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Validation of the Hendrich II Fall Risk Model: The imperative to reduce modifiable risk factors

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ABSTRACT

Aim: To validate the psychometrics of the Hendrich II Fall Risk Model (HIIFRM) and identify the prevalence of intrinsic fall risk factors in a diverse, multisite population.

Background: Injurious inpatient falls are common events, and hospitals have implemented programs to achieve "zero" inpatient falls.

Methods: Retrospective analysis of patient data from electronic health records at nine hospitals that are part of Ascension. Participants were adult inpatients ($N = 214{,}358$) consecutively admitted to the study hospitals from January 2016 through December 2018. Fall risk was assessed using the HIIFRM on admission and one time or more per nursing shift.

Results: Overall fall rate was 0.29%. At the standard threshold of HIIFRM score ≥ 5, 492 falls and 76,800 non-falls were identified (fall rate 0.36%; HIIFRM specificity 64.07%, sensitivity 78.72%). Area under the receiver operating characteristic curve was 0.765 (standard error 0.008; 95% confidence interval 0.748, 0.781; $p < 0.001$), indicating moderate accuracy of the HIIFRM to predict falls. At a lower cut-off score of ≥ 4, an additional 74 falls could have been identified, with an improvement in sensitivity (90.56%) and reduction in specificity (44.43%).

Conclusion: Analysis of this very large inpatient sample confirmed the strong psychometric characteristics of the HIIFRM. The study also identified a large number of inpatients with multiple fall risk factors ($n = 77{,}292$), which are typically not actively managed during hospitalization, leaving patients at risk in the hospital and after discharge. This finding represents an opportunity to reduce injurious falls through the active management of modifiable risk factors.

1. Introduction

Injurious falls are among the most common adverse events in hospitals and are a major contributor to morbidity, mortality, and health care costs. The Agency for Healthcare Research and Quality (AHRQ, 2019) reports an inpatient fall rate of 7.6 per 1000 discharges or 227,000 falls in hospitals in the United States in 2017 (preliminary data). AHRQ also estimates additional hospital inpatient cost per inpatient fall to be $6694, which represents only a fraction of the total economic burden associated with falls. In 2015, total healthcare spending attributable to falls in older adults in the United States was almost $50 billion (Florence et al., 2018). Approximately one in four patients who fall in hospitals suffer an injury as a result of the fall (Bouldin et al., 2013), including fractures, lacerations, excessive bleeding, and head trauma.

Identifying inpatients who are at high risk for injurious falls is essential to reducing the risk of harm. To fill this need, a number of fall risk assessment tools have been developed and evaluated in the clinical setting (Conley, Schultz, & Selvin, 1999; Currie, Mellino, Cimino, & Bakken, 2004; Hendrich, Bender, & Nyhuis, 2003; Hendrich, Nyhuis, Kippenbrock, & Soja, 1995; Hester & Davis, 2013; Lohman et al., 2017; Morse, Black, Oberle, & Donahue, 1989; Morse, Tylko, & Dixon, 1987; Nyberg & Gustafson, 1996; Oliver, Britton, Seed, Martin, & Hopper, 1997; Poe et al., 2018; Schmid, 1990; Tinetti, Williams, & Mayewski, 1986). To be effective, such a tool should be sensitive enough to identify high-risk patients and specific enough to identify patients who are not at risk, thereby allowing for the targeted use of health care resources.

Among the most widely used tools is the Hendrich II Fall Risk Model (HIIFRM). The HIIFRM is an evidence-based tool that requires only

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60–90 s to complete. The initial validation study assessed 355 fall patients and 780 randomized controls (non-falls) in a general acute-care population for 600 potential fall risk variables reported in the literature. Through stepwise logistic regression, eight risk factors were identified as significantly and independently related to inpatient falls. This validation study reported sensitivity of 74.8% and specificity of 73.9% (Hendrich et al., 2003).

In the current payment and regulatory context, many hospitals have implemented fall prevention programs with the goal of achieving "zero" inpatient falls. Beginning in 2008, in response to the costs of managing injurious falls, the Centers for Medicare & Medicaid Services (CMS, 2007) declared preventable, inpatient injurious falls to be "never events" and no longer reimburses hospitals for the treatment of fall-related injuries. Similarly, The Joint Commission National Patient Safety Goals (2020) require hospitals to reduce the risk of patient injury resulting from falls, including the use of a fall reduction program.

