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Original Study - Brief Report

Ability of 3 Frailty Measures to Predict Short-Term Outcomes in Older Patients Admitted for Post-Acute Inpatient Rehabilitation

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A B S T R A C T

Objectives: To evaluate the ability of 3 commonly used frailty measures to predict short-term clinical outcomes in older patients admitted for post-acute inpatient rehabilitation.
Design: Observational cohort study.
Setting and Participants: Consecutive patients (n = 207) admitted to a geriatric inpatient rehabilitation facility.
Methods: Frailty on admission was assessed using a frailty index, the physical frailty phenotype, and the Clinical Frailty Scale (CFS). Predictive capacity of the frailty instruments was analyzed for (1) nonhome discharge, (2) readmission to acute care, (3) functional decline, and (4) prolonged length of stay, using multivariate logistic regression models and receiver operating characteristic (ROC) curves.
Results: The number of patients classified as frail was 91 (44.0%) with the frailty index, 134 (64.7%) using the frailty phenotype, and 151 (73.0%) with the CFS. The 3 frailty measures revealed acceptable discriminatory accuracy for nonhome discharge (area under the curve $\geq$ 0.7) but differed in their predictive ability: the adjusted odds ratio (OR) for nonhome discharge was highest for the CFS [6.2, 95% confidence interval (CI) 1.8-21.1], compared to the frailty index (4.1, 95% CI 2.0-8.4) and the frailty phenotype (OR 2.9, 95% CI 1.2-6.6). For the other outcomes, discriminatory accuracy based on ROC tended to be lower and predictive ability varied according to frailty measure. Readmission to acute care from inpatient rehabilitation was predicted by all instruments, most pronounced by the frailty phenotype (OR 5.4, 95% CI 1.6-18.8) and the frailty index (OR 2.5, 95% CI 1.1-5.6), and less so by the CFS (OR 1.4, 95% CI 0.5-3.8).
Conclusions and Implications: Frailty measures may contribute to improved prediction of outcomes in geriatric inpatient rehabilitation. The choice of the instrument may depend on the individual outcome of interest and the corresponding discriminatory ability of the frailty measure.

The focus of geriatric post-acute rehabilitation is to improve functional independence of older patients so they can return home.[1,2] However, it is challenging on admission to identify those older patients who will benefit from inpatient rehabilitation.[3–5]

Frailty has been identified as a useful predictive measure for adverse clinical outcomes, including mortality, and functional decline in older patients in the community and in the acute care hospital setting.[6] However, studies investigating frailty as predictive measure in the geriatric rehabilitation setting is scarce.[7,8]

The aim of this study was to compare the ability of 3 commonly used frailty instruments to predict short-term clinical outcomes in older patients admitted for post-acute inpatient rehabilitation.

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Methods

Data were analyzed from 207 consecutive patients admitted for geriatric post-acute inpatient rehabilitation in Bern, Switzerland, between September and December 2019. All patients met the following admission criteria: (1) age >75 years, (2) direct transfer from acute care hospital, (3) living in the community (ie, not in a nursing home) prior to acute care hospital admission, (4) potential for functional improvement and discharge home following inpatient rehabilitation.

A standardized comprehensive geriatric assessment was performed on the day of admission by clinically trained assessors. The geriatric assessment included evaluation of cognition, emotion, nutrition, gait and balance, activities of daily living, vision, hearing, and frailty. Clinical outcomes during inpatient rehabilitation (ie, readmission to acute care) and on discharge (ie, nonhome discharge, functional decline, prolonged length of stay) were recorded.

The study was approved by the Ethics Committee in Bern, Switzerland (Req-2020-00125). In accordance with research regulations pertaining to human subjects' health-related data, we analyzed anonymized data so individuals could not be identified.

Frailty Instruments

We developed a frailty index (FI) based on the standard procedure published by Searle et al.[9] We included deficits identified from the geriatric assessment that met Searle's criteria. The FI consisted of 41 health deficits (see Supplementary Table 1). The FI was calculated for each patient by summing deficit points and dividing the sum by the total number of deficits considered. The denominator was 41 if there were no missing data. If there were missing data, the denominator was reduced by the number of missing deficits.[10] Patients with a total score of 0.4 or greater were considered frail. This cut point corresponds with another study conducted in a similar clinical setting.[11] As a post hoc analysis, we applied an additional cutoff definition.[12]

The frailty phenotype, as defined by Fried et al,[13] was the second measure used to assess frailty. The frailty phenotype classifies older people as frail based on 5 characteristics (ie, shrinking, low activity, fatigue, slowness, weakness). Scoring definitions for each characteristic are shown in the Supplementary Material. A score ≥3 out of 5 is considered positive for the frailty phenotype.

