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Original Study

Predictors for the Transitions of Poor Clinical Outcomes Among Geriatric Rehabilitation Inpatients

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A B S T R A C T

Objective: To investigate the associations of morbidity burden and frailty with the transitions between functional decline, institutionalization, and mortality.
Design: REStORing health of acutely unwell adulTs (RESORT) is an ongoing observational, longitudinal inception cohort and commenced on October 15, 2017. Consented patients were followed for 3 months postdischarge.
Setting and Participants: Consecutive geriatric rehabilitation inpatients admitted to geriatric rehabilitation wards.
Methods: Patients' morbidity burden was assessed at admission using the Charlson Comorbidity Index (CCI) and Cumulative Illness Rating Scale (CIRS). Frailty was assessed using the Clinical Frailty Scale (CFS) and modified Frailty Index based on laboratory tests (mFI-lab). A multistate model was applied at 4 time points: 2 weeks preadmission, admission, and discharge from geriatric rehabilitation and 3 months postdischarge, with the following outcomes: functional decline, institutionalization, and mortality. Cox proportional hazards regression was applied to investigate the associations of morbidity burden and frailty with the transitions between outcomes.
Results: The 1890 included inpatients had a median age of 83.4 (77.6-88.4) years, and 56.3% were female. A higher CCI score was associated with a greater risk of transitions from preadmission and declined functional performance to mortality [hazard ratio (HR) 1.28, 95% CI 1.03-1.59; HR 1.32, 95% CI 1.04-1.67]. A higher CIRS score was associated with a higher risk of not recovering from functional decline (HR 0.80, 95% CI 0.69-0.93). A higher CFS score was associated with a greater risk of transitions from preadmission and declined functional performance to institutionalization (HR 1.28, 95% CI 1.10-1.49; HR 1.23, 95% CI 1.04-1.44) and mortality (HR 1.12, 95% CI 1.01-1.33; HR 1.11, 95% CI 1.003-1.31). The mFI-lab was not associated with any of the transitions. None of the morbidity measures or frailty assessment tools were associated with the transitions from institutionalization to other outcomes.
Conclusions and Implications: This study demonstrates that greater frailty severity, assessed using the CFS, is a significant risk factor for poor clinical outcomes and demonstrates the importance of implementing it in the geriatric rehabilitation setting.

As the world population is ageing, the prevalence of age-related diseases and geriatric syndromes are expected to continue rising among older inpatients.[1,2] Multimorbidity, the co-occurrence of multiple chronic conditions or diseases[3] is prevalent in 86% of older inpatients,[4] whereas frailty, the aggregation of physiological conditions leading to heightened vulnerability, has a prevalence of up to 80% among older inpatients.[5,6] Both multimorbidity and frailty have significant prognostic values for poor clinical outcomes such as

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functional decline, institutionalization, and mortality among older inpatients.[7,8]

A wide variety of morbidity measures are used in clinical settings to assess patients' morbidity burden, including the Charlson Comorbidity Index (CCI) and the Cumulative Illness Rating Scale (CIRS).[9] Similarly, frailty is widely assessed among older patients using assessment tools such as the Clinical Frailty Scale (CFS) and Frailty Index (FI). These morbidity measures and frailty assessment tools are validated to be predictors for poor clinical outcomes among older inpatients.[10,11] However, most studies addressed the associations of morbidity measures and frailty assessment tools with a specific clinical outcome but did not take the transition between different outcomes over time into account.[12] Studying patients' transitions between clinical outcomes could assist clinicians in identifying future patients with similar characteristics and providing early interventions.[13,14] In addition, identifying clinical assessment tools that predict the transitions between clinical outcomes could lead to a better detection of older inpatients who are at higher risk of poor clinical outcomes and would allow clinicians to make better informed-care decisions.[15]

The aim of this study is to apply a multistate model to investigate the associations of morbidity burden and frailty with transitions between functional decline, institutionalization, and mortality from 2 weeks preadmission to 3 months postdischarge among geriatric rehabilitation inpatients.