Unfortunately, a major tactic of many hospital fall prevention programs with a focus on achieving "zero falls," especially in the older adult population, is to restrict the mobility of at-risk inpatients (Fehlberg et al., 2017; Growdon, Shorr, & Inouye, 2017). Such programs respond only to the intent (i.e., patient safety), without attending to the underlying fall risk factors themselves (e.g., polypharmacy, dehydration, mentation). One unintended consequence of this type of policy is immobility among at-risk patients, which is known to increase preventable, hospital-acquired conditions and impact quality, safety and cost (Brown, Friedkin, & Inouye, 2004; Brown, Redden, Flood, & Allman, 2009; Brown, Roth, Allman, Sawyer, Ritchie, & Roseman, 2009; Covinsky, Pierluissi, & Johnston, 2011; Kortebein, Ferrando, Lombeida, Wolfe, & Evans, 2007; Krumholz, 2013; Loyd et al., 2019; Wald et al., 2019; Zisberg et al., 2011; Zisberg, Shadmi, Gur-Yaish, Tonkikh, & Sinoff, 2015). Approaches that focus on restricting patient mobility, rather than fostering safe, progressive mobility, leave many patients at risk for falls, increase stress on nurses and caregivers, and miss an opportunity to link fall risk factors to interventions that can improve overall health and mobility (Hoffman, Shuman, Montie, Anderson, & Titler, 2019; King, Pecanac, Krupp, Liebzeit, & Mahoney, 2018).

A recent study found that the CMS policy on inpatient falls has had no effect on the rates of injurious falls, suggesting that new approaches to fall prevention are needed (Waters et al., 2015). Indeed, research-to-date suggests that interventions intended to limit patient movement, such as the use of bed alarms, don't reduce inpatient falls when implemented as primary interventions (Sahota et al., 2014; Shorr et al., 2012), whereas interventions that focus on intrinsic fall risk factors, such as delirium (Babine et al., 2018; Hshieh et al., 2015) or that encourage ambulation (Brown et al., 2016; Hastings, Sloane, Morey, Pavon, & Hoenig, 2014) have shown promise for reducing falls or improving postdischarge mobility.

This study was undertaken to evaluate the diagnostic accuracy of the HIIFRM in today's high-acuity environment within a continuum of care context, using a very large sample (> 200,000 patients) of consecutively admitted adult patients from nine acute-care hospitals in a nonprofit health system. The goals were to: 1) confirm the diagnostic accuracy of the HIIFRM in predicting falls, 2) validate the recommended cut-off score for high fall risk, and *most* importantly 3) describe how these evidence-based risk factors should be mapped to primary interventions to reduce intrinsic fall risk and promote the patient's healthy return to home and community regardless of age.

2. Methods and materials

A retrospective analysis was conducted of all adult patients admitted to the study hospitals from January 2016 through December 2018. The study was conducted at a convenience sample of hospitals from a large, national, not-for-profit health care system (Ascension), which includes 2600 sites of care, 150 hospitals, and > 50 senior care facilities located across 20 states and the District of Columbia. Institutional review board approval was not required, according to Exemption 45 CFR 46.101(b)(4). Access to patient-level data was restricted to analysts with protected security access and storage. Nonidentifiable patient data were extracted from the electronic health record (EHR) of nine hospitals, including seven acute care sites with trauma populations and two critical access sites. Bed numbers at the included sites ranged from 25 to 474, with all levels of acuity and types of inpatient care, including behavioral health, skilled nursing, observation, and emergency departments (EDs), represented in the sample. Pediatric cases (patients < 18 years of age) were excluded.

Study hospitals had large patient populations representative of national diversity for race, gender, age, ethnicity, case-mix, length of stay, licensed bed size, academic and nonacademic settings, and urban and rural locations. Individual fall risk scores were assessed during each hospitalization, and the categorical variable of fall and non-fall (controls) was used to differentiate the populations for statistical evaluation. Importantly, all non-falls (controls) were collected in the sample during the 3-year study period.

Data abstracted from the EHR included facility type, fall occurrence during hospitalization, nursing unit, bed number, unique patient identifier (ID), highest HIIFRM score during hospitalization, date and time of fall, admission date and time, discharge date and time, de-identified medical record number, encounter ID, source of admission, date of birth, race, ethnicity, and sex. Patient encounter data were extracted from the EHR based on the risk assessment date, where the fall event occurred between the admission and discharge dates. Length of stay was calculated as the difference between the discharge and admission dates. Duplicate records were eliminated by using the maximum risk assessment score, maximum patient age, and maximum length of stay based on the combination of encounter IDand admission date. No other data were collected from records for this study.