The third measure used was the Clinical Frailty Scale (CFS) developed by Rockwood et al,[14] an ordinal scale ranging from 1 to 9. A score ≥5 is defined as frail.

Clinical Outcomes

The outcome, nonhome discharge, included patients who were discharged to a nursing home after post-acute care or died during their rehabilitation stay. All other patients were categorized as home discharge (with or without ambulatory assistance at home).

Readmission to acute care was defined as patients who were transferred to an acute care hospital during their stay in the inpatient geriatric rehabilitation.

Functional decline was based on Functional Independence Measure (FIM) scores at admission and discharge. The FIM is an 18-item measurement tool to assess functional status during rehabilitation. Each item is rated on a 7-point scale, with higher scores indicating greater independence. FIM effectiveness was defined as FIM gain/[(126 points) − (FIM scores at admission)].[15] Functional decline was defined as FIM effectiveness <0. Patients who had no FIM score available at discharge, because of readmission to acute care, were classified as having functional decline or functional nondecline based on their ultimate discharge disposition (nonhome vs home discharge, respectively).

Table 1
Clinical Characteristics of Patients (N = 207)

Demographics	
Age, y, mean (SD)	84.3 (6.0)
Women, n (%)	136 (65.7)
Weight, kg, mean (SD)*	69.3 (14.9)
Height, m, mean (SD)	1.6 (0.09)
BMI, mean (SD)*	25.8 (5.2)
Comorbidities, CIRS, median (IQR)	19 (16-22)
Length of stay, d, median (IQR)	19 (13-20)
Functional status	
Total FIM	
FIM score, median (IQR)*	85 (69-96)
FIM gain, median (IQR)	16 (8-24)
FIM effectiveness, mean (SD)	0.41 (0.28)
Motor FIM	
Motor FIM score, median (IQR)	56 (43-66)
Motor FIM gain, median (IQR)	14 (7-22)
Motor FIM effectiveness, mean (SD)	0.43 (0.29)
Cognitive and emotional status	
3-item recall, fail, n (%)	169 (81.6)
Clock score, median (IQR)	5 (3-7)
GDS-5, median (IQR)	1 (1-2)
Physical status	
Gait speed, mean (SD)	0.3 (0.3)
Low grip strength, n (%)	93 (44.9)
Vision impairment, n (%)	71 (34.6)
Hearing impairment, n (%)	110 (53.7)
Frailty status	
Frailty phenotype	
Score, median (IQR)	3 (2-4)
Frail, n (%)	134 (64.7)
Clinical Frailty Scale	
Score, median (IQR)	5 (4-6)
Frail, n (%)	151 (73.0)
Frailty index	
Score, median (IQR)	0.37 (0.30, 0.51)
Frail, n (%)	91 (44.0)
Clinical outcomes, n (%)	
Nonhome discharge	44 (21.3)
Readmission to acute care	30 (14.5)
Death	2 (1.0)
Functional decline	30 (14.5)
Prolonged length of stay	60 (29.0)

BMI, body mass index; CIRS, Cumulative Illness Rating Scale; FIM, functional independence measure; IQR, interquartile range; SD, standard deviation.
*n = 206 (n = 1 missing data).

Length of hospital stay was calculated as the number of days between date of admission and discharge. The average length of stay (LOS) in an inpatient rehabilitation in Switzerland is 21 days. Accordingly, we defined an LOS >21 days as a prolonged LOS.[8] Patients who were readmitted to acute care were categorized as having a prolonged LOS.

Statistical Analysis

Characteristics of the study population are presented by absolute and relative frequencies or by mean with standard deviation for continuous and categorical variables, respectively. Power analysis was based on prior evidence expecting a prevalence of nonhome discharge to be 10% in older patients in a post-acute care setting. At a 2-sided confidence level of 0.05, the sample size of 207 patients yields a precision of ±6.5%.[16] Frailty instruments were correlated by using Spearman correlation coefficients. Predictive capacity [sensitivity, specificity, positive and negative predictive value, and receiver operating characteristic (ROC) curves] of frailty measure were calculated for clinical outcomes. Univariate and multivariate regression models adjusting for age and sex were calculated for each outcome and frailty measure, respectively. All analyzes were computed using Stata, version 16.1 (StataCorp LLC, College Station,

Table 2
Comparison of Predictive and Discriminative Capacity of Frailty Instruments for Clinical Outcomes (N = 207): Univariate Analyses and AUC

