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RESEARCH PAPER

External validation of the hospital frailty risk score among hospitalised home care clients in Canada: a retrospective cohort study

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Abstract

Background: The Hospital Frailty Risk Score (HFRS) is scored using ICD-10 diagnostic codes in administrative hospital records. Home care clients in Canada are routinely assessed with Resident Assessment Instrument-Home Care (RAI-HC) which can calculate the Clinical Frailty Scale (CFS) and the Frailty Index (FI).
Objective: Measure the correlation between the HFRS, CFS and FI and compare prognostic utility for frailty-related outcomes.
Design: Retrospective cohort study.
Setting: Alberta, British Columbia and Ontario, Canada.
Subjects: Home care clients aged 65+ admitted to hospital within 180 days (median 65 days) of a RAI-HC assessment ($n = 167{,}316$).
Methods: Correlation between the HFRS, CFS and FI was measured using the Spearman correlation coefficient. Prognostic utility of each measure was assessed by comparing measures of association, discrimination and calibration for mortality (30 days), prolonged hospital stay (10+ days), unplanned hospital readmission (30 days) and long-term care admission (1 year).
Results: The HFRS was weakly correlated with the FI (ρ 0.21) and CFS (ρ 0.28). Unlike the FI and CFS, the HFRS was unable to discriminate for 30-day mortality (area under the receiver operator characteristic curve (AUC) 0.506; confidence interval (CI) 0.502–0.511). It was the only measure that could discriminate for prolonged hospital stay (AUC 0.666; CI 0.661–0.673). The HFRS operated like the FI and CFI when predicting unplanned readmission (AUC 0.530 CI 0.526–0.536) and long-term care admission (AUC 0.600; CI 0.593–0.606).
Conclusions: The HFRS identifies a different subset of older adult home care clients as frail than the CFS and FI. It has prognostic utility for several frailty-related outcomes in this population, except short-term mortality.

Keywords: frailty, risk assessment, older adults, hospitalisation, older people

Key Points

- The Hospital Frailty Risk Score (HFRS) uses ICD-10 diagnostic codes to automatically grade frailty among older adults
- Home care clients in Canada are routinely assessed with comprehensive health assessments that calculate other frailty measures
- The Hospital Frailty Risk Score (HFRS) was weakly correlated with the Clinical Frailty Scale and the Frailty Index among hospitalised home care clients
- The Hospital Frailty Risk Score (HFRS) predicted prolonged hospital stay, unplanned readmission and long-term care admission, but not short-term mortality

Background

Frailty is an age-associated clinical syndrome defined as a state of heightened vulnerability to stressors due to a loss of physiological reserve across multiple organ systems. Community-dwelling older adults who are identified as frail are more likely to experience functional dependence and require institutional care [1]. Persons experiencing frailty are also at higher risk of falls, hospitalisations and mortality [2].

Frailty measures based on International Classification of Diseases, Tenth Revision (ICD-10) diagnostic codes have recently been put forth as a method to screen for frailty among hospital inpatients [3]. The advantage of this approach is the ability to assess frailty automatically in the absence of functional, cognitive and social measures that are rarely collected in a standardised manner in administrative hospital records [4]. The Hospital Frailty Risk Score (HFRS) is calculated as a weighted count of 109 frailty-related diagnoses [3]. The HFRS uses all ICD-10 codes (i.e. most responsible, comorbid and secondary diagnoses), extracted from hospital discharge abstracts occurring over a 2-year retrospective period. Though convenient, this means that the HFRS is sensitive to diagnostic coding practices, particularly for non-mandatory diagnostic codes (e.g. 'type 3' in Canada).

Several measures have also been developed to detect frailty among older adults using information from interRAI comprehensive health assessment instruments [5]. Perhaps the most ubiquitous approach is the Frailty Index (FI), which is a measure constructed from a minimum of 30–40 deficits including age-related symptoms, signs, diseases, disabilities or other physiological abnormalities that are distributed across a range of body systems [6]. A classification tree algorithm variant of the Clinical Frailty Scale (CFS) can also be calculated using these assessments [7, 8]. These approaches to frailty measurement have been validated among community-dwelling older adults [9] and hospital inpatients [10], including those admitted for critical care [11].

The objective of this study was to measure the correlation between the HFRS, CFS and FI and to compare its prognostic utility for a range of frailty-related outcomes among a large cohort of community-dwelling older adults requiring long-term personal support services or nursing support.

