

ONLINE FIRST PUBLICATION

Online first papers have undergone full scientific review and copyediting, but have not been typeset or proofread. To cite this article, use the DOI number provided. Mandatory typesetting and proofreading will commence with regular print and online publication of the online first papers of the *SMJ*.

Association of the FRAIL scale with rehabilitation outcomes in the community hospital setting

Jeffrey Jiang¹, FCFPS, FAMS, Audrey Yan Yi Han¹, MBBS, MMed, Joel Goh^{2,3,4}, MS, PhD

¹Department of Medicine, St Luke's Hospital, ²Department of Analytics and Operations, NUS Business School, ³NUS Global Asia Institute, National University of Singapore, Singapore, ⁴Harvard Business School, Harvard University, Boston, MA, USA

Correspondence: Dr Jeffrey Jiang, Associate Consultant, Department of Medicine, St Luke's Hospital, 2 Bukit Batok Street 11, Singapore 659674. jeffreyjiang@stluke.org.sg

Singapore Med J 2021, 1–20

<https://doi.org/10.11622/smedj.2021137>

Published ahead of print: 4 October 2021

Online version can be found at
<http://www.smj.org.sg/online-first>

ABSTRACT

Introduction: Frailty is associated with adverse health outcomes and can be measured using the FRAIL scale. In Singapore, its use has been studied in tertiary hospitals but not in community hospitals. A tool to predict rehabilitation outcomes would allow for better risk stratification and allocation of resources. We aimed to determine whether the FRAIL scale is associated with rehabilitation outcomes in patients admitted to the community hospital setting, where post-acute care and rehabilitation are primarily delivered.

Methods: This was a retrospective cohort study. The FRAIL scale was utilised to screen 560 older adults who were admitted to a community hospital for rehabilitation. Data were analysed to determine the relationship between baseline characteristics and frailty status, with rehabilitation outcome measures of absolute functional gain, rehabilitation effectiveness, rehabilitation efficiency, length of stay and discharge destination.

Results: The combined score of the FRAIL scale showed significant negative association with absolute functional gain ($p < 0.001$), rehabilitation effectiveness ($p < 0.001$) and rehabilitation efficiency ($p < 0.001$), whereas it was positively associated with increased length of stay ($p < 0.05$) and a need for continued support in increased care settings ($p < 0.001$). Individual components of the FRAIL scale, in particular, the 'fatigue', 'ambulation' and 'loss of weight' components, appeared to be highly associated with rehabilitation effectiveness and efficiency, especially among pre-frail patients.

Conclusion: The utility of the FRAIL scale as an indicator of frailty status and its association with rehabilitative outcomes in the post-acute care setting were demonstrated. Moreover, the FRAIL scale may better predict the rehabilitative progress of pre-frail patients.

Keywords: frailty, post-acute care, rehabilitation

INTRODUCTION

Over the past few decades, the realm of geriatrics has evolved in accordance with epidemiological changes, with the rise of new geriatric syndromes such as frailty, sarcopenia, the anorexia of aging, and cognitive impairment.⁽¹⁾ Among these ‘modern geriatric giants’, the condition of frailty, in particular, has attracted markedly increased research attention in recent years owing to its associations with adverse health outcomes such as falls, disability, hospitalisations, institutionalisation and mortality.⁽²⁾ The International Association of Gerontology and Geriatrics Frailty Consensus has defined frailty as an age-related state characterised by reduced strength and physiologic malfunctioning that increases an individual’s susceptibility to increased dependency, vulnerability and death.⁽²⁾

