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Validation of the FRAiL model to predict non-vertebral and hip fractures in nursing home residents

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ABSTRACT

Objective: Tools were unavailable to assess fracture risk in nursing homes (NH); therefore, we developed the Fracture Risk Assessment in Long term care (FRAiL) model. The objective of this validation study was to assess the performance of the FRAiL model to predict 2-year risk of non-vertebral and hip fractures in a separate large cohort of NH residents.

Methods: This retrospective cohort study included most long-stay NH residents in the United States (N = 896,840). Hip and non-vertebral fractures were identified using Medicare claims. The Minimum Data Set (MDS) was used to identify characteristics from the original FRAiL model. Multivariable competing risk regression was used to model risk of fracture.

Results: Mean age was 83.8 years (± 8.2 years) and 70.7% were women. Over a mean follow-up of 1.52 years (SD 0.65), 41,531 residents (4.6%) were hospitalized with non-vertebral fracture (n = 30,356 hip fractures). In the fully adjusted model, 14/15 model characteristics remained significant predictors of non-vertebral fracture. Female sex (HR = 1.55, 95% CI 1.52, 1.59), wandering (HR = 1.30, 95% CI 1.26, 1.34), and falls (HR = 1.28, 95% CI 1.26, 1.31) were strongly associated with non-vertebral fracture rate. Total dependence in ADLs (versus independence) was associated with a decrease in non-vertebral fracture rate (HR = 0.57, 95% CI 0.52, 0.64). Discrimination was moderate in men (C-index = 0.68 for hip, 0.66 for non-vertebral) and women (C-index = 0.68 for hip, 0.65 for non-vertebral), and calibration was excellent.

Conclusions: Our model comprised entirely from routinely collected data was able to identify NH residents at greatest risk for non-vertebral fracture.

1. Introduction

Major osteoporotic fractures are common, morbid, and costly among frail older adults, particularly nursing home (NH) residents. Hip fractures are the most common skeletal site for fracture in NH residents, with rates of 20–51 fractures/1000 person years [1–3]. Fractures of the humerus or wrist comprise nearly one fourth of the fractures in the NH setting, [2,4,5] with associated high rates of healthcare utilization [6]. Pelvic fractures occur commonly in this setting as well, [7] with significant excess mortality [8]. Fractures in the NH are associated with declines in functional status [9,10], and so these fractures significantly impact quality of life and increase healthcare spending [10].

To fill the need for a practical, easy to use screening tool for fractures for frail older adults, we previously developed a model to predict the 2-year absolute risk of hip fracture in NH residents. The model is called FRAiL (Fracture Risk Assessment in Long term care) [11], and it utilizes information that is already routinely collected on NH residents as part of the Minimum Data Set (MDS). A practical and validated screening tool could be used to identify residents with a reasonable life expectancy and a high risk for fracture who could potentially benefit from interventions to prevent falls and fracture. The purpose of the current validation study is to assess the performance of the FRAiL model to predict non-vertebral and hip fracture in a cohort of NH residents. We further examined the reasons for any differences in resident

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characteristics associated with non-vertebral fracture versus hip fracture by looking at the distribution of characteristics at different skeletal fracture sites.

2. Materials and methods

2.1. Data sources

The datasets used were the Minimum Data Set (MDS, version 2.0) files linked to the Medicare enrollment files, Parts A, B, and D claims, and hospice claims, from 1/1/2008 to 12/31/2011. The MDS is a comprehensive resident assessment instrument containing over 400 items, and it is federally mandated to be completed on all U.S. NH residents at the time of admission and quarterly thereafter [12]. This research was approved by the Institutional Review Board of Hebrew SeniorLife.

2.2. Study population

The retrospective cohort included all long-stay NH residents > 65 years throughout the United States enrolled in Medicare fee-for-service Parts A, B, and D in the years 2008–2009 (N = 1,392,604). Long-stay was defined as residing in the same NH for at least 100 days with no > 10 consecutive days outside the facility. The index date was defined as the day the resident qualified as long-stay. Because the model was intended to be used as a screening tool to guide osteoporosis medication management in residents for whom treatment is appropriate, we excluded residents without an MDS assessment within 100 days of the index date (n = 902), residents who were enrolled in hospice (n = 133,973), residents without any Part D prescription drug claims (n = 177,950), residents with any dispensing for an osteoporosis medication in the year prior to the index date (n = 119,873), and residents with advanced dementia (n = 63,212), defined as a Cognitive Performance Scale (CPS) of 6.