	OR (95% CI)*	AUC (95% CI)†	Sensitivity		Specificity		PPV		NPV	
			n/n	%	n/n	%	n/n	%	n/n	%
Frailty index										
Nonhome discharge	4.1 (2.0, 8.4)‡	0.73 (0.65, 0.82)	31/44	70.5	103/163	63.2	31/91	34.1	103/116	88.8
Readmission to acute care	2.5 (1.1, 5.6)§	0.67 (0.56, 0.77)	19/30	63.3	105/177	59.3	19/91	20.9	105/116	90.5
Functional decline	2.5 (1.1, 5.6)§	0.66 (0.54, 0.78)	19/30	63.3	105/177	59.4	19/91	20.9	105/116	90.5
Prolonged LOS	5.9 (3.0, 11.4)‡	0.71 (0.64, 0.77)	44/60	73.3	100/147	68.0	44/91	48.3	100/116	86.2
Frailty phenotype										
Nonhome discharge	3.0 (1.3, 6.8)§	0.70 (0.61, 0.78)	36/44	81.8	65/163	39.9	36/134	26.9	65/73	89.1
Readmission to acute care	5.9 (1.7, 20.1)‡	0.68 (0.59, 0.77)	27/30	90.0	70/177	39.6	27/134	20.2	70/73	95.9
Functional decline	2.4 (0.9, 6.3)	0.65 (0.55, 0.76)	19/30	80.0	24/30	37.9	24/134	17.9	67/73	91.8
Prolonged LOS	7.5 (3.1, 18.6)‡	0.68 (0.62, 0.73)	54/60	90.0	67/147	45.6	54/134	40.3	67/73	91.8
Clinical Frailty Scale										
Nonhome discharge	6.6 (1.9, 22.2)‡	0.71 (0.62, 0.79)	41/44	93.2	53/163	32.5	41/151	27.2	53/56	94.6
Readmission to acute care	1.6 (0.6, 4.1)	0.63 (0.41, 0.75)	24/30	80.0	50/177	28.3	24/151	15.9	50/56	89.3
Functional decline	2.7 (0.9, 8.1)	0.67 (0.57, 0.78)	26/30	86.7	52/125	29.4	26/151	17.2	52/56	92.9
Prolonged LOS	4.6 (1.9, 11.5)‡	0.62 (0.57, 0.67)	54/60	90.0	50/147	34.1	54/151	35.8	50/56	89.3

AUC, area under the receiver operating characteristic curve; FIM, functional independence measure; LOS, length of stay; NPV, negative predictive value; PPV, positive predictive value.
*Odds ratio (95% CI) calculated from univariate logistic regression model; all frailty instruments (dependent variables) included as binary variables (frail vs nonfrail).
†AUC calculated from receiver operating characteristic curve; frailty instruments coded as ordinal variables (CFS, frailty phenotype) or continuous variable (FI).
‡$P < .01$ for univariate logistic regression model.
§$P < .05$ for univariate logistic regression model.

TX). An adjusted P value of <.05 was considered statistically significant.

Results

In the study sample of 207 patients, the mean age was 84.3 years (standard deviation 6.0) and 65.7% were women (Table 1). Overall, 134 (64.7%) patients were classified as frail based on the frailty phenotype, 151 (73.0%) based on the CFS, and 91 (44%) based on the FI. Correlation analyses between the frailty instruments showed the following coefficients of Spearman rho (0.52 between frailty phenotype and CFS; 0.63 between frailty phenotype and frailty index; 0.60 between CFS and frailty index; all P values $< .001$).

Overall, 44 patients (21.3%) were not discharged home, 30 (14.5%) were readmitted to acute care, 30 (14.5%) had functional decline, 60 (29.0%) had a prolonged length of stay, and 2 (1%) died.

Predictive Capacity of Frailty Instruments

In univariate logistic regression analyses, all of the frailty instruments were predictive for most of the clinical outcomes (Table 2). Table 2 shows the sensitivity, specificity, positive predictive value, and negative predictive value of each frailty instrument for clinical outcomes.

In multivariate analyses, FI was predictive for all clinical outcomes (Table 3). The frailty phenotype was predictive for nonhome discharge [odds ratio (OR) 2.9, 95% confidence interval (CI) 1.2-6.6], readmission to acute care (OR 5.4, 95% CI 1.6-18.8) and prolonged length of stay (OR 7.0, 95% CI 2.8-17.3). The CFS was predictive for nonhome discharge (OR 6.2, 95% CI 1.8-21.1) and prolonged LOS (OR 4.2, 95% CI 1.7-10.5).

Figure 1 displays the area under the receiver operating characteristic curves for all of the frailty instruments for nonhome discharge (panel A), readmission to acute care (panel B), functional decline (panel C), and prolonged length of stay (panel D).