In Singapore, where this study was conducted, frailty has been increasingly recognised as an indicator of successful ageing and healthcare utilisation.⁽³⁾ Locally, among community-dwelling older adults, the prevalence of frailty and pre-frailty was reported to be 6.2% and 37%, respectively.⁽⁴⁾ The prevalence of frailty was even higher in the outpatient medical clinics⁽⁵⁾ and among inpatients of a tertiary hospital geriatric ward,⁽⁶⁾ at 27% and 50%–87%, respectively. Community hospitals admit patients from tertiary hospitals who require an extended period of inpatient rehabilitation, medical care or social support before discharge. They are part of the spectrum of institutions classified under the residential intermediate and long-term care sector in Singapore. A previous study found that the prevalence of frailty and pre-frailty was 45.6% and 40.2%, respectively, among older adults aged 65 years and above who were admitted to a community hospital in Singapore. The study also demonstrated that the FRAIL scale can be utilised as a practical tool to identify frailty.⁽⁷⁾ The prevalence of frailty makes its early identification, intervention and prevention key to the improvement of population health and mitigation of rising healthcare costs.

The FRAIL scale is a hybrid tool that screens for frailty using elements from the two most commonly used frailty measurement tools: Fried's Frailty Phenotype⁽⁸⁾ and Rockwood and Mitnitski's Frailty Index.⁽⁹⁾ It has been extensively validated and recommended for clinical use by the International Academy Nutrition and Aging⁽¹⁰⁾ and the Asia-Pacific clinical practice guidelines.⁽¹¹⁾ In Singapore, the performance of the FRAIL scale has been compared with those of other frailty measurements (Clinical Frailty Scale [CFS] and Tilburg Frailty Indicator) in the inpatient setting. It was found to correlate with in-hospital mortality and length of hospitalisation.⁽⁶⁾

However, measures such as mortality are of little value in rehabilitation settings, where death is a rare occurrence. Rather, rehabilitation impact indices have been developed in the last decade in response to the need to create composite measures that control for premorbid and prehabilitation functional status, as well as the rate of functional improvement.⁽¹²⁾ Previous studies^(13,14) have proposed the twin measures of rehabilitation effectiveness (REs) and rehabilitation efficiency (REy) as more suitable outcome measures in the rehabilitation setting. REs is defined as the percentage of potential functional improvement actually achieved, and REy is defined as the rate of functional recovery during rehabilitation. In the aforementioned systematic review of all such indices, REy had the most number of supporting studies, followed by REs and absolute functional gain (AFG).⁽¹²⁾

Studies evaluating the correlation of frailty with rehabilitation indices have been reported. One such study investigated the utility of the Edmonton Frailty Scale (EFS). An observational prospective study was conducted in a Geriatric Evaluation and Management (GEM) unit using the EFS as a predictor of functional gain, resource utilisation and destinations for patients in the GEM unit (n = 136). 'Frail' and 'severely frail' subgroups showed more improvement than the 'pre-frail' group did in the mean Functional Independence Measure (FIM) scores at discharge. Higher frailty level also correlated with reduced independence and

greater resource utilisation. It concluded that the EFS could be a prognostic indicator of physical independence and resource utilisation.⁽¹⁵⁾ However, another study reported contrasting findings; although this study similarly applied the EFS, it was observed that the level of frailty measured with the EFS was not a useful predictor of rehabilitation and discharge outcomes for older adults in subacute care. The study was conducted in the subacute rehabilitative setting (n = 75). The level of frailty did not correlate with length of stay (LOS), discharge destination or gains in function.⁽¹⁶⁾

Yet another study utilised the Multidimensional Prognostic Index (MPI) as a measure of frailty in a population of patients undergoing rehabilitation after orthopaedic surgery of the lower limb (n = 81). This study showed that resilience (defined as the capacity of individuals to successfully maintain or regain their mental health in face of significant adversity), but not frailty status, was a predictor of functional status (as indicated by the FIM score) at discharge.⁽¹⁷⁾ However, this study population excluded those with poor Mini-Mental State Examination performance (score < 15/30) as well as those who fell acutely ill and required a transfer back to the acute care setting, which could potentially skew the results in favour of resilience.