2.1. HIIFRM tool

The HIIFRM consists of eight variables that are weighted based on odds ratios developed through logistic regression analysis. The tool includes measures of mental status (confusion, disorientation, impulsivity), symptomatic depression, altered elimination, dizziness/vertigo, two categories of medications (prescribed and administered antiepileptics and benzodiazepines), gender, and functional status (the "Rising From a Chair" item from the Get-Up and Go Test). It is important to note that antiepileptics and benzodiazepines were the only two drug classes identified in the statistical analyses as adding additional risk of falls in the original HIIFRM validation study (Hendrich et al., 2003). The side effects of many other categories of medication contribute to fall risk but are captured in other HIIFRM risk factors, such as effects on mobility, gait, cognition, mood, or elimination changes. The tool is scored by the number of risk factors present and the patient's ability to rise from a chair, balance, walk several steps, and turn around; total scores range from 0 (no risk factors) to 16 (all risk factors). The recommended cut-off score for categorizing patients as high fall risk is ≥ 5, as described in previous studies (Hendrich et al., 2003). The HIIFRM was administered for each patient at multiple times during hospitalization, including on admission and during each nursing shift; some patients were evaluated more than once per nursing shift. For this analysis, the highest recorded fall risk score was used.

2.2. Statistical analysis

The diagnostic ability of the model was assessed using the receiver operating characteristic (ROC) curve, a graphical plot of the true positive rate (sensitivity) against the false positive rate (1-sensitivity). The area under the curve (AUC) of the ROC curve was used to measure how well the test distinguishes between patients with a fall and those without a fall. Positive predictive value (PPV), negative predictive

Table 1
Patient demographics and source of admission by fall and non-fall groups.

Variable	Fall		Non-fall		p-value*
	n	%	n	%	
Sex					
Female	352	56.3	126,134	59	< 0.0001
Male	273	43.7	87,596	41	
Unknown/unspecified	–	–	3	0	
Race					
White	529	84.6	171,195	80.1	< 0.0001
Black or African American	49	7.8	22,712	10.6	
Other	22	3.5	10,066	4.7	
Asian	6	1.0	3165	1.5	
Unknown	11	1.8	2784	1.3	
Declined to specify	5	0.8	1685	0.8	
Multiple	2	0.3	1387	0.6	
American Indian/Alaska Native	1	0.2	543	0.3	
Native Hawaiian/Pacific Islander	0	0	38	0	
American Indian/Eskimo/Aleut	0	0	22	0	
Ethnicity					
Not Hispanic or Latino	520	83.2	154,487	72.3	< 0.0001
Hispanic or Latino	82	13.1	52,261	24.5	
Unknown	11	1.8	3554	1.7	
Declined to specify	12	1.9	3208	1.5	
Source of admission					
Emergency department	494	79.0	123,089	57.6	< 0.0001
Routine admission	48	7.7	43,821	20.5	
Admission through OP services	11	1.8	13,592	6.4	
Transfer from another health care facility	62	9.9	12,301	5.8	
Admitted through OP clinic	0	0	11,856	5.5	
Other	10	1.6	9074	4.2	

Note. OP = outside provider.
* Pearson's chi-squared test.

value (NPV), and positive and negative likelihood ratios were calculated across HIIFRM risk scores. The ROC curve was generated using SPSS Statistics v22. The remaining calculations were performed in Microsoft Excel.

Where appropriate, statistical differences between groups were calculated using Pearson's chi-squared test (categorical variables) and two-tailed *t*-tests (continuous variables).

3. Results

Demographic variables for the patient population are listed in Table 1. A majority of the study population was of female sex and white race, as was the majority of both fall and non-fall groups. The most common source of admission was the ED. Differences between fall and non-fall groups were statistically significant for sex, race, ethnicity, and source of admission (Table 1).

During the 36-month study period, a total of 214,358 consecutive adult cases were identified at the study sites: 625 falls and 213,733 non-falls. Differences between fall and non-fall groups were statistically significant ($p < 0.0001$) for mean HIIFRM risk score, length of stay, and patient age (Table 2).