Methods

Study Design and Setting

REStORing health of acutely unwell adulTs (RESORT) is an observational, prospective, longitudinal inception cohort of consecutive patients admitted to the geriatric rehabilitation wards at a tertiary hospital in Australia. All patients admitted between October 15, 2017, and March 18, 2020, were eligible for inclusion and were approached by researchers for consent. Written informed consent was provided by all included patients or a nominated proxy. Patients were excluded if they were receiving palliative care at admission or were unable to provide informed consent based on the judgment of their treating physicians and had no nominated proxy to consent on their behalf. The study was approved by the ethics committees from the institution and follows the guidelines outlined in the Declaration of Helsinki and the National Statement on Ethical Conduct in Human Research.

Patient Characteristics

Patients with complex and multiple medical and functional conditions were admitted to geriatric rehabilitation wards after discharge from acute hospitalization. Patients' baseline characteristics were assessed within 48 hours of admission and discharge from geriatric rehabilitation by a multidisciplinary team of physicians, nurses, physiotherapists, occupational therapists, dietitians, and social workers following a Comprehensive Geriatric Assessment (CGA).[16] Age, sex, and length of stay in acute and geriatric rehabilitation were extracted from medical records. Patients' accommodation status prior to hospitalization (home, retirement village, nursing home, or others) was assessed through a survey by researchers with the patient and/or carer.

The primary reasons for hospital admission were collected by researchers from the discharge summary in medical records and categorized into the following categories: musculoskeletal, neurologic, cardiovascular, respiratory, infection, gastrointestinal, psychiatric, metabolic, urologic, and others. Cognitive impairment was defined as: dementia or cognitive impairment documented in medical records; a standardized Mini-Mental State Examination score of $<$24 of 30 points; Montreal Cognitive Assessment score of $<$26 of 30 points; or a Rowland Universal Dementia Assessment Scale score of $<$23 of 30 points.[10] Patients' physical performance was assessed by physiotherapists using the Short Physical Performance Battery, with the total score ranging from 0 to 12.[17]

Morbidity Measures and Frailty Assessment Tools

The severity of patients' morbidity burden was assessed by physicians at admission to geriatric rehabilitation using the CCI (total score 37 points) and CIRS (total score 56 points).[18] Higher CCI and CIRS Scores Indicate Greater Morbidity Burden.

Frailty was assessed by physicians at admission to geriatric rehabilitation using the CFS and modified frailty index based on laboratory test (mFI-lab).[19] The CFS is a 9-point scale, with 1 being considered fit and 9 extremely frail. The FI-lab was calculated by dividing the number of abnormal test results over the total laboratory test measured by each patient. The measured ratio for each patient was also calculated by dividing the total laboratory test measured over a total of 77 laboratory tests evaluated. Each patient's mFI-lab score was then calculated by dividing the FI-lab over the measured ratio.[20]

Clinical Outcomes

Patients' functional performances were assessed by occupational therapists at admission and discharge from geriatric rehabilitation using the Katz Index of Activities of Daily Living (ADL)[21] and Lawton and Brody Instrumental (I)ADL.[22] The Katz Index of ADL is a 6-point scale, whereas the IADL is an 8-point scale, with higher scores in both ADL and IADL indicating more independence. Patients' functional performances 2 weeks preadmission were assessed via interview with patients and/or carers. Three months postdischarge, patients' functional performances were assessed by researchers via follow-up phone calls. The interrater reliabilities for Katz Index of ADL and IADL were previously reported to be extremely high ($r > 0.90$).[23,24]

Functional decline was defined as a decrease of 1 point or more in ADL/IADL scores from preadmission ADL/IADL scores as a decrease of 1 point or more in the 6-point ADL and 8-point IADL scales is considered clinically significant.[25] Institutionalization data were collected via medical records and phone call 3 months postdischarge. Mortality data were obtained from medical records and the Registry of Births, Deaths and Marriages, Victoria.