2.3. Model characteristics

The FRAiL model was developed to estimate the absolute two-year risk of hospitalized hip fracture in long-stay NH residents[11]. The model was developed in a large cohort of long-stay residents in 2007, and it was validated (to predict hip fracture) in an internal sample of residents in 2007 and an external sample of residents in 2011. Details have been previously published. We expect that the model could be used to target prescriptions of drugs to reduce fracture risk and deprescribing of psychotropic and other fall- and fracture-inducing medications. Therefore, for this study, we did not include medications in the model and considered only the 15 characteristics in the FRAiL model obtained from the MDS closest to and preceding baseline (i.e., age, sex, race, dementia severity, Activities of Daily Living (ADL) hierarchical summary score, independence in transferring from bed to chair, walking independence, urinary incontinence, prior falls, wandering, being easily distracted, body mass index (BMI), and presence of pressure ulcer, osteoarthritis, and diabetes). Although in the original model developed for hip fracture prediction, cognition was modeled as a continuous variable, we considered cognition as 6 categories (0 = cognitively intact through 5 = severe impairment) according to the validated CPS scale [13] because the association between CPS and non-vertebral fracture risk did not appear linear, as it did for hip fracture.

2.4. Fracture

Hospitalized hip fractures were defined using Part A claims as previously published [11]. Other hospitalized non-vertebral fractures were ascertained using the ICD-9 diagnostic codes for fracture in the primary or second position on Part A claims, with or without an accompanying procedural code. Non-vertebral fractures were defined as any fracture of the hip, femoral shaft, pelvis, patella, lower leg, ankle, upper arm, wrist, or clavicle/scapula. The estimated positive predictive value (PPV) using a similar claims based definition for these fracture types as comapred wtih chart review ranges from 79 to 98% [14]. To be sure that we were excluding encounters for the follow-up care of a prior fracture, we only counted the first fracture after the index date without a hospitalization for the same fracture type in the previous 100 days.

Table 1
Select characteristics of 896,840 nursing home residents included in the FRAiL model to predict the absolute 2- year risk of non-vertebral fracture.

Characteristic	n (%) or mean (SD)
Age, mean years (SD)	83.8 (8.2)
Female (%)	634,275 (70.7)
Race (%)	
White	753,076 (84.0)
Black	107,908 (12.0)
Other	35,856 (4.0)
Cognition[a]	
Intact-borderline (0-1)	226,096 (25.2)
Mild-moderate impairment (2-3)	505,706 (56.4)
Severe impairment (4-5)	165,038 (18.4)
Bladder continence	
Mostly continent	463,920 (51.7)
Frequent incontinence	183,656 (20.5)
Total incontinence	249,233 (27.8)
Previous fall	398,807 (44.5)
Independent or supervision with transfers	245,328 (27.4)
Wandering	77,307 (8.6)
BMI (per kg/m^2)	26.1 (6.3)
Diabetes	293,458 (32.7)
Non-vertebral fracture site	
Hip	30,356 (3.4)
Pelvis	2,978 (0.3)
Femoral shaft	3,828 (0.4)
Lower leg	1,304 (0.2)
Ankle	1,409 (0.2)
Patella	196 (0.02)
Upper arm	2,135 (0.2)
Lower arm/wrist	1,212 (0.1)
Scapula/clavicle	1,464 (0.2)

[a] Measured by the Cognitive Performance Scale.

2.5. Statistical analysis

Competing risk proportional hazards regression using the Fine and Gray method [15] was used to model the association between each characteristic and risk of hip and non-vertebral fracture, accounting for observed mortality [16]. Adjusted hazard ratios (HRs) with 95% confidence intervals (CIs) were estimated from these analyses. Residents with missing data on any of the covariates (< 5%) were not included in the models.

We assessed discrimination of the model as a continuous measure using the concordance index (C-index). Calibration was assessed by comparing the observed versus expected frequency of fracture across deciles of predicted risk. Whenever the associations between the resident characteristics and non-vertebral fracture outcome differed from models for hip fracture, we compared the proportion of residents with and without each of the nine fracture types separately using a Chi-squared test. We calculated the sensitivity, specificity, and likelihood ratio of hip and non-vertebral fracture using a FRAiL threshold of ≥6% to define high risk. A cutpoint of 6% was selected because it approximates the highest quintile of risk.