To the best of our knowledge, no study utilising the FRAIL scale has been performed in the post-acute rehabilitative setting. A pilot study conducted in West China Hospital in Chengdu, China used the FRAIL scale to predict outcomes in Chinese older adults with Type 2 diabetes mellitus. The findings showed that both pre-frailty and frailty were significantly associated with disability in activities of daily living (odds ratio [OR] 2.84 and 6.58, respectively), as well as mobility impairment, as indicated by the Timed Up and Go test (OR 3.89 and 22.15, respectively).⁽¹⁸⁾ In addition, frailty predicted a greater number of hospitalisations in the year following enrolment (OR 5.99). This was the only study conducted on a predominantly Chinese population, similar to ours. However, its generalisability is limited,

given that it was conducted in the tertiary setting, and only patients with Type 2 diabetes mellitus were studied. Further, although functional indicators were assessed at admission, functional improvement over the course of time was not determined, thus precluding a conclusion about the association between frailty status and rehabilitative progress.

We are aware of two other studies that have utilised the FRAIL scale; however, neither of them assessed the relation of frailty status with rehabilitative progress. One study investigated the relation of frailty with hospital LOS and the need for post-acute rehabilitation in a population of patients who underwent elective lower limb orthopaedic surgery.⁽¹⁹⁾ The study concluded that the CFS,⁽²⁰⁾ but not the FRAIL scale, was significantly associated with both outcomes. The second study applied the FRAIL scale to patients admitted to a Level 1 trauma centre for orthopaedic injuries.⁽²¹⁾ A significant association was observed between frailty and the LOS, frequency of postoperative complications and discharge disposition.

The available evidence is insufficient to ascertain whether the addition of frailty status assessment to routine assessments in older adults entering a community hospital would be truly beneficial. Therefore, the FRAIL scale should be tested in the community hospital setting as a prognostic indicator, against clearly defined and relevant endpoints such as rehabilitation outcomes. If this is successful, community hospital practitioners could use frailty status to tailor the type and intensity of interventions for frail patients. Further, frailty status may potentially be recognised as a standard indicator of patient complexity across community hospitals, thus garnering financial and governmental support to invest in frailty-specific interventions and programmes. Moreover, it can be used to stratify patients requiring a comprehensive geriatric assessment, closer follow-up by care coordinators after discharge and serve as a trigger to the primary physician to decide whether the patient would benefit from referral to the community hospital's outpatient services for comprehensive geriatric care.

METHODS

The study participants were inpatients at a community hospital located in western Singapore. The community hospital is a 243-bedded subacute inpatient rehabilitation hospital providing multidisciplinary team-based rehabilitation for patients from tertiary hospitals who require stepdown care. Inpatients who require complex medical care or care coordination are offered follow-up in the outpatient clinic on discharge. Based on the hospital's historical data of the fiscal year 2017, there were 2,091 inpatient hospital admissions, of which 84% were for the purpose of rehabilitation.

The cohort of participants comprised inpatients admitted to the hospital from 1 July 2017 through 30 April 2018 who had stayed in the hospital for at least one day. Participants were included if they were between the ages of 65 years and 100 years upon admission, and if they had the ability or potential to ambulate. There was no restriction on ethnicity or gender. Participants diagnosed with a terminal illness, those with a prognosis of less than six months and those who were chronically bedbound were excluded from the study. The final number of participants included in this study was 560. The demographics of the study population are shown in Table I.