Methods

Study design

We completed a retrospective cohort study of community-dwelling older adults (age $\geq$ 65 years) with home care service needs from three Canadian provinces. All persons in the cohort were admitted to an acute care hospital within 180 days of being assessed with the interRAI Resident Assessment Instrument-Home Care (RAI-HC) assessment. We examined four patient subgroups: medical and surgical patients, those admitted to an intensive care unit (ICU), and those who experienced delayed discharge from hospital.

Ethics clearance for secondary data analysis was provided by the University of Waterloo Office Research Ethics (File#: 30975).

Data sources

We performed record-level data linkage between several clinical and administrative databases maintained by the Canadian Institute for Health Information (CIHI). This included the Discharge Abstract Database (DAD), the National Ambulatory Care Reporting System (NACRS), the Home Care Reporting System (HCRS) and the Continuing Care Reporting System (CCRS).

The DAD includes discharge abstracts for acute care hospital separations for most Canadian provinces and territories. A maximum of 25 ICD-10-CA diagnostic codes may be assigned to each record.

The HCRS database contains clinical assessment information for all persons in Canada assessed with the validated RAI-HC instrument [12, 13]. The RAI-HC assessment is administered as standard of practice for non-palliative, long-stay home care clients (i.e. > 60 days of nursing and personal support services) [14]. Information from the RAI-HC assessment is used to guide care planning [15], inform resource allocation at the client-level [16] and evaluate quality of care [17]. The inter-rater reliability of the items included on the RAI-HC [13], and the internal consistency of items used in summary measures for instrumental and basic activity of daily living dependence [18] are strong.

Study cohort

All patients in the cohort were admitted to an acute inpatient hospital unit located in either British Columbia, Alberta or Ontario within 180 days of the RAI-HC assessment date. We selected the RAI-HC assessment that was most proximate to the hospital admission date when multiple assessments were completed during the accrual period. All four databases covered a period from 1 April 2010 to 31 March 2015. We selected index hospital admissions that took place after 1 April 2012, to ensure that 2 years of retrospective hospitalisation data were available to calculate the HFRS (Supplementary Appendix S1).

The surgical patient subgroup included patients who were assigned to an intervention partition of a Major Clinical Category as defined in CIHI's Case Mix Groups+ methodology [19]. All other patients were classified as medical. Thus, these two patient subgroups are mutually exclusive. This method has been used to delineate medical and surgical patients in health system performance indicators based on the DAD [20].

The ICU subgroup included all patients admitted to an ICU during a non-elective hospital admission. ICU case-finding using the DAD is reliable [21]. The delayed discharge subgroup included patients designated as requiring an 'Alternate Level of Care' (ALC), a Canadian term denoting patients that no longer require the intensity of resources and services provided in hospital but occupy a staffed inpatient bed while awaiting discharge to a more appropriate care setting, typically a long-term care home [22, 23]. To account for the possibility of administrative discharge barriers, we only included patients in this subgroup if they had been designated as ALC for 7 or more days. All patients in the ICU and delayed discharge patients also belonged to one of the medical or surgical patient subgroups. Patients may have been classified into both the ICU admission and delayed discharge subgroups.

Exposures: Frailty measures

We calculated the HFRS using the approach and weights described by Gilbert *et al*. [3]. We used all ICD-10-CA codes that were assigned on the DAD discharge abstract 2 years prior to, and including, the index hospitalisation record.

We calculated the two other frailty measures using information from the most recent RAI-HC assessment prior to hospital admission. The 9-point CFS classification tree [8] was scored using RAI-HC assessment items. This approach has been used in a previous study [11]. We also calculated a 58-deficit FI that was previously used in studies for acute inpatients [10, 24].

We discretised each frailty measure into quintiles to allow comparison across measures. For patient subgroup analyses, the quintiles were re-calculated among only patients in the subgroup. Nearly 60% of patients in the overall cohort and patient subgroups had a CFS score of 6. Thus, we allocated those patients to the third quintile and did not define the second and fourth quintiles (Supplementary Appendix S2).

Outcomes of interest

We measured time to all-cause mortality within 30 days of the hospital admission. As in a previous study [11], we determined date of death by observing discharge disposition in all four linked databases: HCRS, DAD, NACRS and CCRS. We were only able to measure survival time for deaths that occurred in home care, hospital (acute and post-acute), ambulatory care and long-term care. Therefore, we right censored patients in the cohort using the last known discharge date observed across all four databases.