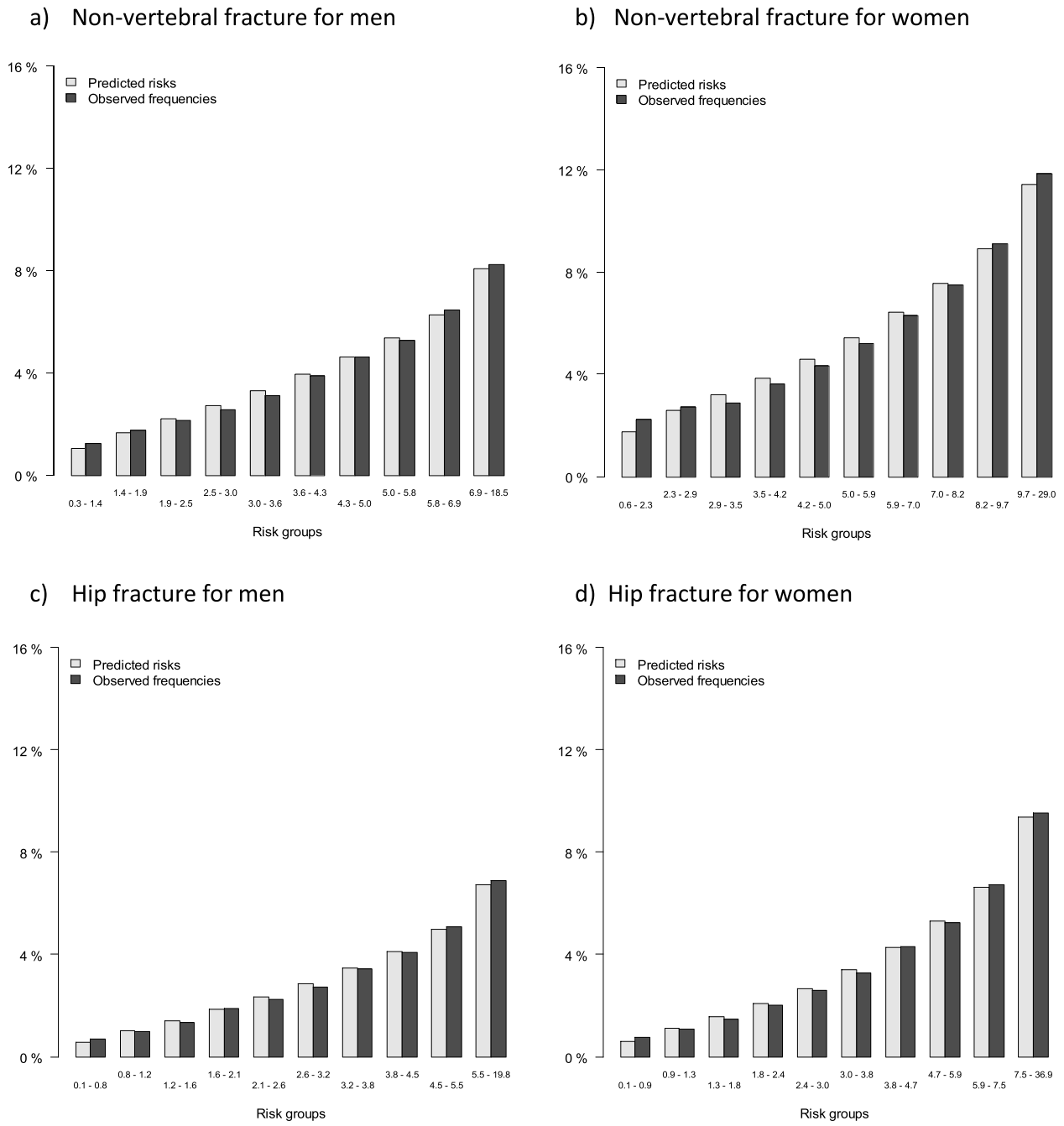

Fig. 1. Calibration curves comparing the observed to expected number of non-vertebral and hip fracture across deciles of predicted risk using FRAiL model.