The fall rate for the entire study population was 0.29%. A total of 77,292 cases were identified with a maximum HIIFRM score of ≥5, making up 36% of the study population. Of cases with an HIIFRM score of ≥5, 492 falls and 76,800 non-falls were identified (fall rate 0.36%; Fig. 1). At the standard cut-off score of ≥5, PPV was 0.64%; using a cut-off score of ≥4, the fall rate was 0.18% and PPV 0.47% (Fig. 1 and Table 3). As illustrated in Fig. 2, the AUC for the ROC curve was 0.765 (standard error 0.008; 95% confidence interval [CI] 0.748, 0.781; $p < 0.001$). This value indicates moderate accuracy to predict falls in the study population.

The full results of the psychometric evaluation of the HIIFRM are illustrated in Table 3. At the standard cut-off score of ≥5, the HIIFRM

Table 2
HIIFRM risk scores, length of stay, and age of patients in fall and non-fall groups.

Variable	Minimum	Maximum	Mean	SD	p-value*
HIIFRM risk score					
Falls	0	15	7.61	3.26	< 0.0001
Non-falls	0	16	4.38	3.28	
Length of stay, days					
Falls	0	48	5.54	5.89	< 0.0001
Non-falls	0	294	3.63	4.88	
Age, years					
Falls	18	103	74.55	15.92	< 0.0001
Non-falls	18	119	54.47	19.60	

* Two-tailed *t*-test.

had a specificity of 64.07%, sensitivity 78.72%, PPV 0.64%, NPV 99.9%, negative likelihood ratio 0.33, and positive likelihood ratio 2.19. At the lower cut-off score of ≥4, an additional 74 falls could have been identified, with a corresponding improvement in sensitivity (90.56%) and reduction in specificity (44.43%).

4. Discussion

Injurious falls are among the most common and dangerous adverse events for hospitalized patients, and their reduction should be a national safety imperative. As part of this effort, accurate fall risk assessment is critical to the efficient application of limited hospital resources. However, inpatients are a broad and diverse population, and published studies of fall risk assessment tools have depended on relatively small samples of inpatients, often from a single institution or nursing unit. These studies have typically been based on random samples or matched cohorts of falls and controls (non-falls). The size and design of this validation study set it apart from other studies of fall risk assessment tools. The current study included a diverse sample of 214,358 adult inpatients (625 falls) admitted consecutively over 36 months to nine acute-care sites. To our knowledge, this is the largest inpatient sample included in any validation study of a fall risk assessment tool.

4.1. HIIFRM psychometrics

The HIIFRM demonstrated a sensitivity of 78.72% and specificity of 64.07% at risk score ≥ 5. The AUC of 0.765 indicates moderate predictive accuracy. It is important to note that the study was conducted in hospitals in which fall prevention programs were long-standing with continuous fall reduction goals in place, which was documented to have reduced the fall rate over many years, thereby artificially reducing the AUC and underestimating diagnostic accuracy. The duration of this study (3 years), the large sample size, and the representative diversity of the study population support the generalizability of the findings and should minimize the impact of variations in local practice patterns.

These results compare favorably to previous studies of the HIIFRM and other fall risk tools. Published studies of the HIIFRM, using various methodologies (e.g., retrospective case-control, prospective observational, cross-sectional) and undertaken across various clinical settings (e.g., general acute care, geriatric acute care, psychiatric care, rehabilitation) and countries (e.g., China, Portugal, Italy, Lebanon), have reported AUC of 0.62 to 0.82, sensitivities of 45.8% to 100%, and specificities of 35% to 89.3% (Caldevilla, Costa, Teles, & Ferreira, 2013; Campanini et al., 2018; Chapman, Bachand, & Hyrkas, 2011; Cho, Boo, Chung, Bates, & Dykes, 2019; Hendrich et al., 1995, 2003; Ivziku, Matarese, & Pedone, 2011; Jung & Park, 2018; Kim, Mordiffi, Bee, Devi, & Evans, 2007; Lovallo, Rolandi, Rossetti, & Lusignani, 2010; Nassar, Helou, & Madi, 2014; Van Dyke, Singley, Speroni, & Daniel, 2014; Zhang, Wu, Lin, Jia, & Cao, 2015). However, no study of the HIIFRM or