Table I. Patient demographics. (n = 560)

Characteristic	No. (%)
Gender	
Male	245 (43.8)
Female	315 (56.2)
Ethnicity	
Chinese	473 (84.5)
Malay	54 (9.6)
Indian	26 (4.6)
Others	7 (1.2)
Mean age (yr)	79.12
Age group (yr)	
65–74	200 (35.7)
75–84	229 (40.9)

85–100	131 (23.4)
Frailty status	
Robust	83 (14.8)
Pre-frail	228 (40.7)
Frail	249 (44.5)
Frailty components	
F (Fatigue)	206 (36.8)
R (Resistance)	421 (75.2)
A (Ambulation)	399 (71.2)
I (Illnesses)	144 (25.7)
L (Loss of weight)	97 (17.3)
Ward class	
Upper ward class (Class A/B)	54 (9.6)
Lower ward class (Class C)	506 (90.4)
Subsidy level	
High	455 (81.2)
Low	105 (18.8)

We performed a retrospective study on de-identified data from the frailty registry database of the hospital. Data was extracted by co-investigators under the supervision of the principal investigator. Ethics approval was obtained from the local Institutional Review Board (St Luke’s Hospital IRB reference no. IRB-04-2019-01-03), with study support sought from the hospital management.

Based on the hospital’s current admission protocol, all patients were screened using the well-validated five-point FRAIL scale if they were at least 65 years of age and had the ability or potential to ambulate. The five items include fatigue (have felt tired most or all of the time in the past four weeks), resistance (have difficulty or unable to climb a flight of steps), ambulation (have difficulty or unable to walk a block), illness (have more than five illnesses, the range of which includes hypertension, diabetes mellitus, cancer [other than a minor skin cancer], chronic lung disease, heart attack, congestive heart failure, angina, asthma, arthritis, stroke and kidney disease) and loss of weight (more than 5% unintentional weight loss over 12 months).⁽²²⁾ Participants were classified as ‘frail’ if they had positive answers for three or more

domains, 'pre-frail' if they had positive answers for one or two domains and 'robust' if they had no positive answers.

Age at screening, gender and ethnicity were measured as basic demographic variables for all participants. Admission ward class and eligible government healthcare subsidy rate (based on household means testing) were recorded as surrogates of socioeconomic status (SES).

Individual-level measures of SES have been shown to be independent factors that influence major disease and health outcomes.⁽²³⁾ Examples of individual-level measures of SES include educational level, income status, employment status and the level of financial assistance received.⁽²⁴⁾ SES based on hospital admission ward class and means testing has been analysed in other local studies conducted in the community hospital setting of Singapore.⁽²⁵⁾ Wards are classed by the sophistication and availability of physical amenities, although patients across all wards receive the same standard of medical, nursing and rehabilitative care. Patients in all wards are reviewed twice a day, five days a week, by physical and occupational therapists. In the study hospital, both 'A' and 'B' class wards are air-conditioned. 'A' class rooms are one-bedded (private), whereas 'B' class rooms are five-bedded (semi-private). 'C' class wards are six- to eight-bedded and are not air-conditioned. The average monthly inpatient bill sizes for patients undergoing rehabilitation in 'A' and 'B' classes are SGD 17,400 and SGD 15,000, respectively. By contrast, the average monthly inpatient bill size for a 'C' class bed ranges from SGD 4,290–11,520 for Singapore citizens and SGD 8,400–12,840 for permanent residents, because of a heavy government subsidy for citizens. Singapore citizens or permanent residents have a choice of ward class upon admission, but those who decide on the 'C' class ward are subject to household means testing by the Ministry of Health to determine the level of government subsidies that they are eligible for. Government subsidy is then awarded according to the assessed financial circumstances (per capita monthly household income) of the patient

and their family.⁽²⁶⁾ ‘A’ or ‘B’ class patients do not receive any government subsidies. Therefore, we defined ward class as a binary variable – ward class ‘A’ and ‘B’ were grouped together as ‘upper ward class’, whereas ward class ‘C’ was grouped separately as ‘lower ward class’. Similarly, eligibility for additional subsidies among citizens and permanent residents was classified as a binary variable – patients with a subsidy level of 0%–20% were classified as having a ‘low subsidy’, whereas those who had subsidy levels exceeding 20% were classified as having a ‘high subsidy’.