2.6. Stability analyses

We repeated models for non-vertebral fractures using a broader definition that included hospitalized and non-hospitalized fractures identified from both Part A (inpatient) and Part B (outpatient) claims. For fractures identified using Part B claims only, we required a procedural code for fracture management on same date as the diagnostic code [17,18]. A complete list of diagnostic and procedural codes is included in Appendix 1. All analyses were done using SAS (v9.3) and R (Prediction Error Curves (PEC) pkg).

3. Results

The final sample included 896,840 residents. Mean (SD) age of the residents was 83.8 (± 8.2 years), 70.7% were women, 84.0% were white, and 12.0%, black. Most residents (56.0%) had moderate-to-severe cognitive impairment. Thirty -one percent required no assistance or limited assistance with their ADLs, whereas 3.2% required extensive assistance with all ADLs. Other characteristics are presented in Table 1.

Over a mean 1.52 years of follow-up (SD 0.65), 41,531 residents (4.6%) were hospitalized with non-vertebral fracture. The most frequent non-vertebral fracture site was hip (n = 30,356), followed by the femoral shaft (n = 3828), pelvis (n = 2978), and upper arm (n = 2135).

In the model with hospitalized fracture, all characteristics in the original FRAiL model remained significant predictors non-vertebral and hip fracture except for "being easily distracted." Female sex (HR = 1.55, 95% CI 1.52, 1.59), wandering (HR = 1.30, 95% CI 1.26, 1.34), and prior falls (HR = 1.28, 95% CI 1.26, 1.31) were the characteristics associated with the greatest increase in non-vertebral

Table 2
Association[a] between the characteristics included in the FRAiL model and the rate of non-vertebral fracture over 2-years (N = 896,840).

	Hip fractures identified by inpatient claims (n = 30,356)	Non-vertebral fractures identified by inpatient claims (n = 41,531)	Non-vertebral fractures identified by inpatient and outpatient claims (n = 80,462)
Resident characteristic		HR (95% CI)	
Age, yrs (per 1-year increment)	1.00 (1.00, 1.00)	1.00 (1.00, 1.00)	0.99 (0.99, 0.99)
Female	1.28 (1.25, 1.32)	1.55 (1.51, 1.59)	1.74 (1.71, 1.77)
Race			
White	REF	REF	REF
Black	0.53 (0.50, 0.55)	0.58 (0.56, 0.60)	0.61 (0.60, 0.63)
Hispanic	0.93 (0.85, 1.02)	1.03 (0.95, 1.11)	1.01 (0.96, 1.07)
Asian	0.64 (0.56, 0.73)	0.67 (0.59, 0.75)	0.71 (0.66, 0.77)
Native American	1.13 (0.96, 1.32)	1.13 (0.99, 1.30)	1.06 (0.96, 1.17)
Other/Unknown	0.75 (0.65, 0.86)	0.81 (0.72, 0.91)	0.76 (0.70, 0.83)
Cognitive Performance Score			
Intact (0)	REF	REF	REF
Borderline intact (1)	1.03 (0.98, 1.08)	1.00 (0.96, 1.04)	0.99 (0.96, 1.01)
Mild impairment (2)	1.10 (1.05, 1.15)	1.03 (0.99, 1.06)	1.00 (0.98, 1.02)
Moderate impairment (3)	1.21 (1.16, 1.25)	1.06 (1.03, 1.10	1.01 (1.00, 1.03)
Mod-severe impairment (4)	1.15 (1.08, 1.21)	0.97 (0.93, 1.02)	0.90 (0.87, 0.93)
Severe impairment (5)	1.15 (1.08, 1.22)	0.96 (0.91, 1.01)	0.89 (0.86, 0.92)
ADL Hierarchy Scale			
Independent or mild dependence (0-2)	REF	REF	REF
Extensive assistance 1 (3)	1.01 (0.98, 1.05)	1.00 (0.98, 1.03)	0.98 (0.96, 1.00)
Extensive assistance 2 (4)	0.92 (0.88, 0.97)	0.90 (0.86, 0.93)	0.94 (0.91, 0.96)
Dependent (5)	0.80 (0.75, 0.84)	0.78 (0.75, 0.82)	0.89 (0.87, 0.92)
Total dependence (6)	0.57 (0.49, 0.67)	0.57 (0.52, 0.64)	0.60 (0.56, 0.65)
Locomotion in Room			
Independent or supervision	REF	REF	REF
Limited assistance	0.83 (0.80, 0.86)	0.86 (0.83, 0.89)	0.87 (0.85, 0.89)
Extensive assistance	0.73 (0.69, 0.77)	0.76 (0.73, 0.80)	0.79 (0.77, 0.82)
Total dependence	0.48 (0.45, 0.50)	0.60 (0.58, 0.63)	0.75 (0.73, 0.77)
Bladder continence			
Mostly continent	REF	REF	REF
Frequent incontinence	0.85 (0.82, 0.88)	0.83 (0.81, 0.85)	0.82 (0.80, 0.83)
Total incontinence	0.75 (0.72, 0.78)	0.77 (0.75, 0.80)	0.74 (0.72, 0.75)
Previous fall	1.30 (1.27, 1.33)	1.28 (1.26, 1.31)	1.53 (1.51, 1.55)
Transfer Performance			
Independent or supervision	REF	REF	REF
Limited assistance	0.94 (0.91, 0.98)	0.95 (0.92, 0.99)	0.96 (0.93, 0.98)
Extensive assistance	0.73 (0.69, 0.77)	0.80 (0.76, 0.83)	0.91 (0.88, 0.94)
Total dependence	0.54 (0.50, 0.59)	0.75 (0.71, 0.80)	0.92 (0.88, 0.96)
Easily distracted	1.04 (1.01, 1.07)	1.01 (0.98, 1.04)	1.01 (0.99, 1.03)
Wandering	1.37 (1.32, 1.42)	1.30 (1.26, 1.34)	1.19 (1.16, 1.21)
Osteoarthritis	0.93 (0.91, 0.95)	0.94 (0.90, 0.98)	0.98 (0.96, 0.99)
BMI (per kg/m^2)	0.95 (0.94, 0.95)	1.08 (1.06, 1.11)	0.98 (0.96, 0.98)
Pressure ulcer (any stage II-IV versus none)	0.87 (0.82, 0.92)	0.94 (0.90, 0.98)	1.13 (1.10, 1.16)
Diabetes	1.05 (1.02, 1.08)	1.08 (1.06, 1.11)	1.03 (1.01, 1.05)

