

RESEARCH LETTERS

**Predicting Hip and Major Osteoporotic Fractures Using Administrative Data**

The Fracture Risk Assessment tool (FRAX) was released in 2008 by the World Health Organization (WHO).<sup>1</sup> The FRAX algorithm uses bone mineral density (BMD) and 11 additional clinical and physiological risk factors to estimate a person's 10-year probability of hip and other major osteoporotic frac-

ture.<sup>2</sup> The latter is defined by the WHO as a hip, clinical vertebral, distal forearm, or humerus fracture. Ensrud et al,<sup>3</sup> using risk prediction models that included only age and BMD or age and fracture history, concluded that these few risk factors predicted 10-year risk of hip and other major osteoporotic fractures as well as FRAX-based models. We performed a similar evaluation using administrative claims data, which do not include information on BMD. We derived and examined several fracture risk prediction models to determine if demographics, history of fracture, and comorbidities—all identifiable within administrative claims data—could be used to predict hip fracture and major osteoporotic fractures, as well as models with additional clinical information or models de-

**Table. Weighted C Statistics in Predicting Hip and Major Osteoporotic Fractures<sup>a</sup>**

| Variable  | Model 1 <sup>b</sup><br>(Demographic, Fracture History, Comorbidity) | Model 2 <sup>c</sup><br>(Demographic, Fracture History, Comorbidity, and Extra Variables From Survey <sup>e</sup> ) | Model 3 <sup>d</sup><br>(Model 2 + FRAX Score for Hip Fracture [for Hip Fracture Outcome] or FRAX Score for Major Osteoporotic Fracture [for Major Fracture Outcome]) | Model 4<br>(Only FRAX Score for Hip Fracture [for Hip Fracture Outcome] or FRAX Score for Major Osteoporotic Fracture [for Major Fracture Outcome]) |
|---|--|---|---|---|
| Hip fracture is the outcome of interest                             |  |   |   |   |
| All subjects  | 0.74 (0.70-0.77)   | 0.75 (0.72-0.78)  | 0.75 (0.72-0.78)  | 0.64 (0.60-0.68)  |
| Sex   |  |   |   |   |
| Female  | 0.71 (0.67-0.75)   | 0.73 (0.68-0.77)  | 0.73 (0.68-0.77)  | 0.66 (0.62-0.70)  |
| Male  | 0.78 (0.73-0.83)   | 0.81 (0.75-0.85)  | 0.81 (0.75-0.85)  | 0.67 (0.60-0.73)  |
| Ethnicity   |  |   |   |   |
| White   | 0.74 (0.70-0.78)   | 0.75 (0.72-0.79)  | 0.75 (0.72-0.79)  | 0.64 (0.60-0.67)  |
| African American  | 0.74 (0.50-0.93)   | 0.81 (0.50-0.94)  | 0.81 (0.50-0.95)  | 0.70 (0.57-0.81)  |
| Major osteoporotic fracture is the outcome of interest <sup>f</sup> |  |   |   |   |
| All subjects  | 0.71 (0.69-0.73)   | 0.72 (0.69-0.74)  | 0.72 (0.70-0.74)  | 0.55 (0.53-0.58)  |
| Sex   |  |   |   |   |
| Female  | 0.67 (0.65-0.70)   | 0.68 (0.65-0.71)  | 0.69 (0.66-0.71)  | 0.64 (0.61-0.66)  |
| Male  | 0.71 (0.67-0.76)   | 0.75 (0.71-0.78)  | 0.75 (0.71-0.79)  | 0.67 (0.62-0.72)  |
| Ethnicity   |  |   |   |   |
| White   | 0.71 (0.68-0.73)   | 0.71 (0.69-0.74)  | 0.72 (0.70-0.74)  | 0.54 (0.51-0.56)  |
| African American  | 0.74 (0.50-0.85)   | 0.78 (0.66-0.88)  | 0.78 (0.67-0.88)  | 0.52 (0.44-0.63)  |

Abbreviations: ADL, activities of daily living; BMI, body mass index; FRAX, Fracture Risk Assessment tool; IADL, instrumental ADL.