Unplanned hospital readmission was measured as time-to-event within 30 days of the index hospital discharge. This outcome was measured among patients discharged alive following the index hospital admission. We measured long-term care admission as the time-to-event within 1 year discharge from the index of hospitalisation among all patients that were discharged alive and not admitted directly to long-term care. Acute hospital length of stay of 10 days or longer was considered as a prolonged hospital stay and is consistent with previous validation studies of the HFRS [3, 25]. Days spent waiting for discharge (i.e. ALC days) were not counted. We measured this outcome among patients that survived to discharge.

Statistical analysis

We calculated Spearman rank-order coefficient statistics between the continuous form of all three frailty measures. There are numerous ways to interpret the strength of correlation coefficients. We used the thresholds provided by Schober *et al*. [26]. We performed sensitivity analyses to account for the possibility of change in frailty status between the RAI-HC assessment date and index hospital admission date. We repeated this analysis using a secondary cohort of patients that were assessed with the RAI-HC 7 days before or after the hospital discharge date. RAI-HC assessments completed in hospital are typically used to determine long-term care eligibility.

We used Cox proportional hazards models to estimate mortality hazards among quintiles of the HFRS, CFS and the FI. Each model adjusted for age, sex, Major Clinical Category based on admitting hospital diagnosis and neighbourhood area income quintile. We did not include comorbid health conditions or comorbidity indices to avoid collinearity within the model, particularly for the HFRS. Cause-specific Cox proportional hazards models were used to estimate hazards of unplanned hospital re-admission and long-term care admission, while accounting for death as a competing. We used logistic regression models to estimate the odds of prolonged hospital stay. These models adjusted for the same set of covariates as the mortality models.

Time-dependent area under the receiver operator characteristic curve (AUC) and Brier score statistics from unadjusted and adjusted models using 100 repetitions of bootstrap cross-validation were used to measure overall discrimination and calibration. We used the continuous form of

Table 1. Frailty measure distribution among the overall cohort and sub-groups

Characteristic	Overall cohort (n = 167,316)	Medical admission (n = 140,289)	Inpatient surgery (n = 27,027)	ICU admission (n = 10,482)	Delayed discharge (n = 25,034)
Age (mean, standard deviation)	82.81 (7.95)	82.81 (7.95)	81.48 (7.88)	80.24 (7.89)	84.00 (7.51)
Female Sex	59.64% (99,784)	59.39% (83,314)	60.94% (16,470)	54.54% (5,717)	59.78% (14,965)
Canadian Province					
Ontario	72.34% (12,1,041)	72.55% (101,783)	71.25% (19,258)	87.72% (9,195)	68.54% (17,158)
British Columbia	17.60% (29,443)	16.87% (23,666)	21.37% (5,777)	7.52% (788)	20.74% (5,191)
Alberta	10.06% (16,832)	10.58% (14,840)	7.37% (1,992)	4.76% (499)	10.73% (2,685)
HFRS					
Low risk (<5)	31.63% (52,914)	29.80% (41,805)	41.10% (11,109)	26.16% (2,742)	11.71% (2,932)
Intermediate risk [5–15]	45.89% (76,775)	46.87% (65,757)	40.77% (11,018)	47.68% (4,998)	52.46% (13,133)
High risk (>15)	22.49% (37,627)	23.33% (32,727)	18.13% (4,900)	26.16% (2,742)	35.83% (8,969)
CFS					
1–3 (Very Fit to Managing Well)	4.02% (6,728)	3.58% (5,022)	6.31% (1,706)	3.83% (401)	2.13% (534)
4 (Living with very mild frailty)	1.71% (2,863)	1.61% (2,256)	2.25% (607)	2.01% (211)	1.05% (262)
5 (Living with mild frailty)	12.20% (20,407)	11.71% (16,426)	14.73% (3,981)	11.69% (1,225)	10.75% (2,690)
6 (Living with moderate frailty)	55.70% (93,195)	55.45% (77,788)	57.01% (15,407)	55.26% (5,792)	59.10% (1,4,795)
7 (Living with severe frailty)	24.32% (40,696)	25.38% (35,612)	18.81% (5,084)	25.93% (2,718)	25.50% (6,384)
8 (Living with very severe frailty)	0.71% (1,195)	0.80% (1,121)	0.27% (74)	0.43% (45)	0.58% (145)
9 (Terminally Ill)	1.33% (2,232)	1.47% (2,064)	0.62% (168)	0.86% (90)	0.89% (224)
FI					
<0.1	2.26% (3,776)	1.97% (2,758)	3.77% (1,018)	2.11% (221)	1.34% (335)
0.1–<0.2	16.48% (27,571)	15.60% (21,888)	21.03% (5,683)	15.56% (1,631)	13.25% (3,316)
0.2–<0.3	28.82% (48,214)	28.23% (39,601)	31.87% (8,613)	29.72% (3,115)	27.26% (6,825)
0.3–<0.4	28.65% (47,938)	28.98% (40,660)	26.93% (7,278)	29.46% (3,088)	31.65% (7,923)
0.4–<0.5	17.39% (29,099)	18.28% (25,651)	12.76% (3,448)	17.27% (1,810)	19.83% (4,965)
0.5–<0.6	5.57% (9,320)	6.01% (8,433)	3.28% (887)	5.34% (580)	5.80% (1,452)
≥ 0.6	0.84% (1,398)	0.93% (1,298)	0.37% (100)	0.54% (57)	0.87% (218)
Sub-group membership					
Medical admission	83.85% (140,289)	100.00% (140,289)	0.00% (0)	74.63% (7,823)	86.71% (21,706)
Inpatient surgery	16.15% (27,027)	0.00% (0)	100.0% (27,027)	25.37% (2,659)	13.29% (3,328)
ICU admission	6.26% (10,482)	5.58% (7,823)	9.84% (2,659)	100.00% (10,482)	4.75% (1,190)
Delayed discharge	14.96% (25,034)	15.47% (21,706)	12.31% (3,328)	11.35% (1,190)	100.00% (25,034)