Statistical Analysis

A power calculation was conducted to identify the ideal sample size. A sample of 991 patients on a covariate with a standard deviation of 0.2 achieves 80% power at a .05 significance level to detect a regression coefficient equal to 0.995. The sample size was adjusted for an anticipated event rate of 0.2.[26,27] The power calculation was conducted using the Power Analysis and Sample Size software, version 2021.0.3 (PASS; NCSS Statistical Software).

Descriptive statistics were used to present the patients' characteristics at admission. Parametric variables were reported as means (SDs), whereas nonparametric variables were reported as medians (interquartile ranges). CFS was the only independent variable with missing data (174 patients with missing CFS score) that was identified as not missing completely at random (MCAR) via the Little test ($P = .003$) and assumed to be missing at random. The missing data from the CFS were then imputed using the Sequential Regression Multivariate Imputation approach, and the estimates were pooled according to the Rubin's rules.[28] Descriptive statistics and the Sequential Regression Multivariate Imputation approach were performed using the Statistical Package for the Social Sciences software (IBM SPSS Advanced Statistics, version 26.0; IBM Corp).

Time to event was calculated from 2 weeks preadmission to 3 months postdischarge. Four distinct outcomes were defined as (1) improved or same as preadmission functional performance, (2) functional decline, (3) institutionalization, and (4) mortality. All 4 outcomes are mutually exclusive. Patients who transition to 2 outcomes at the same time were classified to the more severe outcome. For instance, patients who had functional decline (outcome 2) and were institutionalized (outcome 3) at discharge from geriatric rehabilitation were classified as institutionalized (outcome 3) at discharge from geriatric rehabilitation. The mean sojourn time in each outcome, expressed as the estimates ± SE, and the probabilities of transitioning to other outcomes, expressed as the probability (95% CI), were calculated. The associations of each morbidity measure and frailty assessment tool with the transitions between outcomes were evaluated using the Cox proportional hazards regression method, expressed as hazard ratio (HR) with 95% CI. The patients remaining in the same outcome were set as the reference group for each analysis. Models included a crude and an age- and sex-adjusted model. A scaling factor of 8000 was applied to minimize the −2*log-likelihood and prevent the overflow problems within the optimization of the models. A *P* value of <.05 was considered statistically significant. The multistate model and the Cox proportional hazard regression analysis were performed using the msm package in R (R Foundation for Statistical Computing).[29]

Results

In total, 2692 inpatients were admitted to geriatric rehabilitation wards, of which 356 refused participations in the study and 446 inpatients were excluded, resulting in 1890 included patients (Table 1). The patients had a median age of 83.4 (77.6-88.4) years and 56.3% of them were female. The primary reasons for hospital admission were musculoskeletal (47.2%), neurologic (15.1%), cardiovascular (7.5%), respiratory (6.8%), infection (6.2%), gastrointestinal (5.5%), psychiatric (4.2%), urologic (2.8%), and metabolic (2.6%). The median length of stay during acute hospitalization was 7.2 (4.0-12.5) days, followed by a median of 19.9 (13.1-31.0) days in geriatric rehabilitation. The median CCI, CIRS, CFS, and mFI-lab scores at geriatric rehabilitation admission were 2 (1-4), 12 (9-16), 6 (5-7), and 0.51 (0.38-0.69), respectively. The median ADL and IADL scores 2 weeks preadmission were 6 (4-6) and 5 (2-7) respectively. At 3 months postdischarge, a total of 334 patients (17.7%) were lost to follow-up. The median ADL and IADL scores 3 months postdischarge were 4 (2-6) and 3 (1-5), respectively.