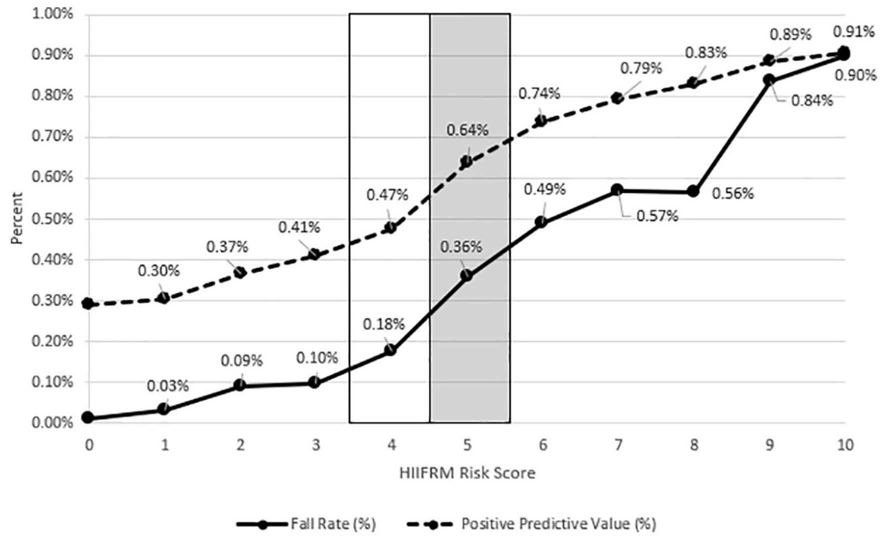

Fig. 1. Fall rate and positive predictive value (PPV) by maximum HIIFRM risk score.
Note. Overall fall rate for the entire study population was 0.29%. The standard cut-off for high fall risk on the HIIFRM is score ≥ 5.

any other fall risk model included as robust and diverse a patient sample from acute-care settings representative of hospitals nationwide as the current study.

The very large sample size may account for the statistical differences between groups in patient demographics (Table 1). However, these findings could introduce new hypotheses regarding fall risk in specific populations. For example, male gender is a risk factor on the HIIFRM, and the proportion of males was significantly higher in the falls group. Patients of male sex made up 41% of the study population (n = 87,869) but 43.7% of those who fell, whereas patients of female sex made up 59% of the study population (n = 126,486) but 56.3% of those who fell ($p < 0.0001$). Also, a higher proportion of patients in the falls group were admitted via the ED, which reflects today's admission patterns and highlights that intrinsic fall risk factors travel with the patient and are present on admission. This finding points to the larger opportunity to reframe modifiable fall risk factors as part of a holistic, cross-continuum plan of care, not just as part of the hospital falls program. The influence of race and ethnicity on inpatient fall risk has not yet been explored but should be in future studies (Sun, Huang, Varadhan, & Agrawal, 2016).

Predictably, higher mean HIIFRM risk scores were noted in the falls group (Table 2). Length of stay was also greater, possibly reflecting underlying health status (comorbidities), lack of modifiable risk factor management in the outpatient setting, and/or prolonged care due to an injurious fall. Mean age was 20 years greater in the falls group, reflecting the higher prevalence of multiple risk factors and the frailty and acuity of some older patients. As recently noted by a consortium of experts (Carpenter et al., 2019), age-related diseases may cause cognitive decline, which may in turn increase fall risk, but age itself is *not* a risk factor for cognitive impairment. Indeed, the initial HIIFRM risk factor validation studies failed to identify a significant, independent relationship between age and fall risk (Hendrich et al., 2003); hence, in the current large, psychometric study, the model again predicted fall risk using validated risk factors that do not include age. Age correlates with fall risk when other risk factors are paired with it, but age alone is not causal or predictive.

4.2. Thresholds for high fall risk on the HIIFRM

The standard cut-off score to define high fall risk on the HIIFRM is ≥5. The findings of this study demonstrate that patients with a fall risk score of 4 still have a moderate risk of falling. If ≥4 had been used as the cut-off, an additional 74 falls could have been identified, with a

Table 3
Psychometrics of HIIFRM at risk scores 1 to 16.