each frailty measure. We also assessed discrimination and calibration for the unadjusted models graphically. A generalised additive model was used to produce calibration curves with 95% confidence intervals.

Cohort creation, including HFRS scoring, was performed using SAS 9.4 (SAS Institute, Inc., Cary, NC). Statistical analysis was performed in R 4.1.2 (R Core Team, 2021).

Results

Cohort characteristics

A total 167,316 older adults met our cohort selection criteria. The mean age of the overall cohort was 82.81 years (SD = 7.95), and female sex was most prevalent (59.64%; Table 1). The median time from the RAI-HC assessment date to the index hospitalisation was 65 days (IQR 27–115). Other patient sociodemographic and clinical characteristics are presented in Supplementary Appendix S3.

Prevalence of frailty

According to the HFRS, 45.89% of the overall cohort were at intermediate risk of frailty, and an additional 22.49% were at high risk of frailty. According to the CFS, most of the overall cohort were living with either mild (10.63%), moderate (55.83%) or severe (26.75%) frailty. The FI followed a normal distribution among the overall cohort, which is common among morbid groups [27] (Table 1).

Correlation between frailty measures

The HFRS was weakly correlated with the CFS (range 0.11–0.24) and FI (range 0.17–0.30). The FI and the CFS were moderately positively correlated with each other (range 0.62–0.66; Figure 1).

Spearman correlation coefficients between frailty measures were not sensitive to temporal variance between the RAI-HC assessment date and hospital admission date. The frailty measures were similarly correlated for patients assessed with the RAI-HC in hospital near discharge (Supplementary Appendix S4).

Mortality (30 days)

Based on Kaplan–Meier survival estimates, 81.68% (confidence interval (CI) 81.49–81.87%) of the overall cohort survived to 30 days after hospital admission. Thirty-day