The prevalence of patients and the transitions between the 4 outcomes—improved or same as preadmission functional performance, functional decline, institutionalization and mortality, from 2 weeks preadmission to 3 months postdischarge—is illustrated in Figure 1. The majority of the patients were not institutionalized 2 weeks preadmission (n = 1839, 97.3%) and the majority of the patients experienced functional decline at admission to geriatric rehabilitation (n = 1772, 93.8%). At discharge from geriatric rehabilitation, 20.6% of the patients (n = 389) recovered to their preadmission functional performance, 62.2% of the patients (n = 1175) had functional decline, 13.4% of the patients (n = 253) were institutionalized, and 3.9% of the patients (n = 73) had died. At 3 months postdischarge, 9.5% of the patients (n = 179) improved or remained as their preadmission functional performance, 40.3% of the patients (n = 762) had functional decline, 21.7% of the patients (n = 410) were institutionalized, and 7.0% of the patients (n = 132) had died.

The mean sojourn time in each outcome and the probabilities of transitioning to other outcomes are shown in Table 2. The mean sojourn time for improved or same as preadmission functional performance, functional decline, and institutionalization were 5.3 ± 0.6, 15.0 ± 2.0, and 105.1 ± 30.1 days, respectively. Patients from improved or same as preadmission functional performance were most likely to experience functional decline (probability: 0.945, 95% CI 0.923-0.956). From functional decline, the highest probability of transition was toward improved or back to preadmission functional performance (probability: 0.983, 95% CI 0.964-0.988). For institutionalized patients, the highest probability of transition was to mortality (probability: 0.406, 95% CI 0.152-0.503).

Table 1
Characteristics of Geriatric Rehabilitation Inpatients (N = 1890)

	Median (IQR) or n (%)
Age, y	83.4 (77.6-88.4)
Female	1065 (56.3)
Accommodation status	
Home	1724 (91.3)
Retirement village	67 (3.5)
Nursing home	51 (2.7)
Other	48 (2.5)
Primary reason for hospital admission	
Musculoskeletal	893 (47.2)
Neurologic	285 (15.1)
Cardiovascular	142 (7.5)
Respiratory	129 (6.8)
Infection	118 (6.2)
Gastrointestinal	104 (5.5)
Psychiatric	80 (4.2)
Urologic	52 (2.8)
Metabolic	49 (2.6)
Other	38 (2)
Acute length of stay, d	7.2 (4.0-12.5)
Geriatric rehabilitation length of stay, d	19.9 (13.1-31.0)
Cognitive impairment	1231 (65.1)
CCI score at admission	2 (1-4)
CIRS score at admission, score	12 (9-16)
CFS score at admission, score	6 (5-7)
SPPB score at admission, score	1 (0-4)
mFI-lab score at admission, score	0.51 (0.38-0.69)
ADL score 2 wk preadmission, score	6 (4-6)
IADL score 2 wk preadmission, score	5 (2-7)
ADL score at admission, score	2 (1-2)
IADL score at admission, score	1 (0-2)
ADL score at discharge, score	4 (1-5)
IADL score at discharge, score	2 (1-5)
ADL score at 3 mo postdischarge, score	4 (2-6)
IADL score at 3 mo postdischarge, score	3 (1-5)
Institutionalization at discharge	254 (13.4)
Institutionalization at 3 mo postdischarge	430 (22.8)
In-hospital mortality	73 (3.9)
3-mo mortality	132 (7.0)

IQR, interquartile range; SPPB, Short Physical Performance Battery.

Table 3 shows the associations of the morbidity measures and frailty assessment tools with the transitions from improved or same as preadmission functional performance to other outcomes. After adjusting for age and sex, a higher CCI score was significantly associated with a greater risk of mortality (HR 1.278, 95% CI 1.025-1.594) compared with patients remaining in their preadmission functional performance. A higher CFS score was significantly associated with greater risks of institutionalization (HR 1.281, 95% CI 1.102-1.489) and mortality (HR 1.119, 95% CI 1.012-1.325).

Both higher CIRS and CFS scores were significantly associated with lower chance of transition from functional decline toward improved or same as preadmission functional performance (HR 0.798, 95% CI 0.688-0.926 and HR 0.839, 95% CI 0.723-0.974, respectively) in comparison to patients remaining with functional decline (Table 4). A higher CCI score was significantly associated with greater risk of mortality (HR 1.319, 95% CI 1.040-1.673) whereas a higher CFS score was associated with greater risk of institutionalization (HR 1.226, 95% CI 1.042-1.443) and mortality (HR 1.110, 95% CI 1.003-1.308).