[a] Among > 95% of residents with complete characteristics and who were included in the final model.

fracture rate. Black race (versus white; HR = 0.58, 95% 0.56, 0.60), and total dependence in ADLs (versus independence; HR = 0.57, 95% CI 0.52, 0.64) were the characteristics associated with the greatest reduction in non-vertebral fracture rate. Residents with moderate cognitive impairment were at the greatest risk for non-vertebral fracture (HR compared with intact residents: 1.06, 95% CI 1.03, 1.10). In the model predicting hip fracture, the C-index was 0.68 in both women and men. Results were similar in the model predicting non-vertebral fracture (C-index = 0.65 in women, 0.66 in men). Calibration was excellent for hip fracture in men and women and for non-vertebral fracture in men across deciles of predicted risk (Fig. 1). Calibration was only slightly diminished for non-vertebral fracture in women.

In the model with hospitalized and non-hospitalized fracture, we identified 80,462 residents with non-vertebral fracture (9.0%). Nearly two thirds (65.5%) of pelvic fractures were identified using Part A (inpatient) claims, whereas < 15% of wrist fractures were identified using Part A claims. In stability analyses with fractures ascertained from inpatient and outpatient claims (Table 2), results were largely similar. Discrimination was less: C-index = 0.63 in men and women.

Associations between the 15 clinical characteristics and the risk of hospitalized hip versus non-vertebral fracture differed in 3 instances: female sex, cognition and BMI. Female sex was associated with a greater rate of hospitalized hip and non-vertebral fracture, although the association was stronger for non-vertebral fracture (HR for hip 1.28, 95% CI 1.25, 1.32 vs HR for non-vertebral 1.55, 95% CI 1.51, 1.59). Higher BMI was associated with a decreased rate of hospitalized hip fracture (HR 0.95, 95% CI 0.94, 0.95), whereas it was associated with an increased rate of hospitalized non-vertebral fracture (HR 1.08, 95% CI 1.06, 1.11). When inpatient and outpatient claims were used to ascertain fracture, the association between pressure ulcers differed in hip versus non-vertebral fractures. The presence of a pressure ulcer was associated with a decrease in the rate of hospitalized hip fracture and hospitalized non-vertebral fracture, whereby pressure ulcers were associated with an increased rate of non-vertebral fracture when outpatient claims were included (HR 1.13, 95% CI 1.10, 1.16).