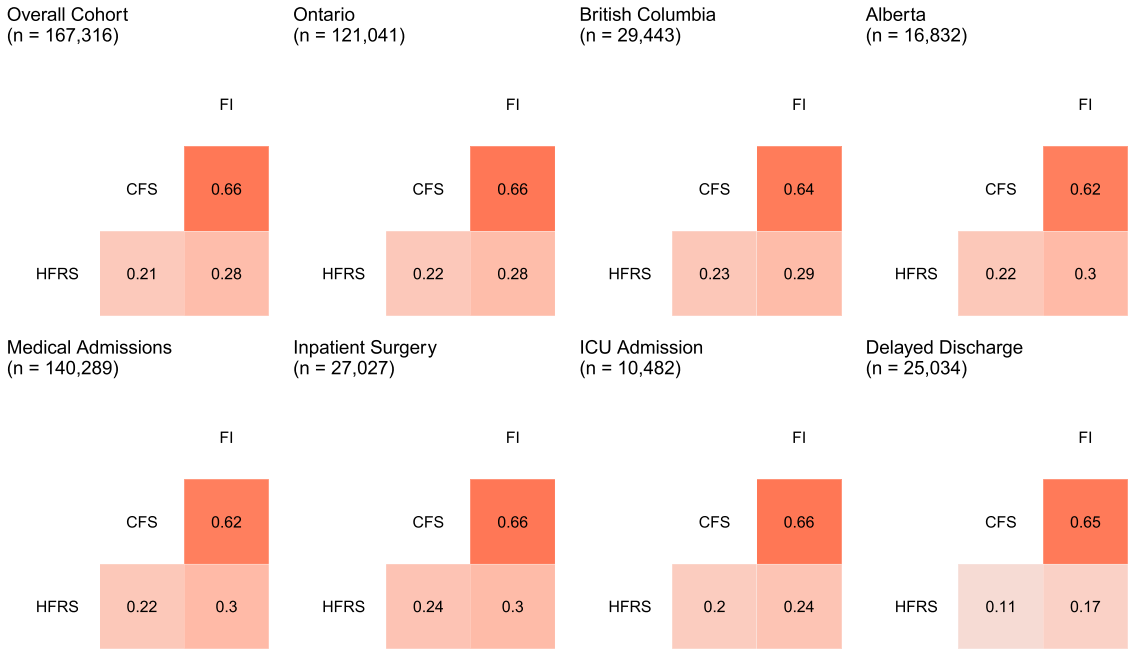

Figure 1. Spearman rank-order correlation coefficients between frailty measures for the overall cohort and sub-groups

Table 2. AUC ROC discrimination and brier score calibration statistics for unadjusted and adjusted frailty measure models

	Mortality (30 days)	Long-term care admission (1 year)	Unplanned readmission (30 days)	Prolonged hospital stay (10+ days)
AUC ROC Unadjusted Model				
HFRS	0.506 (0.502–0.511)	0.600 (0.593–0.606)	0.530 (0.526–0.536)	0.666 (0.661–0.673)
FI	0.580 (0.575–0.584)	0.609 (0.602–0.615)	0.513 (0.507–0.520)	0.508 (0.500–0.516)
CFS	0.588 (0.584–0.593)	0.559 (0.554–0.565)	0.504 (0.498–0.509)	0.497 (0.488–0.507)
AUC ROC Adjusted Model				
HFRS	0.686 (0.682–0.690)	0.649 (0.644–0.656)	0.598 (0.592–0.605)	0.698 (0.692–0.704)
FI	0.696 (0.692–0.701)	0.666 (0.659–0.672)	0.590 (0.584–0.597)	0.627 (0.618–0.632)
CFS	0.698 (0.694–0.702)	0.646 (0.639–0.652)	0.590 (0.583–0.596)	0.627 (0.619–0.632)
Brier Score Unadjusted Model				
HFRS	0.149 (0.148–0.151)	0.147 (0.144–0.149)	0.093 (0.092–0.095)	0.046 (0.045–0.047)
FI	0.148 (0.146–0.149)	0.146 (0.143–0.148)	0.093 (0.092–0.095)	0.047 (0.046–0.048)
CFS	0.147 (0.145–0.148)	0.147 (0.145–0.150)	0.093 (0.092–0.095)	0.047 (0.046–0.048)
Brier Score Adjusted Model				
HFRS	0.140 (0.139–0.141)	0.075 (0.071–0.078)	0.092 (0.091–0.094)	0.046 (0.045–0.047)
FI	0.139 (0.137–0.140)	0.074 (0.071–0.078)	0.093 (0.091–0.094)	0.046 (0.045–0.047)
CFS	0.138 (0.136–0.139)	0.075 (0.071–0.078)	0.093 (0.091–0.094)	0.046 (0.045–0.047)

Adjusted models include one frailty measure, age, sex, major clinical category (MCC) and neighbourhood income quintile.

survival estimates were lower for medical patients (79.80%; CI 79.58–80.00%) than surgical patients (91.51%; CI 91.17–91.85%). Thirty-day survival estimates for patients in the ICU and delayed discharge subgroups were 60.42% (CI 59.47–61.35%) and 93.49% (CI 93.18–93.79%), respectively. Overall, 1,404 (0.84%) patients were censored because they were discharged alive from home care with no subsequent health service during the follow-up period to measure additional survival time.