The associations of the morbidity measures and frailty assessment tools with the transitions from institutionalization to other outcomes are shown in Table 5. The adjusted model showed that none of the

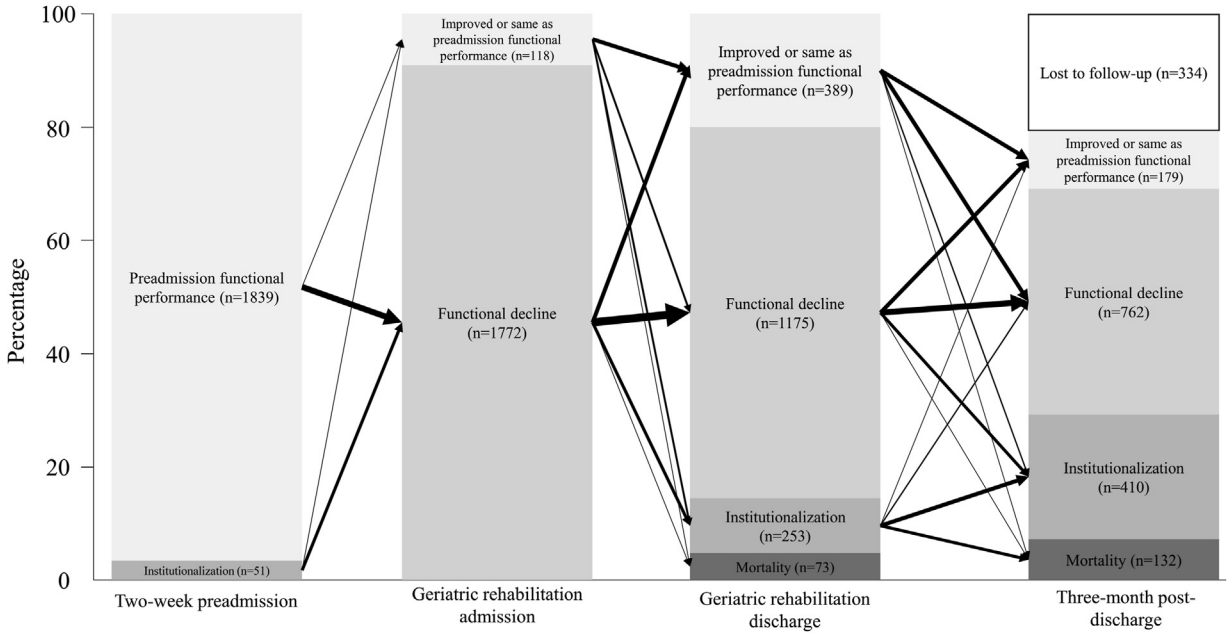

Fig. 1. Multistate model on the transition between 4 outcomes and the corresponding prevalence from 2 weeks preadmission to 3 months postdischarge. (Thickness of the arrow indicates the relative percentages of patients' transition into each outcome.).

morbidity measures or frailty assessment tools were associated with the transitions from institutionalization toward improved or same as preadmission functional performance, functional decline, or mortality.

Discussion

A higher CCI score was significantly associated with greater risk of mortality among geriatric rehabilitation inpatients. Both higher CIRS and CFS scores were associated with higher risk of not recovering from functional decline. A higher CFS score was also significantly associated with greater risk of institutionalization and mortality. None of the morbidity measures or frailty assessment tools were associated with the transition from institutionalization to other outcomes.