Sensitivity analyses using different classifications of clinical outcomes and another cutoff definition of the frailty index are displayed in the Supplementary Material.

Discussion

This study among 207 patients assessed with different frailty instruments in geriatric rehabilitation demonstrates a high prevalence of frailty by any instrument of frailty, ranging from 44% (FI) to 73% (CFS). Regarding the outcomes, there appeared to be a similar pattern across the frailty instruments for the prediction of nonhome discharge, readmission to acute care, functional decline, and prolonged length of stay. Although stated with caution because of the sample size, our analyses suggest some variation in discriminatory accuracy between frailty instruments. For nonhome discharge, the CFS exhibited the best predictive ability compared with the 2 other measures. In contrast, for hospital readmission, the frailty phenotype was the measure with the best performance.

Our findings of a high frailty prevalence in rehabilitation inpatients is consistent with findings in similar patient populations. In geriatric

Table 3
Comparison of Predictive Capacity of Frailty Instruments for Clinical Outcomes: Multivariate Analyses (N = 207)

	Frailty Index*		Frailty Phenotype*		Clinical Frailty Scale*	
	Adjusted OR† (95% CI)	P Value	Adjusted OR† (95% CI)	P Value	Adjusted OR† (95% CI)	P Value
Nonhome discharge	3.9 (1.9, 8.2)	<.01	2.9 (1.2, 6.6)	.01	6.2 (1.8, 21.1)	<.01
Readmission to acute care	2.5 (1.1, 5.6)	.04	5.4 (1.6, 18.8)	<.01	1.4 (0.5, 3.8)	.51
Functional decline	2.5 (1.1, 5.6)	.03	2.4 (0.9, 6.3)	.07	2.7 (0.9, 8.2)	.09
Prolonged LOS‡	5.5 (2.8, 10.9)	<.01	7.0 (2.8, 17.3)	<.01	4.2 (1.7, 10.5)	<.01

FIM, functional independence measure; LOS, length of stay.
*All frailty instruments (dependent variables) included as binary variables (frail vs nonfrail).
†Multivariate logistic model adjusted for age and sex.
‡n = 175 [patients with readmission to acute care (n = 30) and dying during rehabilitation stay (n = 2) excluded].

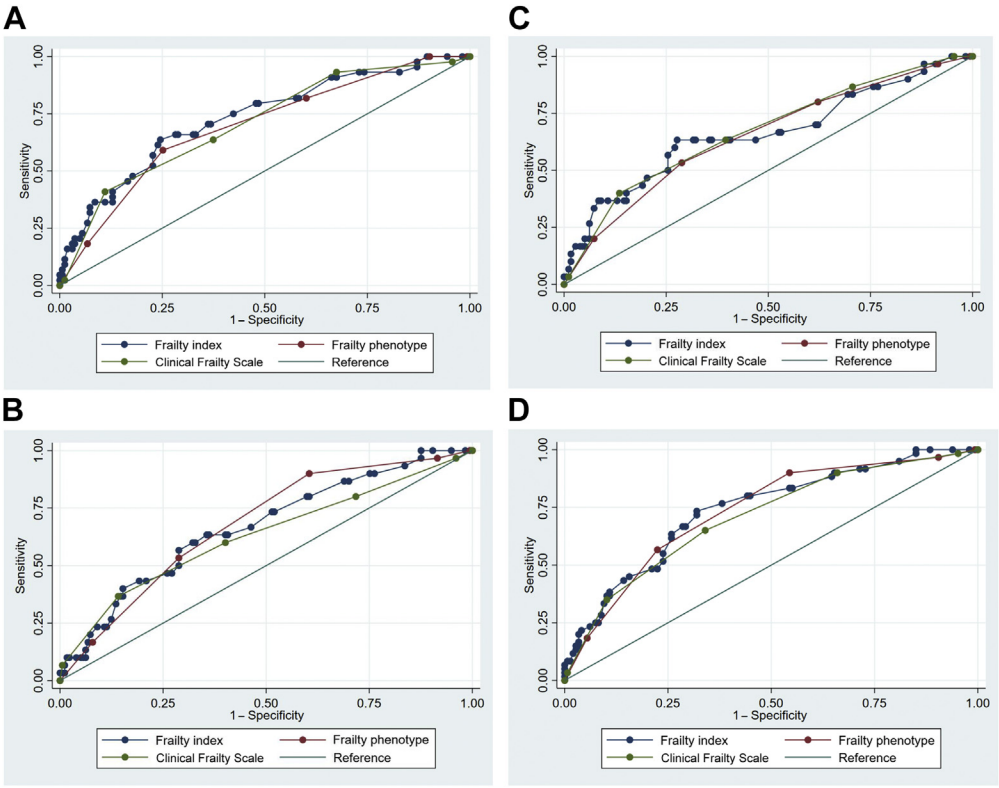

Fig. 1. Receiver operating characteristic curves of frailty instruments for clinical outcomes (N = 207): (A) nonhome discharge; (B) readmission to acute care; (C) functional decline; (D) prolonged length of stay.