Among the overall cohort and the four patient subgroups, ascending grades of frailty according to the FI and CFS were generally associated with greater risk of mortality. The HFRS operated in a different manner. Mortality hazards were similar across all quintiles in the overall cohort (Figure 3). For patients in the medical admission, ICU admission and delayed discharge subgroups, ascending grades of frailty were generally associated with lower risk of mortality. Among the inpatient surgery subgroup, higher

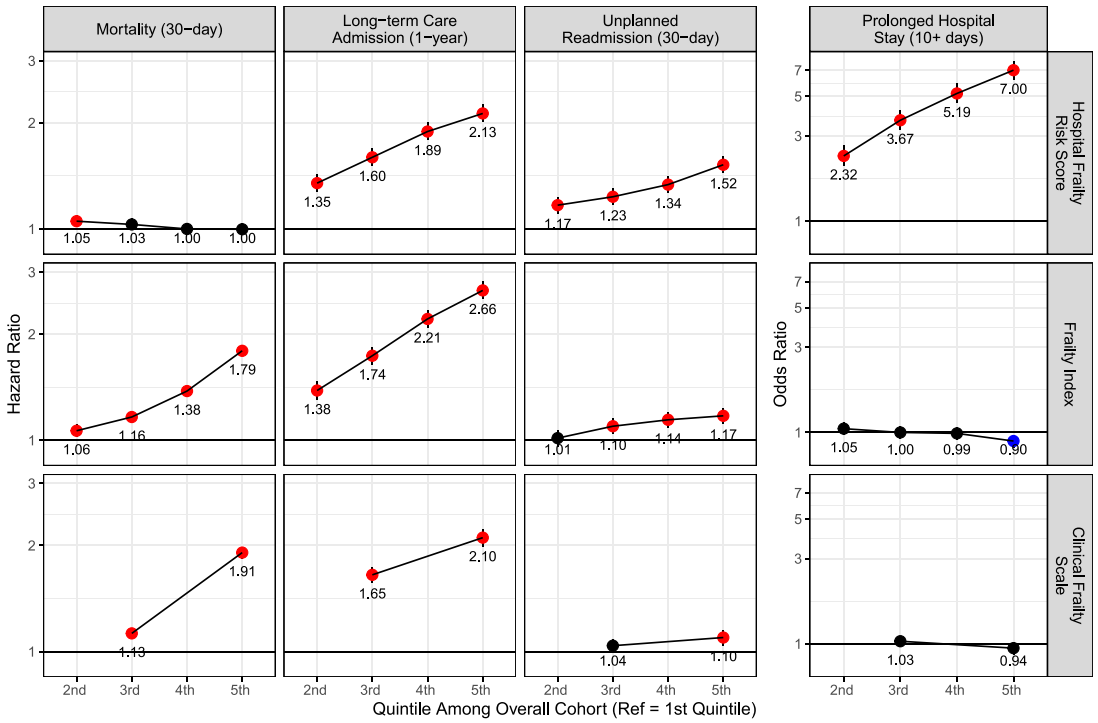

Figure 2. Adjusted hazard ratio statics for 30-day mortality, 30-day unplanned hospital readmission and 1-year long-term care admission among the overall cohort, and odds ratio statistics for prolonged hospital stay. All models adjust for age, sex, major clinical category (MCC) and neighbourhood income quintile.

HFRS scores were associated with greater risk of mortality; however, there was little difference from the third to fifth quintile (Supplementary Appendix S5).

The HFRS was unable to discriminate for mortality 30 days after hospital admission in the overall cohort (unadjusted AUC 0.506; CI 0.502–0.511) and was outperformed by both the FI and CFS (Table 2). Within the overall cohort, the CFS was best calibrated according to the Brier score and calibration curves (Table 2, Figure 3). The HFRS slightly outperformed the CFS and FI on discrimination in the inpatient surgery and delayed discharge subgroups (Supplementary Appendix S9). All three frailty measures had similar discriminatory power in the adjusted models fit among the overall cohort and subgroups (Table 2, Supplementary Appendix S9).

Long-term care admission (1 year)

Overall, 17.21% (CI 17.00–17.48%) of the patients were admitted to long-term care within 365 days of hospital discharge. Long-term care admission hazards generally increased monotonically with frailty severity for all measures in the overall cohort and subgroups (Figure 2, Supplementary Appendix S6). The FI was the most discriminant frailty measure for this outcome in both the unadjusted (AUC 0.609; CI 0.602–0.615) and adjusted model (AUC 0.666; CI 0.659–0.672; Table 2). This was also the case in the subgroups, except inpatient surgery (Supplementary Appendix S10).

Unplanned hospital readmission (30 days)

Within 30 days hospital discharge, 7.21% (CI 7.07–7.34%) of the overall cohort were re-admitted to hospital. Unplanned hospital readmission hazards generally increased with frailty severity for all measures in the overall cohort and subgroups (Figure 2, Supplementary Appendix S7). All frailty measures had weak discriminatory power for this outcome in the overall cohort and all subgroups (Table 2, Supplementary Appendix S11).