It is noticeable that most of the patients admitted to geriatric rehabilitation have declined in their functional performance compared with preadmission. This is consistent with a previous study investigating the trajectories of functional performance among geriatric rehabilitation inpatients, in which the majority of patients had a decline in ADL and/or IADL at admission.[10] Despite this, patients suffering from functional decline were more likely to improve or recover to their preadmission functional performance than being institutionalized or to die, indicating that the decline in functional performance is reversible and the rehabilitation program could help patients in regaining functional performance.[30] However, there were more patients with functional decline who did not recover after rehabilitation than patients who did. This indicates the need to further explore the clinical characteristics that might contribute to patients recovering from functional decline and potential interventions in improving patients' rehabilitation outcome.

Most of the patients who were institutionalized after discharge from geriatric rehabilitation remained institutionalized at 3 months postdischarge, indicating that the majority of the patients were institutionalized for permanent care.[31] Risk factors for long-term institutionalization shown in previous study were cognitive impairment, ADL dependency and diabetes.[32] In the situation where patients were transitioning from institutionalization, it was shown that patients were most likely to die. Similar results were shown in previous studies, further emphasizing the unlikelihood of community discharge from institutional care.[33–35]

This study demonstrates that a higher CCI was significantly associated with mortality, which aligns with previous systematic review demonstrating the performance of morbidity measures in predicting mortality among older inpatients.[18] The morbidities and their corresponding weight listed in the CCI were validated on their associations with mortality in various clinical settings.[18] Patients' morbidity burden at admission to geriatric rehabilitation should be assessed to reflect those with a higher risk of mortality. The CCI was not associated with functional decline, which is in line with a systematic review.[36]

Table 2
Mean Sojourn Time in Each Outcome and the Probabilities of Transition to Each Outcome

	To Improved or Same as Preadmission Functional Performance, Probability (95% CI)	Functional Decline, Probability (95% CI)	Institutionalization, Probability (95% CI)	Mortality, Probability (95% CI)
From (mean sojourn time, d)				
Improved or same as preadmission functional performance (5.31 ± 0.57)	—	.95 (.92-.96)	.06 (.04-.07)	.001 (<.001-.012)
Functional decline (15.03 ± 1.95)	.98 (.96-.99)	—	.001 (<.001-.019)	.016 (.011-.023)
Institutionalization (105.11 ± 30.09)	.32 (.032-.80)	.27 (.019-.78)	—	.41 (.15-.50)
Mortality (N/A)	—	—	—	—

Mean sojourn time is expressed as estimates ± SE.

Table 3
The Associations of the Morbidity Measures and Frailty Assessment Tools With the Transition From Improved or Same as Preadmission Functional Performance to Other Outcomes

Transition From Improved or Same as Preadmission Functional Performance				
	Improved or Same as Preadmission Functional Performance (n = 551)*	Functional Decline (n = 1331)*	Institutionalization (n = 252)*	Mortality (n = 94)*
	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)
Crude model				
CCI, per 1 point	1.00 (ref)	**0.902 (0.836-0.973)**	1.002 (0.947-1.059)	**3.342 (1.011-11.05)**
CIRS, per 1 point	1.00 (ref)	**0.962 (0.929-0.996)**	1.005 (0.983-1.027)	1.053 (0.556-1.996)
CFS, per 1 point	1.00 (ref)	**0.576 (0.341-0.972)**	**1.461 (1.259-1.695)**	0.773 (0.191-3.123)
mFI-lab, per 0.1 point	1.00 (ref)	0.995 (0.990-1.001)	0.996 (0.992-1.001)	1.001 (0.963-1.051)
Adjusted for age and sex				
CCI, per 1 point	1.00 (ref)	0.879 (0.694-1.078)	1.101 (0.947-1.280)	**1.278 (1.025-1.594)**
CIRS, per 1 point	1.00 (ref)	0.926 (0.837-1.025)	1.024 (0.881-1.190)	1.092 (0.876-1.362)
CFS, per 1 point	1.00 (ref)	0.889 (0.423-1.034)	**1.281 (1.102-1.489)**	**1.119 (1.012-1.325)**
mFI-lab, per 0.1 point	1.00 (ref)	0.997 (0.987-1.007)	0.998 (0.983-1.014)	1.002 (0.980-1.025)

Boldface indicates statistical significance ($P < .05$).
*The number of patients transitioned from institutionalization to other 4 outcomes are included in parentheses (n).