<sup>a</sup>Data are given as weighted C statistic (95% confidence interval). A total of 12 413 beneficiaries were eligible for hip fracture analysis with 187 identified hip fractures, while 12 337 beneficiaries were eligible for major osteoporotic fracture analysis with 430 identified major osteoporotic fractures.

<sup>b</sup>Logit (Hip Fracture) = -5.5487 + 0.5909 (Age 70-74 years) + 0.7710 (Age 75-79 years) + 1.0513 (Age 80-84 years) + 2.0719 (Age 85-89 years) + 2.3560 (Age ≥90 years) - 0.4015 (African American) - 0.6153 (Male) + 0.7380 (Baseline Fracture) + 0.3830 (Baseline Comorbidity).

Logit (Major Fracture) = -4.5842 + 0.5112 (Age 70-74 years) + 1.0129 (Age 75-79 years) + 1.3373 (Age 80-84 years) + 1.8804 (Age 85-89 years) + 2.0844 (Age ≥90 years) - 0.7225 (African American) - 0.8138 (Male) + 1.2146 (Baseline Fracture) + 0.4028 (Baseline Comorbidity).

<sup>c</sup>Logit (Hip Fracture) = -5.1061 + 0.5747 (Age 70-74 years) + 0.7397 (Age 75-79 years) + 0.9847 (Age 80-84 years) + 1.9628 (Age 85-89 years) + 2.1978 (Age ≥90 years) - 0.4404 (African American) - 0.5592 (Male) + 0.7204 (Baseline Fracture) + 0.3463 (Baseline Comorbidity) - 0.0178 (BMI) - 0.0041 (ADL) + 0.1791 (IADL).

Logit (Major Fracture) = -4.6038 + 0.4907 (Age 70-74 years) + 0.9785 (Age 75-79 years) + 1.2894 (Age 80-84 years) + 1.8103 (Age 85-89 years) + 1.9624 (Age ≥90 years) - 0.7806 (African American) - 0.7844 (Male) + 1.1905 (Baseline Fracture) + 0.3595 (Baseline Comorbidity) + 0.0004 (BMI) - 0.005 (ADL) + 0.1906 (IADL).

<sup>d</sup>Logit (Hip Fracture) = -5.1435 + 0.5536 (Age 70-74 years) + 0.6586 (Age 75-79 years) + 0.8568 (Age 80-84 years) + 1.8108 (Age 85-89 years) + 2.0499 (Age ≥90 years) - 0.3516 (African American) - 0.6362 (Male) + 0.6513 (Baseline Fracture) + 0.3414 (Baseline Comorbidity) - 0.0169 (BMI) - 0.0032 (ADL) + 0.1754 (IADL) + 0.0185 (FRAX Score).

Logit (Major Fracture) = -4.7421 + 0.4641 (Age 70-74 years) + 0.8654 (Age 75-79 years) + 1.1004 (Age 80-84 years) + 1.5980 (Age 85-89 years) + 1.7747 (Age ≥90 years) - 0.5796 (African American) - 1.0428 (Male) + 1.0016 (Baseline Fracture) + 0.3495 (Baseline Comorbidity) + 0.0004 (BMI) - 0.004 (ADL) + 0.1860 (IADL) + 0.0258 (FRAX Score).

<sup>e</sup>Comorbidity is coded as dichotomous: 1, have any glucocorticoid-related disease, bone disease, cancer, depression, diabetes, fall-related disease, other heart disease, or renal disease; 0, otherwise. The extra variables from the survey included BMI, ADL, and IADL, while BMI was derived from self-reported weight and height.

<sup>f</sup>World Health Organization-defined major fracture including hip, clinical vertebral, distal forearm, and humerus for FRAX.

rived from FRAX. This type of prediction model might be useful for large health plans to target higher-risk individuals for more aggressive screening efforts including BMD testing.

**Methods.** We performed a retrospective cohort study using the Medicare Current Beneficiary Survey (MCBS), a rotating panel in-home survey of approximately 12 000 community- or institutional-dwelling beneficiaries linked to Medicare claims data, for the years 1999 through 2005. The MCBS can provide national estimates for the US Medicare population owing to its unique multistage sampling design. Eligible subjects for this analysis were 65 years or older and had Medicare part A and B coverage, 1 year of baseline data, and 2 years of follow-up data. For analyses of each type of fracture, beneficiaries with any claims for the particular fracture during the baseline were excluded.