Prolonged hospital stay (10+ days)

Among patients that survived to discharge, 4.38% (95% CI 4.28–4.49%) experienced prolonged hospital stay of 10 or more days. Only the Hospital Frailty Risk achieved near-acceptable discrimination in unadjusted models among the overall cohort (AUC 0.666; 0.661–0.673) and patient subgroups (range 0.606–0.738; Table 2, Supplementary Appendix S12). It was well calibrated except among the highest risk patients (Figure 3, Supplementary Appendix S13-S16). In contrast, the CFS and FI had little to no ability to discriminate for this outcome (Table 2, Figure 3, Supplementary Appendix S12). Among patients

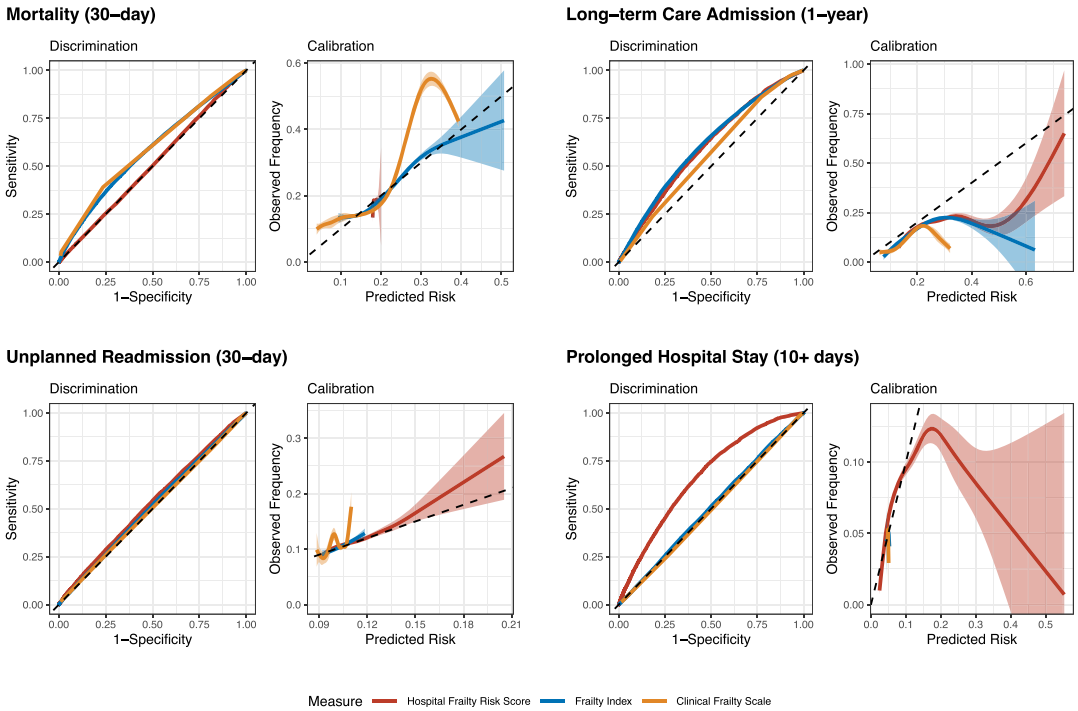

Figure 3. Discrimination and calibration curves for unadjusted models fit among the overall cohort. Calibration curves and 95% confidence intervals plotted using a generalised additive model. In the discrimination plots, the dashed diagonal reference line indicates random classification (i.e. AUC ROC = 0.5). Deviance from this reference line is desirable. In the calibration plots, the dashed diagonal reference line indicates perfect calibration. Deviance from this reference line is not desirable.

in the medical admission and delayed discharge subgroups, higher scores on these measures were associated with lower adjusted odds of prolonged hospital stay (Supplementary Appendix S8).

Discussion

The HFRS scored using administrative hospital records is weakly correlated with the CFS and FI scored using a comprehensive health assessment completed before hospital admission. The HFRS has limited ability to stratify home care recipients by risk of mortality after hospital admission. On the other hand, it was able to classify patients according to risk of unplanned hospital re-admission and long-term care admission in a similar manner as the CFS and FI. It was the only frailty measure able to predict prolonged hospital stay, excelling among inpatient surgery and ICU admission subgroups.