This might be due to the predefined weighted diseases included in the CCI being developed and validated to predict mortality, limiting the capacity to reflect other poor clinical outcomes. Typically disabling diseases or conditions such as sarcopenia, stroke, and arthritis were shown to be associated with functional decline among older inpatients,[37,38] and the exclusion of these diseases in the morbidity measures contributes to the insignificant association between the CCI and functional decline.

The association between the CIRS and mortality was insignificant. Although this result was surprising, the CCI has been reported to be stronger in predicting mortality than the CIRS among older inpatients.[39] Moreover, a previous study showed that there is little evidence to support the predictive validity of CIRS[40] and that the interrater and test-retest reliability of CIRS are low.[41] The scoring of CIRS in each organ system is more subjective compared to the CCI where all diseases included have a preassigned weight. This could potentially result in the inconsistency of the CIRS scoring among the geriatric rehabilitation inpatients as several physicians were involved in the assessment of patients' CIRS score.

The finding of higher CFS being significantly associated with higher risk of institutionalization and mortality emphasizes the importance of assessing patients' frailty at admission to geriatric rehabilitation. The CFS and its association with mortality has been widely studied across different clinical setting, and the significant association shown in this study aligns with the results from previous studies.[42] On the contrary, literature on the association between CFS and institutionalization is limited.[42] This study suggests that worsening frailty assessed by the CFS could reflect patients who are at higher risk of institutionalization. Frailty is characterized by a decline in physiological functions across multiple organ systems and increased vulnerability to stressors, which in turn increase the risk of poor clinical outcomes.[43] The CFS is an assessment tool that combines clinical judgment with objective measurement and can be conducted easily; hence, it has been seen as one of the most promising and practical ways of assessing frailty in routine assessment.[44] Furthermore, it could help tailor hospital services and discharge destinations to the biologically and pathologically heterogeneous population of older inpatients.[45] A preadmission assessment of the frailty state might help with early discharge planning. Patients with a high preadmission CFS scores were unlikely to recover from functional decline during rehabilitation stay. Early indications of institutional care admission can benefit patients by providing the support they need.[46]

The insignificant association shown between the mFI-lab and the transitions to other outcomes demonstrated the need to further explore the prognostic value of the frailty assessment tool based on laboratory test. The notion of modifying the standard FI-lab came from

Table 4
The Associations of the Morbidity Measures and Frailty Assessment Tools With the Transition From Functional Decline to Other Outcomes

Transition From Functional Decline				
	Improved or Same as Preadmission Functional Performance (n = 331)*	Functional Decline (n = 575)*	Institutionalization (n = 192)*	Mortality (n = 77)*
	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)
Crude model				
CCI, per 1 point	0.918 (0.837-1.006)	1.00 (ref)	0.962 (0.031-29.57)	**1.224 (1.148-1.304)**
CIRS, per 1 point	**0.959 (0.920-0.998)**	1.00 (ref)	1.009 (0.304-3.348)	**1.065 (1.032-1.098)**
CFS, per 1 point	**0.518 (0.304-0.883)**	1.00 (ref)	0.450 (0.097-2.085)	**1.577 (1.061-2.346)**
mFI-lab, per 0.1 point	0.996 (0.990-1.003)	1.00 (ref)	0.994 (0.838-1.179)	**1.014 (1.001-1.019)**
Adjusted for age and sex				
CCI, per 1 point	0.873 (0.752-1.013)	1.00 (ref)	0.937 (0.796-1.103)	**1.319 (1.040-1.673)**
CIRS, per 1 point	**0.798 (0.688-0.926)**	1.00 (ref)	1.030 (0.875-1.212)	1.050 (0.828-1.332)
CFS, per 1 point	**0.839 (0.723-0.974)**	1.00 (ref)	**1.226 (1.042-1.443)**	**1.110 (1.003-1.308)**
mFI-lab, per 0.1 point	1.001 (0.986-1.016)	1.00 (ref)	0.999 (0.982-1.015)	1.003 (0.979-1.027)

Boldface indicates statistical significance ($P < .05$).
*The number of patients transitioned from institutionalization to other 4 outcomes are included in parentheses (n).