Functional status, as measured by performance in activities of daily living (ADL), was assessed using the Shah-modified Barthel Index (BI), which is currently used by all subacute rehabilitation hospitals in Singapore, as recommended by national healthcare guidelines.⁽²⁷⁾ The Shah-modified BI has five subcategories for each ADL category and 100 possible discrete values.⁽¹⁴⁾ A score of zero reflects complete ADL dependence, and a score of 100 reflects complete ADL independence. Admission BI was scored within 48 hours of admission and repeated at least every two weeks until discharge, in accordance with the same set of local guidelines. Assessments were performed by occupational therapists, and the scores were treated as a continuous variable in the study. The first BI recorded was considered as the admission BI, and the last BI was considered as the discharge BI; the dates of both scorings were recorded.

Absolute functional gain (AFG) is the amount of improvement achieved with rehabilitation, and was calculated as follows:

$$\text{AFG} = \text{discharge BI score} - \text{admission BI score}$$

A patient’s LOS is defined as the number of days from admission to discharge. Similar to other studies, we used the log-transformed LOS (LOGLOS) as our outcome measure in this study to account for right-skew in the raw LOS data.

Rehabilitation effectiveness (REs) is the percentage of potential improvement actually achieved during rehabilitation, and was calculated as follows:

$$\text{REs} = \frac{\text{AFG}}{(\text{maximum BI score}) - (\text{admission BI score})}$$

There is no current consensus regarding the value that should be used as the ‘maximum BI score’ in the denominator. Some studies use the maximum score of the functional measure tool, whereas other studies use the premorbid function of the patient.⁽¹²⁾ We chose the upper limit of the BI (i.e. 100) as the maximal functional score attainable for a participant, as opposed to premorbid functional status, as recommended by some authors.⁽²⁸⁾ This is because few patients would have baseline BI assessed before the onset of their disabling illness, and using the latter assumes that a participant cannot improve beyond his/her premorbid functional status with rehabilitation.

Rehabilitation efficiency (REy) is the rate of functional improvement during rehabilitation, and was calculated as follows: $\text{REy} = \frac{\text{AFG}}{\text{LOS}}$

Participants could have negative REs or REy if their functional status declined during rehabilitation. Participants were categorised according to whether they were discharged to their own home, a nursing home or transferred out to a tertiary hospital for escalation of care.

We used multiple linear regressions to evaluate the associations between the combined frailty score and the outcomes of AFG, LOGLOS, REs, and REy, while controlling for demographic and SES covariates. We used a separate set of multiple linear regressions to evaluate the associations of each of the individual frailty score components on these same outcomes, while controlling for the same set of covariates. Because the patients’ discharge status comprised three categorical outcomes that represented successive escalations of care (respectively, the patient’s home, a nursing home or a tertiary hospital), we used two separate multiple ordinal logistic regressions to assess the impact of the combined frailty score and the

individual frailty score components on the patients' discharge destination. All analyses were performed using R software version 3.5.2 (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

Women constituted 56.2% of the study population, and the ethnic composition of the study cohort was generally representative of the Singapore population. The prevalence of frailty based on the FRAIL scale was 44.5%. The components of frailty that were the primary contributors to the identification of frailty were 'R' (resistance) and 'A' (ambulation). No significant differences were observed between men and women.

In terms of outcome measures, only the combined frailty score ($p < 0.001$) and patients' age ($p < 0.05$) were significantly associated with poorer AFG (Table II). A unit increase in the combined frailty score was associated with a reduction of 1.69 points in AFG. When individual components of the FRAIL scale were analysed, only the 'F' component (fatigue) was associated with poorer AFG ($p < 0.001$), and a unit increase in this component of the score was associated with a decrease of around 4.70 points in AFG.

A higher combined frailty score had a significant positive association with patients' LOS ($p < 0.05$). A unit increase in the combined frailty score increased the average LOGLOS by 0.048, which corresponded to an approximately 4.9% increase in the patients' LOS. Individual components of the FRAIL scale were not significantly associated with the LOS.