We used inpatient and outpatient administrative claims data to obtain demographic, baseline comorbidity, and fracture history information and used MCBS survey data to obtain information on height, weight, activities of daily living, body mass index (BMI), current smoking status, osteoporosis drug use and glucocorticoid use. Alcohol status and fracture history were obtained from both claims and survey data. Because the MCBS does not contain information regarding family history of hip fractures, we used population-based data<sup>4</sup> to simulate this risk factor according to previously published methods.<sup>5</sup>

We used multivariable logistic regression modeling to evaluate the predictive ability of models with varying degrees of complexity. The C statistic, a measure of area under the receiver operating characteristic curve, was reported and compared across models. To provide statistically valid inferences and account for sampling, we used survey logistic regression for the analysis.<sup>6</sup> To obtain the weighted C statistic and its 95% confidence interval, we applied bootstrapping methods reported by Izsrael et al.<sup>7</sup>

**Results.** Of the more than 12 000 beneficiaries eligible for evaluation of risk of hip fracture and other major osteoporotic fracture, 187 experienced a hip fracture and 430 had a major osteoporotic fracture (**Table**). In the analysis of hip fracture, the sex-specific, weighted C statistic was 0.74 for the model using only administrative claims data containing demographic characteristics, fracture history, and comorbidities, which minimally changed to 0.75 when we added the extra variables from MCBS. The C statistic for the model that used FRAX score only (using BMI) was 0.64. The analysis of major osteoporotic fractures found similar patterns with modestly lower C statistics. The C statistics were numerically higher in men than in women and higher in African American than in white beneficiaries, but confidence intervals were wide.

**Comment.** Our results indicate that simple models based on administrative claims data are useful for predicting hip and major osteoporotic fractures. Although BMD and BMI were not available in claims data, our models generated using only administrative data yielded compa-

table results compared with more complex models with clinical risk factors or FRAX without BMD. This result is consistent with those reported by Ensrud et al,<sup>3</sup> and our C statistics are comparable with their results, including models with BMD. Because the follow-up time in MCBS was limited to 2 years, we could not assess the calibration of the risk prediction models, only their discrimination. However, our well-defined cohort is generalizable to the United States Medicare population. Our findings, which suggest that administrative data alone can risk stratify patients to identify those who should be considered higher priorities for further fracture risk assessment including BMD testing, have implications for screening at a population level by health plans with ready access to administrative data.

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## Early Ambulation and Length of Stay in Older Adults Hospitalized for Acute Illness

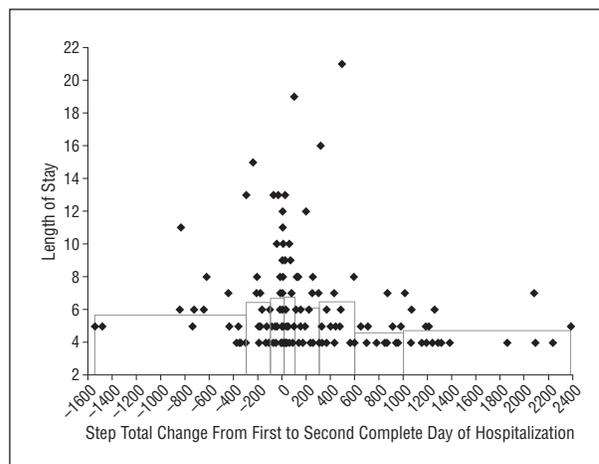
There are no therapeutic guidelines regarding ambulation for older adults hospitalized for acute illness.<sup>1</sup> The importance of early ambulation to recovery in other patient populations is well established.<sup>2,3</sup> For example, time to ambulation after hip fracture surgery is a predictor of complications such as prolonged length of stay (LOS).<sup>4</sup> In the present study, we examined the association between ambulation and LOS in geriatric patients admitted for acute illnesses. We hypothesized that increase in ambulation within the 48 hours after admission would predict LOS after adjusting for risk factors.