Risk score	Specificity	Sensitivity	Positive predictive value	Negative predictive value	Negative likelihood ratio	Positive likelihood ratio
1	4.12%	99.84%	0.30%	99.99%	0.04	1.04
2	22.24%	97.76%	0.37%	99.97%	0.10	1.27
3	32.91%	94.40%	0.41%	99.95%	0.17	1.41
4	44.43%	90.56%	0.47%	99.94%	0.21	1.63
5	**64.07%**	**78.72%**	**0.64%**	**99.90%**	**0.33**	**2.19**
6	73.64%	66.88%	0.74%	99.87%	0.45	2.54
7	78.58%	58.56%	0.79%	99.85%	0.53	2.73
8	81.53%	52.80%	0.83%	99.83%	0.58	2.86
9	84.83%	46.40%	0.89%	99.82%	0.63	3.06
10	89.31%	33.44%	0.91%	99.78%	0.75	3.13
11	93.03%	21.92%	0.91%	99.76%	0.84	3.14
12	95.98%	13.12%	0.95%	99.74%	0.91	3.26
13	98.18%	5.28%	0.84%	99.72%	0.96	2.90
14	99.33%	0.96%	0.42%	99.71%	1.00	1.43
15	99.80%	0.48%	0.68%	99.71%	1.00	2.40
16	99.96%	0.00%	0.00%	99.71%	1.00	0.00

Note. The standard cut-off for high fall risk is score ≥ 5.

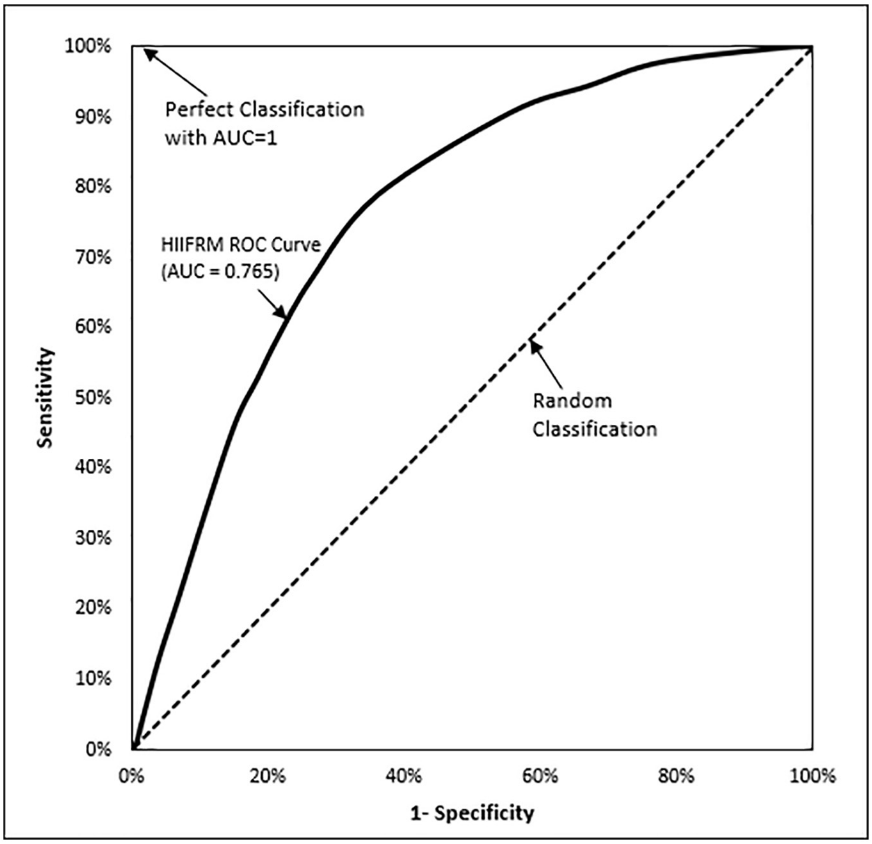

Fig. 2. Receiver operating characteristic (ROC) curve of HIIFRM.
Note. A diagnostic model with perfect classification has AUC = 1, a model with moderate to high accuracy has AUC > 0.7, and a model with low accuracy has AUC < 0.5. The dashed line represents a non-discriminatory test where classification is random. Any ROC curve below this line indicates poor performance. The HIIFRM ROC curve is above the random classification line, with an AUC of 0.765 (standard error 0.008; 95% confidence interval 0.748, 0.781; $p < 0.001$), which indicates very good performance.

corresponding trade-off in lower specificity (Table 3). A cut-off of ≥4 would add 42,036 patients to the 77,292 patients with scores ≥5, for a total of 119,328 at-risk inpatients, or 55.7% of the entire sample, a 54.4% increase in the number of patients under modifiable risk factor or injurious fall reduction protocols. Of the 74 patients with a risk score of 4 who fell, it is not possible to know how many would have avoided a fall if they had been categorized as high risk.