The association between cognition, BMI, and pressure ulcers and non-hip lower extremity fracture (femoral shaft, tibia, fibula, patella, ankle) differed from the association with hip and fractures not involving the lower extremity (Table 3). For example, the mean BMI of residents with hip fracture was 24.2 kg/m^2 whereas the mean BMI of

Table 3
Unadjusted association between cognition, BMI, pressure ulcers, and hospitalized non-vertebral fracture across the 9 individual fracture sites.

Fracture site[a]	Moderate cognitive impairment[b], n (%)		p-value	BMI, mean kg/m^2 (SD)		p-value	Pressure ulcer[c], n (%)		p-value
	Fracture	No fracture		Fracture	No fracture		Fracture	No fracture	
Hip	12,742 (42.0)	324,875 (37.5)	< 0.001	24.2 (5.1)	26.2 (6.3)	< 0.001	1,348 (2.0)	67,824 (7.8)	< 0.001
Pelvis	1,087 (36.5)	336,530 (37.7)	0.20	23.8 (5.0)	26.1 (6.3)	< 0.001	161 (5.4)	69,011 (7.7)	< 0.001
Femoral shaft	1,396 (36.5)	336,221 (37.7)	0.13	26.9 (6.8)	26.1 (6.3)	< 0.001	385 (10.1)	68,787 (7.7)	< 0.001
Lower leg	398 (30.5)	337,219 (37.7)	< 0.001	27.4 (7.1)	26.1 (6.3)	< 0.001	138 (10.6)	69,034 (7.7)	0.001
Ankle	435 (30.9)	337,182 (37.7)	< 0.001	30.0 (7.2)	26.1 (6.3)	< 0.001	89 (6.3)	69,083 (7.7)	0.14
Patella	71 (36.2)	337,546 (37.7)	0.68	26.1 (5.9)	26.1 (6.3)	0.87	16 (8.2)	69,156 (7.7)	0.97
Upper arm	802 (37.6)	336,815 (37.7)	0.94	25.8 (6.4)	26.1 (6.3)	0.01	115 (5.4)	69,057 (7.7)	< 0.001
Lower arm/wrist	443 (36.6)	337,174 (37.7)	0.43	24.9 (5.7)	26.1 (6.3)	< 0.001	475 (3.9)	69,125 (7.7)	< 0.001
Scapula/clavicle	58 (36.0)	337,559 (37.7)	0.67	24.7 (6.4)	26.1 (6.3)	0.004	< 11[d]	69,163 (7.7)	0.60

[a] Residents were classified according to whether they experienced any hospitalized fracture at that site during follow-up.
[b] Among the 337,617 residents with moderate cognitive impairment, defined as a score of 3 on the MDS Cognitive Performance Scale before long-stay qualification.
[c] Among the 69,172 residents with a pressure ulcer, defined as any stage II-IV pressure ulcer in the 7 days before the long-stay qualification MDS assessment.
[d] Actual number not displayed to comply with CMS cell size suppression policy.

residents with ankle fracture was 30.0 kg/m^2. Among residents with hip fracture, 2% had a documented pressure ulcer prior to the fracture as compared with 10.6% and 16.3% of residents with lower leg and ankle fractures, respectively.

Using a threshold of ≥6% to define high risk, the FRAiL model had a specificity of 62% to identify non-vertebral fracture for women and 83% for men (sensitivity 62% and 34% for women and men, respectively). Using the same threshold for hip fractures, the specificity was 82% for women and 93% for men (sensitivity 43% and 17% for women and men, respectively). The likelihood ratio for predicting 2-year non-vertebral fracture was 1.6 in women and 1.9 in men, and for hip fracture 2.3 in women and 2.6 in men, respectively.

4. Discussion

We found that our straightforward model comprised entirely from readily accessible MDS data was able to identify NH residents at greatest risk for non-vertebral fracture. Discrimination was somewhat less as compared with the model predicting hip fracture, but calibration was excellent. Overall, we observed consistency in the associations between the fifteen characteristics in the FRAiL model when fractures were identified using inpatient claims exclusively, or both inpatient and outpatient claims. Consequently, the FRAiL model can be used by researchers, NH administrators, and policy-makers interested in identifying residents at greatest risk for fracture. It is possible that this tool might also be useful to predict fracture in other frail populations, such as Assisted Living.