**Methods.** Patients 65 years or older admitted to an Acute Care for Elders unit were studied. A Step Activity Monitor (SAM) was placed on patients at admission, and participants were instructed to walk as usual. Data were collected over 4 months in 2009. Patients with an orthopedic surgical diagnosis or a contraindication to wearing the SAM (eg, bilateral leg infection or severe edema) were excluded. Patients (N=162) who spent 2 or more days in hospital were included in the analysis. Institutional review board approval was obtained.

The SAM is a pager-sized accelerometer attached at the ankle. It will not record leg movements in bed and has been shown to be 98% accurate in clinical populations.<sup>5-7</sup> Steps were recorded in 1-minute intervals synchronized to a 24-hour clock, resulting in a temporal series of 1440 observations per day.

Total steps were summed for each 24-hour day. A step change score was calculated using the difference in step totals between the first and second day. Mean daily steps were calculated using the number of complete days the SAM was worn. Demographic and clinical characteristics were obtained from medical records.

Generalized estimating equation models were used to examine the association between step change score and LOS with and without adjustment for covariates. The best fitting model was the one in which LOS was discontinuous with a large drop at 600 steps or more. We used  $\chi^2$  and *t* tests to examine differences between patients who



**Figure.** Unadjusted step total change scores and step change score deciles by length of stay. Bars are mean length of stay for change score deciles:  $\leq -300$  steps;  $-300$  to  $-100$  steps;  $-100$  to  $0$  steps;  $0$  to  $99$  steps;  $100$  to  $299$  steps;  $300$  to  $599$  steps;  $600$  to  $1000$  steps; and more than  $1000$  steps. Adjacent deciles in the range  $-100$  to  $100$  steps were combined. The unadjusted mean difference in length of stay between those who increased their step total by  $600$  steps or more from the first to second complete day of hospitalization and those who did not was  $1.73$  days (95% confidence interval,  $0.60$  to  $2.85$  days); after adjusting for demographic and clinical characteristics (see “Methods” section), the difference was  $2.13$  days (95% confidence interval,  $1.02$  to  $3.93$  days).

increased their walking by  $600$  steps or more from the first to second day vs those who did not. Statistical analyses were performed using SAS version 9.2 software (SAS Institute Inc, Cary, North Carolina). Testing was 2-sided, and  $P < .05$  was considered significant.

**Results.** Mean (SD) age was  $77.4$  ( $7.7$ ) years;  $55.7\%$  were women; mean (SD) body mass index was  $26.5$  ( $6.5$ ) (calculated as weight in kilograms divided by height in meters squared); and  $21.4\%$  reported a fall in the past year. Reasons for admission included cardiopulmonary ( $30.8\%$ ), infections ( $25.2\%$ ), and gastrointestinal ( $16.4\%$ ), neurologic ( $6.2\%$ ), and other ( $21.4\%$ ) complications. The all patient refined diagnosis related group severity of illness classification<sup>8</sup> was minor ( $10.6\%$ ), moderate ( $43.8\%$ ), major ( $36.2\%$ ), and extreme ( $9.4\%$ ). Mean (SD) LOS was  $6.1$  ( $2.9$ ) days (range,  $4$ - $26$  days).

Prior to admission,  $52.8\%$  were independent ambulators,  $35.2\%$  used a cane or walker, and  $12.0\%$  required help from another person. Ambulation was restricted at admission by tubing and/or monitoring equipment in  $28.9\%$  of patients. Physician activity orders at admission were “as tolerated” ( $53.0\%$ ), “ambulate with assist” ( $16.6\%$ ), and “bed rest” ( $29.6\%$ ).

Patients averaged  $662.1$  (SD,  $784.9$ ) steps per day. Mean (SD) number of steps for the first complete day was  $540.6$  ( $812.9$ ) and  $737.0$  ( $904.1$ ) for the second day. Mean (SD) step change score between the first and second day was  $196.5$  steps ( $669.3$ ) (range,  $-1546.0$  to  $2378.0$ ).

Only sex ( $\beta = 269.4$  [SE,  $112.8$ ];  $P = .02$ ) was significantly associated with the step change score; men increased their step count significantly more than women.

The **Figure** shows the unadjusted step total change scores and step change score deciles by LOS. Patients with low or negative change scores had longer LOS. The unadjusted mean difference in LOS between those who in-