Table 5
The Associations of the Morbidity Measures and Frailty Assessment Tools With the Transition From Institutionalization to Other Outcomes

Transition From Institutionalization	Improved or Same as Preadmission Functional Performance (n = 20)*	Functional Decline (n = 31)*	Institutionalization (n = 219)*	Mortality (n = 34)*
	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)
Crude model				
CCI, per 1 point	0.749 (0.183-3.063)	**1.344 (0.861-2.099)**	1.00 (ref)	**1.253 (1.121-1.399)**
CIRS, per 1 point	1.035 (0.951-1.126)	1.021 (0.851-1.224)	1.00 (ref)	**1.063 (1.012-1.116)**
CFS, per 1 point	**5.124 (1.159-22.665)**	0.671 (0.446-1.011)	1.00 (ref)	1.384 (0.891-2.150)
mFI-lab, per 0.1 point	1.004 (0.994-1.014)	1.005 (0.993-1.017)	1.00 (ref)	1.006 (1.001-1.011)
Adjusted for age and sex				
CCI, per 1 point	0.988 (0.466-2.097)	1.026 (0.704-1.494)	1.00 (ref)	1.201 (0.837-1.724)
CIRS, per 1 point	1.064 (0.501-2.258)	1.050 (0.721-1.529)	1.00 (ref)	1.090 (0.759-1.564)
CFS, per 1 point	1.013 (0.477-2.150)	0.963 (0.661-1.403)	1.00 (ref)	1.054 (0.734-1.513)
mFI-lab, per 0.1 point	1.004 (0.928-1.079)	1.004 (0.963-1.039)	1.00 (ref)	1.003 (0.967-1.039)

Boldface indicates statistical significance ($P < .05$).
*The number of patients transitioned from institutionalization to other 4 outcomes are included in parentheses (n).

the finding of the significant association shown with the presence of laboratory tests and mortality, independent of the test results.[45] By dividing the standard FI-lab with the measured ratio of the laboratory tests, previous study showed improvement in its performance in predicting mortality among geriatric rehabilitation inpatients but remained weaker than the CFS. This study demonstrates the superiority of using the CFS as a frailty assessment tool. Furthermore, it raises a question as to the prognostic value of laboratory tests at geriatric rehabilitation admission, and future studies should look into whether results from laboratory tests at hospital admission is predictive of poor clinical outcomes postdischarge.[47]

To date, this is the first study that investigates the associations of morbidity measures and frailty assessment tools with the transition between preadmission functional performance, functional decline, institutionalization, and mortality in a multistate model. This study has a few limitations. First, although this is a large cohort of geriatric rehabilitation inpatients, it is a single-site study, and therefore the results should be interpreted with caution because of the generalizability issue. This is because clinical characteristics of the patients admitted to the geriatric rehabilitation such as socioeconomic status and frailty severity differ in various regions and countries and therewith might influence the results. Second, multiple clinicians were involved over the course of data collection; hence, there is a potential for inconsistency in the assessments of some subjective tools, including the CFS and CIRS. Lastly, in-hospital complications such as falls, infection, delirium, and renal failure were not collected in this study. They are important confounders and could potentially affect the results of the analysis.

Conclusion and Implications

Patients' morbidity burden and frailty should be assessed using the CCI and CFS at admission to geriatric rehabilitation. Greater attention and emphasis on the interventions regarding the severity of frailty is needed to reduce the risks of poor clinical outcomes. The CFS was shown to be a strong prognostic tool in reflecting patients with higher likelihood of recovering from functional decline, as well as higher risk of institutionalization and mortality. Future studies should investigate the association of the morbidity burden and frailty with other clinical outcomes in a longer follow-up period.

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