The HFRS is contingent on the reliability of ICD-10 diagnosis coding of most responsible, secondary and co-morbid conditions, which varies based on the completeness of physician documentation [28] and financial reimbursement practices [29]. Chart re-abstraction of the DAD indicates that the reliability of numerous conditions used in the HFRS is poor [30]. This includes highly weighted conditions such as Alzheimer's disease, dementia in Alzheimer's disease and sequelae of cerebrovascular disease. These conditions are potentially underreported by as much as 30% for Alzheimer's disease and 60% for stroke in hospital administrative records [31]. This may explain why a previous Canadian validation study of the HFRS found that only 2.6% of older adult inpatients were at 'high risk' of frailty [32], compared with 20.0% in England [26] and 17.5% in France [3]. Thus, it is likely that > 22.5% of our cohort home care clients are at 'high risk' of frailty and that the low correlation between the CFS and FI is partially attributable to underreporting of frailty-related conditions in Canada. This challenges its relevance as a means to implement national frailty measurement standards built on existing hospital information infrastructure in Canada [4, 33].

Previous studies have reported poor agreement between the HFRS and the FI [34], and the HFRS and the CFS [35]. Low concordance between other frailty measures has also been noted in prior studies [36, 37], suggesting that different measurement approaches may reflect different frailty concepts. Indeed, the clinician-scored version of the CFS, and not the HFRS, had prognostic value for predicting 30-day readmission and death [35]. Similarly, among persons with COVID-19, the CFS, and not the HFRS, is associated with in-hospital mortality [38, 39]. Our results were similar with respect to short-term mortality. Although the CFS and FI generally grade frailty severity in a similar manner, the HFRS will identify a different subset of older adults at risk of frailty-related adverse outcomes.

The prognostic utility of frailty measures depends on the care setting and patient population in which they are applied [37]. Although the HFRS appears to be a valid means of identifying older adults at risk of short-term mortality in general cohorts of hospitalised older adults [3, 25, 32], the CFS and FI may be preferred for dependent patient populations, for example this cohort of older adults with home care service needs. Most home care and long-term recipients in Canada are routinely assessed with interRAI comprehensive health assessments. Through information sharing, providers in hospital could benefit from baseline frailty, functional and cognitive status, social functioning, and caregiver distress measures when care planning [15].

Limitations

Our cohort of persons assessed to determine home care service needs represents a highly selected subgroup of older adults admitted to hospital in Canada. In our study, the CFS and FI reflect patient health status a maximum of 180 days prior to hospital admission. Nearly 20% of home care clients experience a significant change in either cognitive or functional performance within a 6-month period [14]; thus, in some instances, the HFRS may more accurately reflect an individual's frailty status at the time of hospitalisation. At the same time, when used at admission to screen for frailty, it is only based on information from past hospitalisations [40]. Doing so hinders its discriminatory power [3]. Less than 1% of the cohort may have been censored prematurely if they died outside of home care, hospital and long-term care.

Conclusion

The HFRS offers a means to estimate frailty using existing administrative hospital records; however, it is weakly correlated with the CFS and FI among home care clients, thus identifying a different subset of older adults as frail. Users should be aware that its prognostic utility varies by target outcome and patient subgroup. In this cohort, the HFRS can discriminate for several frailty-related adverse outcomes, except for mortality. These differences between automated frailty measurement approaches are important to consider when selecting a measure to inform patient care and system-level capacity planning.

Supplementary Data: Supplementary data mentioned in the text are available to subscribers in *Age and Ageing* online.

Declaration of Conflicts of Interest: Kenneth Rockwood has asserted copyright of the CFS through Dalhousie University's Industry, Liaison and Innovation Office. Use is free for education, research and not-for-profit health care. Users agree not to change, commercialise or charge for the scale. He is Associate Director of the Canadian Consortium on Neurodegeneration in Aging, itself funded by the Canadian Institutes for Health Research, the Alzheimer Society of Canada and several other charities. In addition to academic and hospital appointments, KR is Co-founder of Ardea Outcomes (until 2021 DGI Clinical) in the past 3 years has contracts with pharma and device manufacturers (Danone, Hollister, INmune, Novartis, Takeda) on individualised outcome measurement. In 2020, he attended an advisory board meeting with Nutricia on dementia, and chaired a Scientific Workshop & Technical Review Panel on frailty for the Singapore National Research Foundation. Otherwise any personal fees are for invited guest lectures, rounds and academic symposia, received directly from event organisers, for presentations on frailty.

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Data Availability Statement: The data that support the findings of this study are available upon reasonable request from the Canadian Institute for Health Information.

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