The combined frailty score was significantly associated with lower REs ($p < 0.001$), where a unit increase in the combined frailty score was associated with a 0.067-point reduction in the patients' average REs. The combined frailty score was significantly associated with lower REy ($p < 0.001$), where a unit increase in the frailty score was associated with a 0.109-point reduction in the patients' average REy.

Patients with a higher combined frailty score were significantly more likely to be discharged to facilities with higher levels of care, relative to lower levels of care ($p < 0.001$). For every unit increase in the combined frailty score, the odds of being discharged to a tertiary hospital (relative to being discharged to a nursing home or the patient's home) increased by a factor of 1.49. Because of the structure of the ordinal logistic regression, this means that every unit increase in the combined frailty score also increased the odds of being discharged to either a tertiary hospital or a nursing home (relative to being discharged to the patient's home). Female patients had significantly lower odds of being discharged to settings with higher levels of care ($p < 0.05$). The 'L' (loss of weight) component of the FRAIL scale was significantly associated with discharge to settings with higher levels of care ($p < 0.001$). A unit increase of the 'L' component of the score increased the odds of care escalation by a factor of 2.56.

Overall, the combined frailty score was significantly associated with all five outcome measures. Lower ward class and low subsidy level were significantly negatively associated with REs and REy. Age was also negatively associated with AFG, REs and REy. Tables II and III provide a detailed report of all regression results.

Table II. Regression analyses of rehabilitation outcome measures on aggregate FRAIL score and covariates.

Parameter	Coefficient (standard error)				
	AFG*	LOGLOS*	REs*	REy*	Discharge destination [†]
Combined FRAIL score	-1.688 [‡] (0.47)	0.048 [§] (0.02)	-0.067 [‡] (0.01)	-0.109 [‡] (0.02)	0.401 [‡] (0.09)
Female gender	1.089 (1.22)	-0.011 (0.06)	0.021 (0.03)	0.058 (0.05)	-0.533 [§] (0.23)
Non-Chinese ethnicity	1.409 (1.70)	0.046 (0.09)	0.014 (0.04)	0.012 (0.07)	0.095 (0.31)
Age	-0.161 [§] (0.08)	-0.005 (0.00)	-0.007 [‡] (0.00)	-0.008 [§] (0.00)	0.016 (0.02)
Lower ward class	-4.324 (2.78)	0.164 (0.14)	-0.126 [§] (0.06)	-0.239 [§] (0.11)	0.759 (0.60)
Low subsidy level	-2.940 (2.12)	-0.010 (0.11)	-0.097 [§] (0.05)	-0.162 [§] (0.08)	0.159 (0.39)

*Calculated using linear regression. †Calculated using ordinal logistic regression. § $p < 0.05$. ‡ $p < 0.001$. AFG: absolute functional gain; LOGLOS: log-transformed length of stay; REs: rehabilitation effectiveness; REy: rehabilitation efficiency

Table III. Regression analyses of rehabilitation outcome measures on individual components of the FRAIL score and covariates.