wards, frailty prevalence between 50% and 75% has been reported.[17,18] Also, several previous studies in other geriatric patient populations reported that frailty prevalence differs according to the frailty instrument used and demonstrated limited agreement.[18–21]

Our study reports that frailty seems to be a useful predictor for nonhome discharge in geriatric rehabilitation inpatients. In fact, all 3 frailty measures demonstrated moderate discriminatory accuracy for the outcome "nonhome discharge" (area under the curve values >0.70). Among the 3 evaluated frailty tools, the CFS had the best predictive ability. Earlier studies in other geriatric settings found a predictive value of frailty for discharge disposition as well.[22–24]

We also found that the FI and frailty phenotype were statistically significant predictors of discharge to an acute care hospital from inpatient rehabilitation. In contrast, the association between the CFS and readmission to acute care was statistically nonsignificant. Potentially, the subdomains included in the measurement of the frailty phenotype, including measurements of physical functional status (eg, grip strength, gait speed, nutritional status, activities of daily living), might be reflective of a general health condition predisposing these patients to acute complications during their stay at the rehabilitation ward. The hypothesis that poor physical function is associated with the risk of hospital readmission is supported by earlier studies.[25,26]

Additionally, we found that all frailty measures were associated with prolonged LOS, which is in accordance with previous findings in a geriatric rehabilitation hospital.[7,27]

The most likely hypothesis to explain the differences between the 3 frailty instruments in frailty prevalence and predictive abilities may lie in the different underlying methodological concepts. Although there is consensus that frailty reflects a state of increased vulnerability for developing increased dependence and/or mortality when exposed to stressors,[28] different frailty concepts coexist. The frailty phenotype reflects a clinical syndrome including weakness, slowness, weight loss, fatigue, and low activity first defined by Fried et al.[13] In contrast, the frailty concept of "deficit accumulation" describes an accumulation of health and function problems that contribute to an individual's health state and is usually referred to as "frailty index."[29]

Our study has some limitations. First, this is a single-site study in a relatively small sample of a post-acute inpatient rehabilitation clinic. Second, we selected 3 commonly used frailty instruments and applied their usual cutoffs for defining frailty. Therefore, our results may not apply to other frailty measures or to the use of different cutoffs of frailty or prefrailty. Third, we applied usual definitions of clinical outcomes in a rehabilitation setting and further performed sensitivity analyses using other definitions of clinical outcomes to account for potential misclassification. Fourth, although our data suggest that these 3 frailty measures cannot be used interchangeably for predicting clinical outcomes in a post-acute inpatient rehabilitation setting, we cannot determine which frailty measure is most valid because of our small sample size, and the data, for example, on sensitivity and specificity, need to be interpreted with caution. Larger observational cohort studies from other rehabilitation hospitals are needed to answer this question.

Conclusions and Implications

From a clinical perspective, it would be helpful to have 1 predictive measure to use at admission that could help in patient selection and guide treatment choices and discharge planning. However, our results demonstrate that even though all 3 frailty instruments are predictive for clinical outcomes, predictive abilities vary between frailty measures depending on the clinical outcome. Moreover, sensitivity and specificity may play a role in selecting the frailty measure. Whereas a sensitive tool may be chosen to identify all patients potentially at risk

for readmission to acute care, a more specific tool may be preferred to facilitate early discharge planning (eg, find a feasible institution for nonhome discharge).

Overall, our results demonstrate that discriminatory capacity of these frailty tools is moderate but not excellent. Therefore, frailty may not be a stand-alone measure for clinical decision making in individual patients. Further study is needed to determine if frailty measures provide additional predictive value to existing clinical parameters, such as mobility measures, and activities of daily living.[5,11,30] The goal would be to develop better clinical prediction models to guide decision making to improve risk stratification, as well as treatment and discharge planning for older patients undergoing post-acute rehabilitation.

Frailty is highly prevalent in geriatric rehabilitation inpatients and is a risk factor for negative health-related outcomes with a similar pattern but some variation in prevalence and predictive abilities between frailty measures. Our hypothesis-generating study suggests that frailty measures have the potential to predict short-term outcomes in geriatric rehabilitation inpatients with some variation in discriminatory accuracy between instruments.

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Supplementary Data

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