One possible harm of adopting a cut-off score of ≥4, rather than the current standard of ≥5, could be wider use of fall prevention measures that limit the mobility of an even larger inpatient population, with all the attendant risks to health and well-being this entails. Changing the high risk cut-off score to 4 may only be desirable if there is a paradigm shift in how hospitals approach fall reduction, a shift from a culture of "zero falls" to one of "safe mobility," achieved through interventions that address modifiable risk factors and that include progressive mobility protocols. This paradigm shift requires thoughtful review of existing injurious fall events, the integration of progressive mobility programs with injurious fall prevention strategies, and interprofessional interventions to address modifiable risk factors. It requires a rethinking of the difficult balance between hospital liability, regulatory compliance, existing fall prevention cultures, continuum care models and philosophies, and promotion of progressive, safe mobility and recovery of patients.

4.3. Fall risk factor management

The findings of this study confirm what many clinicians intuitively know: A large proportion of inpatients have high fall risk, and these patients' fall risk factors are typically not actively managed during hospitalization, leaving them at risk both in the hospital and after discharge. At the standard cut-off score of ≥5 on the HIIFRM, 36% of the sample (77,292 inpatients) were considered high fall risk, representing a substantial dedication of hospital resources (time and documentation).

Inpatient falls have been classified as accidental (i.e., slipping or tripping due to environmental hazards), anticipated physiologic (i.e., falls by patients at risk for falling), and unanticipated physiologic falls (i.e., falls attributed to factors that could not be predicted). It is well-known that the majority of hospital falls can be attributed to physiologic or intrinsic causes. Therefore, the design of the Hendrich II Fall Risk Model focused on identifying factors intrinsic to the patient. However, as noted, many hospital fall prevention strategies emphasize *only* extrinsic factors. Fall prevention programs at the sites sampled in this study used visual alerts (e.g., patient bracelets), bed alarms, nonslip footwear, adequate lighting, and assistance with ambulation and toileting. These approaches may prevent some falls in a specific department or nursing unit but do not manage the larger, underlying contributors to intrinsic fall risk. Few hospital-based programs connect modifiable fall risk factors to a more holistic approach by integrating the risk factors with the medical problem list.

By focusing on intrinsic risk factors that travel with the patient, validated fall risk assessment tools, such as the HIIFRM, support specific interventions to manage the underlying cause(s) of the identified risk factors. For example, although confusion, a risk factor that is part of the HIIFRM, is not a diagnosis, etiologies of confusion are both prevalent and underdiagnosed in acute-care facilities. In general medical and geriatric wards, the rate of occurrence of delirium in older adults ranges from 29 to 64% (Inouye, Westendorp, & Saczynski, 2014; Wan & Chase, 2017). In the ED, 7–17% of older adults present with delirium (Han et al., 2009; Inouye et al., 2014; Rosen et al., 2015), with studies reporting that the diagnosis is missed in these ED patients in > 75% of cases (Han et al., 2009; Hustey, Meldon, Smith, & Lex, 2003; Rosen et al., 2015). The prevalence and underdiagnosis of delirium in the ED take on added urgency when considering that, in the current study, the highest proportion of patients who fell were admitted through the ED. Identification of a risk factor like confusion should trigger an immediate evaluation to differentiate delirium from other encephalopathies and/or sepsis and determine what type of diagnostics or more in-depth assessment is needed. In this way, fall risk factors become a window onto the patient's condition and are reframed as part of a comprehensive assessment, contributing to a holistic care plan and diagnostic processes to maximize treatment efficacy and outcomes and reduce redundancy, while also reducing the risk of injurious falls. This approach must extend beyond the hospital setting, with interprofessional care teams across the continuum promoting follow-up visits, self-care, and appropriate person-centered interventions with progressive, safe mobility, whenever possible.

A recent study focusing on the implementation of evidence-based fall prevention interventions targeted to patient-specific fall risk factors represents a move in this direction (Titler et al., 2016). Another intriguing approach is the development of an innovation center model in which a fall reduction program is a component of a comprehensive, dynamic, and synergistic framework to support the evidence-based, cross-continuum care of an aging population (Allen, Hazelett, Martin, & Jensen, 2020).