Parameter	Coefficient (standard error)				
	AFG*	LOGLOS*	REs*	REy*	Discharge destination [†]
F (fatigue)	-4.696 [‡] (1.37)	0.012 (0.07)	-0.137 [‡] (0.03)	-0.194 [‡] (0.05)	0.270 (0.25)
R (resistance)	0.378 (2.11)	-0.039 (0.11)	-0.044 (0.05)	0.065 (0.08)	0.772 (0.45)
A (ambulation)	-2.304 (2.00)	0.135 (0.10)	-0.058 (0.04)	-0.212 [§] (0.08)	0.159 (0.40)
I (illness)	0.199 (1.42)	0.104 (0.07)	-0.054 (0.03)	-0.061 (0.05)	0.097 (0.26)
L (loss of weight)	-2.464 (1.64)	0.050 (0.08)	-0.062 (0.04)	-0.160 [¶] (0.06)	0.937 [‡] (0.27)
Female gender	0.661 (1.23)	-0.012 (0.06)	0.014 (0.03)	0.039 (0.05)	-0.485 [¶] (0.24)
Non-Chinese ethnicity	1.351 (1.70)	0.042 (0.09)	0.018 (0.04)	0.008 (0.06)	0.127 (0.31)
Age	-0.167 [¶] (0.08)	-0.005 (0.00)	-0.008 [‡] (0.00)	-0.008 [§] (0.00)	0.016 (0.02)
Lower ward class	-4.265 (2.79)	0.157 (0.14)	-0.123 [¶] (0.06)	-0.231 [¶] (0.11)	0.746 (0.61)
Low subsidy level	-2.896 (2.11)	-0.014 (0.11)	-0.096 [¶] (0.05)	-0.157 (0.08)	0.164 (0.39)

*Calculated using linear regression. †Calculated using ordinal logistic regression. ‡ $p < 0.001$. § $p < 0.01$. ¶ $p < 0.05$. AFG: absolute functional gain; LOGLOS: log-transformed length of stay; REs: rehabilitation effectiveness; REy: rehabilitation efficiency

We performed a subgroup analysis by analysing participants according to their frailty status (frail or pre-frail). Among frail participants, only the ‘F’ (fatigue) component of the FRAIL scale was marginally associated with REy ($p < 0.1$). Similarly, only younger age ($p < 0.01$) and the ‘F’ (fatigue) component of the FRAIL scale ($p < 0.05$) were associated with REs.

Among pre-frail participants, younger age ($p < 0.01$), female gender ($p < 0.05$), the ‘F’ (fatigue) component ($p < 0.05$), ‘A’ (ambulation) component ($p < 0.01$) and ‘L’ (loss of weight) component ($p < 0.05$) were significantly associated with REy. Similarly, among pre-frail

participants, younger age ($p < 0.001$), female gender ($p < 0.05$), the ‘F’ (fatigue) component ($p < 0.001$), ‘R’ (resistance) component ($p < 0.01$), ‘A’ (ambulation) component ($p < 0.01$), ‘I’ (illness) component ($p < 0.01$) and ‘L’ (loss of weight) component ($p < 0.001$) were significantly associated with REs.

The results of the subgroup analysis for frail and pre-frail participants in association with REs and REy are shown in Table IV.

Table IV. Results of subgroup analysis of frail and pre-frail patients.

Parameter	Coefficient (standard error)			
	REy (frail)	REs (frail)	REy (pre-frail)	REs (pre-frail)
F (fatigue)	−0.134 (0.07)	−0.084* (0.04)	−0.322* (0.16)	−0.338† (0.09)
R (resistance)	0.081 (0.27)	−0.003 (0.15)	−0.004 (0.14)	−0.227‡ (0.08)
A (ambulation)	−0.039 (0.19)	−0.021 (0.11)	−0.312‡ (0.11)	−0.186‡ (0.06)
I (illness)	−0.018 (0.06)	−0.027 (0.04)	−0.148 (0.17)	−0.265‡ (0.10)
L (loss of weight)	−0.101 (0.07)	−0.013 (0.04)	−0.358* (0.16)	−0.340† (0.09)
Female gender	−0.059 (0.06)	−0.033 (0.03)	0.202* (0.08)	0.126‡ (0.05)
Non-Chinese ethnicity	0.031 (0.07)	0.048 (0.04)	0.094 (0.12)	0.031 (0.07)
Age	−0.005 (0.00)	−0.006‡ (0.00)	−0.015‡ (0.01)	−0.011† (0.00)
Lower ward class	−0.042 (0.14)	−0.024 (0.08)	−0.162 (0.17)	−0.049 (0.10)
Low subsidy level	−0.039 (0.10)	−0.058 (0.06)	−0.082 (0.14)	−0.025 (0.08)