Previously we developed the FRAiL model to predict the absolute risk of hip fracture in long-stay NH residents. Using administrative data from the MDS that is already routinely collected on all U.S. NH residents in 2007, the FRAiL model was able to discriminate residents at risk for hip fracture with good accuracy (C-index = 0.71 in women and 0.69 in men). In the present cohort (2008-2009), the model had similar performance in predicting hip fracture (0.68 in men and women). Discrimination measures were slightly lower when predicting non-vertebral fracture (0.65 in women and 0.66 in men) as compared with hip fracture. However, this model's performance is similar to the validated and often-used FRAX tool without BMD, where the C-index for major osteoporotic fracture ranges from 0.60 to 0.67 [19]. It is also similar to the discrimination of a one-year prediction model developed for Canadian NH residents (C-statistic for hip fracture: 0.64–0.67) [20]. Thus, the FRAiL model may be used to identify NH residents at risk for any non-vertebral fracture.

The lower discrimination with non-vertebral fractures may be due to increased misclassification of non-hip fractures. Prior validation studies using Medicare claims found the PPV of inpatient claims to identify hip fracture to be 97%, as compared with a PPV of 86–99% for the other fracture sites we included [18]. It is also likely that the model has lower discrimination to predict a composite fracture outcome if some fracture sites have unique risk factors. Our findings that residents with pressure ulcers are more likely to experience a non-hip lower extremity fracture suggest the possibility that these fracture types are occurring in immobile residents. Removing non-hip lower extremity fracture outcomes would enhance the discrimination of the model; however, providers are unlikely to use different prediction models for these sites, and a composite assessment of fracture risk is likely to be most useful clinically.

Our study has several limitations. First, our model included data captured by MDS version 2.0 in order to have sufficient follow-up for all fracture types. MDS version 3.0 is presently being used in the U.S., although version 2.0 remains in use in many countries. We previously validated the hip fracture model in a more contemporary cohort (2011) using MDS version 3.0, and the results were similar [11]. Therefore, we expect that our model for non-vertebral and vertebral fracture will perform similarly with the updated MDS version. Second, we did not have information on calcium and non-prescription forms of Vitamin D, nor did we have information on disease severity or every clinical characteristic that could be associated with fracture, such as orthostatic blood pressure or bone mineral density. Adding these and other characteristics may improve our model performance, but it compromises the ease of use of the present tool and the potential for automated calculation during routine MDS assessments. Third, the quality of the data that the MDS captures may vary according to facility and state, and this may limit the validity of our tool in facilities with lower quality data collection. Fourth, only complete case analysis was considered. Cases with missing data were rare (< 5%), and using a similar cohort, we found no evidence that missingness was related to the outcome of fracture [21]. Fifth, characteristics such as independence in walking are likely to change over time in NH residents. Although modeling the risk of fracture with time varying characteristics would likely improve

model performance, it would have prohibited the use of the model as a screening tool in clinical practice. Finally, this validation study was conducted in a very large smaple of U.S. NH residents (2008-2009) that are mostly unique from the development cohort (2007), but the model has not been prospectively validated.

5. Conclusion

This study demonstrates that the FRAiL model may be a useful tool to identify NH residents at greatest risk for hip and non-vertebral fracture. Facilities, providers, researchers, and policy-makers interested in using the tool can access the published web-based calculator to facilitate calculation: https://ifar-frail.hsl.harvard.edu. Alternatively, it is possible to develop an automated calculation version because all model characteristics are already collected as part of the MDS. All NH facilities must regularly report MDS data to the Centers for Medicare & Medicaid Services, regardless of whether they have adopted an electronic medical record. Routine identification of high risk residents at the time of MDS completion would allow facilities to efficiently target interventions to prevent falls and fracture, such as initiation of osteoporosis treatments or deprescribing of treatments associated with falls and fracture, in residents at greatest risk.

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Prior presentation

This work was submitted in part as an abstract to be presented at the 2018 annual conference for the Gerontological Society of America in Boston, MA.

Declaration of competing interest

Dr. Andrew Zullo, Dr. Tingting Zhang, Ms. Yoojin Lee, and Mr. Kevin McConeghey declare they have no conflicts of interest. Dr. Sarah Berry and Dr. Douglas Kiel receive royalties from Wolters Kluwer for a chapter in Up-to-Date.

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