To implement a state-of-the-art injurious fall reduction program—a program that takes a person-centered, holistic, team-based approach—may demand that an organization reimagine its culture around how fall reduction is achieved. Moving away from the language of "zero falls" and toward a language of "progressive, safe mobility and independence," from "fall committee" to "safe mobility committee," could positively alter how providers and organizations perceive and manage at-risk persons. Ultimately, the high prevalence of fall risk factors impacts overall healthcare utilization, including readmissions, injuries, and hospitalizations, as well as external rankings. Undiagnosed and untreated, many of the modifiable risk factors that lead to injurious falls impact the independence and safety of the individual. By mapping these risk factors to evidence-based interventions, we can reduce the patient's intrinsic fall risk and promote a coordinated return to home and community, with appropriate referrals and follow-ups to ensure risk factors continue to be monitored and addressed.

4.4. Study limitations

Limitations of this study include its retrospective retrieval of EHR data, potential variations in HIIFRM scoring between clinicians, and the presence of tenured fall prevention standards at the study sites. Attempts were made to increase reliability by including all consecutive adult admissions during the study period at the hospitals, thereby minimizing risk for bias in patient selection, and by conducting comprehensive data scrubbing. Furthermore, the duration (3 years), large sample size (nine sites, 214,358 patients), and representative diversity of the sample should minimize the impact of variations in local practice patterns and increase the generalizability of the findings. To control for variation in assessments between clinicians, only the highest HIIFRM fall risk score during hospitalization was used for analysis. Moreover, all nurses at the study sites are required to complete a yearly standardized competency assessment on the definitions of the HIIFRM risk factors and how to score fall risk. Importantly, none of the hospitals changed their standards or practices for basic fall prevention, which would have reduced the fall rate, thereby reducing AUC and underestimating diagnostic accuracy. Finally, a small proportion of inpatient falls also result from unpredictable first occurrence events or hazards (slips/trips, seizures, transient ischemic attacks, arrhythmias) and therefore reduce the predictive ability of fall risk assessment tools.

5. Conclusions

The HIIFRM demonstrated very good ability to predict inpatient falls in a large study population representative of today's complex care continuum. The larger, untapped opportunity, however, is to use the intrinsic HIIFRM risk factors to alert clinicians to underlying conditions that are associated with these risk factors and that require active management during the hospital stay and postdischarge. These risk factors must be sequentially assessed, diagnosed, and actively managed with evidence-based interventions as part of holistic, interprofessional practice, with the teamwork of nurses, providers, pharmacists, and allied health professionals extending across the care continuum.

This way of approaching fall risk factors, as *part* of a comprehensive assessment, is a paradigm shift from traditional fall prevention programs that may prevent some inpatient falls in the short term but limit the person's true health potential and may increase the risk of complications that negatively impact quality of life and independence. This study found that the majority of patients who fall in the hospital are admitted through the ED, indicating that fall risk factors travel with the person and must be addressed by a coordinated, multidisciplinary team across the continuum. Too many hospital departments still view fall risk as specific to the department's physical space. While the environment matters, the risk factors should be viewed more holistically since they are intrinsic to the person and move with that person across care settings. An approach that focuses on managing modifiable fall risk factors as part of a comprehensive, person-centered care plan will require significant practice and policy changes to accelerate the evolution of the nurse's role as part of a collaborative, interprofessional team. Such a shift must be supported by broadscale education of the care team. Hosptials should also look toward programmatic change like that of "Building Age-Friendly Healthcare Sytems-the 4 M's" for evidenced-based approaches.

A validated fall risk assessment, such as the HIIFRM, will inform a person-centered care plan while also reducing injurious falls. By actively managing modifiable risk factors, interprofessional care teams can foster and promote independence, self-care, and progressive, safe mobility of patients across the care continuum. Fall programs that emphasize restricted mobility will continue to have the potential unintended consequence of contributing to a decline in functional status and independence of the person at risk.

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CRediT authorship contribution statement

Ann L. Hendrich: Conceptualization, Methodology, Validation, Investigation, Resources, Writing - original draft, Writing - review & editing, Supervision, Project administration. **Angelo Bufalino:** Software, Formal analysis, Methodology, Data curation, Writing - review & editing. **Clariecia Groves:** Software, Formal analysis, Methodology, Data curation, Writing - review & editing.

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