta$=0.77), admission FIM motor scale ratings ($\alpha$=0.08, $\beta$=0.93), discharge FIM motor scale ratings ($\alpha$=0.08, $\beta$=0.93), change in FIM motor scale ratings ($\alpha$=0.08, $\beta$=0.94), and CART ($\alpha$=0.09, $\beta$=0.92). Discrimination characteristics (C-statistics [AUC]) for the different models were: CMS (0.58), admission FIM motor scale ratings (0.64), discharge FIM motor scale ratings (0.69), change in FIM motor ratings (0.69), and CART (0.67). The observed 30-day rehospitalization rates in the lowest and highest risk quintiles were: CMS (26.2%-44.8%), admission FIM motor scale ratings (23.4%-54.9%), discharge FIM motor scale ratings (18.5%-61.4%), change in FIM motor scale ratings (18.0%-61.5%), and CART (18.4%-57.9%). The 3 variables together identified in CART were comparable to the full models across each parameter.

## Discussion

For patients at high risk for readmission who are deconditioned and have medically complex diagnoses, functional outcomes of the rehabilitation stay and the length of stay are potentially important predictors of an acute care readmission. An algorithm using 3 of these variables classified 4 clinical subgroups with readmission probabilities ranging from 34% to 75%.

Our findings underscore a distinction between risk standardization at the hospital level and risk prediction at the patient level. The approach we used to initially stratify patients by readmission risk was based on the proposed CMS

methodology for standardizing patient risk across inpatient rehabilitation hospitals and units.[9] Models designed for these purposes must be deployable in large populations and use reliable data that can be easily obtained. In contrast, risk prediction at the level of the patient attempts to provide a more clinically relevant stratification and is done in real time. Both methods assume the risk of readmission can be modified by the quality and type of care provided.[3] The current study provides a methodology for using both approaches to help clinicians identify older patients at highest risk for readmission following inpatient rehabilitation.

Although discharge planning begins early in the rehabilitation stay, clinicians are able to alter plans based on available information. Our findings suggest that for patients in this rehabilitation impairment category, poor functional improvement should be considered a "red flag" for early acute readmission. Physical functioning and mobility are a central focus of inpatient rehabilitation for patients who are deconditioned. Function is also a recognized global marker of health status in older adults.[22,23] Lack of functional improvement after a recent debilitating acute illness could be an indication of a worsening underlying health condition.[24] It also elevates the importance of the patient's response to rehabilitation over his or her initial admission presentation, as discharge function was a better predictor of readmission than admission function.

Although the impact of length of stay on the functional outcomes was not the focus of this study, we found that shorter stays (≤9.5 days) were associated with increased risk of readmission. This association was strongest for patients who showed less than 12.5 points of improvement on the FIM motor scale. Length of stay for IRFs has declined markedly over the past 15 years.[25] Penalties for greater than expected readmission rates and proposed bundled payment models for clinically defined episodes of care[26] will no doubt increase the importance of length of stay considerations for IRFs.

Our study had several limitations. We were limited to variables for billing and administrative functions, so we did not have information on factors such as health behaviors, nutrition, or education level. This limitation may account for the relatively small differences in C-statistics that we observed across models. There is an underlying assumption in the CMS models that latent discrimination between patients who are readmitted and those who are not readmitted depends more on the quality of care received than on individual patient characteristics or behaviors.[27] Another limitation is that only patients in the Medicare fee-for-service plan were included in our sample, so findings may not be generalizable to those in Medicare Advantage plans. Although we accounted for planned readmissions in our outcome, we did not distinguish between potentially preventable and unpreventable readmissions. In addition, we did not have information on the type or quality of care that patients received following discharge from inpatient rehabilitation regardless of whether they were rehospitalized.

In conclusion, for patients identified as high risk for readmission at IRF admission using the proposed CMS risk standardization model, patient-level factors related to the rehabilitation stay could help target the delivery of resource-intensive interventions. Applying an algorithm of 3 variables, the probability of readmission increased from 34% to 75%. How much the patient improved in functioning, length of rehabilitation stay, and function at discharge, together, are potentially important predictors of an early acute readmission. Further research is needed to validate these findings. Additional research also is warranted on the use of this methodology with different impairment categories (eg, stroke, hip fracture) and other important variables and outcomes, such as measure of care coordination and discharge destination.

Dr Fisher and Dr Graham provided concept/idea/research design and data analysis. Dr Fisher, Dr Krishnan, and Dr Ottenbacher provided writing. Dr Ottenbacher provided project management and fund procurement.

The study was approved by the appropriate institutional review board.

This study was funded, in part, by grants from the National Institutes of Health (R24 HD065702, R24 HS022134, R01 HD069443) and the National Institute on Disability, Independent Living and Rehabilitation Research (H133G140127).

DOI: 10.2522/ptj.20150034

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