* $p < 0.05$, † $p < 0.001$, ‡ $p < 0.01$. REs: rehabilitation effectiveness; REy: rehabilitation efficiency

DISCUSSION

This study found that the combined score of the FRAIL scale was significantly negatively associated with AFG, REs and REy, and was positively associated with increased LOS and need for discharge to a nursing home or transfer to a tertiary hospital for escalation of care. Positivity of the individual components of the FRAIL scale, especially for the ‘F’, ‘A’ and ‘L’

components, appeared to be highly associated with REy and REs, especially among the pre-frail participants. Younger patients tended to have better REs and REy. Lower ward class and low subsidy level were also significantly negatively associated with REs and REy.

These findings demonstrate the utility of the FRAIL scale as an indicator of frailty status and its association with rehabilitative outcomes in the local (predominantly Chinese) population of older adults who were admitted to the post-acute care setting. Its merits include a relatively larger sample size than that in previous studies and the inclusion of patients with inter-current acute medical problems punctuating the rehabilitative course (whether or not this required an eventual transfer back to the tertiary hospital) as well as patients with varying severity of cognitive impairment. Presumably, these subsets of patients are frailer. As postulated by a previous study,⁽¹⁹⁾ the FRAIL scale has indeed shown to be useful in a population with higher frailty prevalence. Further, excluding patients with severe cognitive impairment, as in most other studies evaluating frailty and rehabilitative outcomes, might influence the accuracy and applicability of estimates in rehabilitative recovery, and hence, the determination of the predictive value of frailty scoring for rehabilitative recovery. This is relevant because severe cognitive impairment has been found to be a negative predictor of functional recovery in rehabilitation.⁽²⁹⁾

Our study also supports the findings of other studies that frailty is associated with the LOS^(30,31) and discharge disposition.⁽³¹⁾ It is noteworthy that these studies had utilised other frailty measurements such as the CFS and frailty index.

Moreover, in our study, the FRAIL scale appears to be more helpful in predicting the rehabilitative progress of pre-frail patients in terms of REs and REy. This finding, combined with the emergence of specific frailty components (fatigue, ambulation and weight loss) that boast of a stronger correlation to rehabilitative outcomes, compels community hospitals to take specific steps to improve the rehabilitative outcomes of pre-frail patients. In the inpatient

setting, this could take the form of frailty education, nutritional rehabilitation, and frailty-specific exercises, with the option to enrol in a frailty-specific rehabilitation programme on discharge. This approach is supported by studies that have reported that patients who are less frail are more likely to show rehabilitation gains than frailer patients.⁽²⁹⁻³¹⁾ While evidence to the contrary also exists,⁽¹⁵⁾ we do not advocate therapeutic nihilism towards frailer patients, because it is widely acknowledged that rehabilitation generally benefits all patients along the spectrum of frailty. Future research should be performed in the context of a frailty-specific inpatient rehabilitation programme, as has been done before on an outpatient basis, with proven benefit.⁽³²⁾ Progress of pre-frail and frail patients could also be monitored over time, as patients transit to the outpatient setting.

The limitations of our study include a paucity of details regarding the rehabilitative process, including the time spent and the type of exercises performed during therapy. Further, with regard to rehabilitative outcomes, alternative rehabilitative outcome measures used in other studies include tests for gait speed, grip strength, Timed Up and Go, balance and mobility.⁽³⁰⁾ The SES indicators employed were also weak. The ward classes of the patients are not always correlated with their financial status, as wealthier patients may still choose 'C' class wards, and ward assignments may also be affected by the bed availability in the various ward classes. The subsidy levels offered to the patients are, therefore, more reliable indicators of their SES; however, this indicator does not capture the financial status of patients admitted to 'A' and 'B' class wards. Nevertheless, it is noteworthy that two previous local studies did not find any significant correlation between frailty and socioeconomic factors.^(7,33)

To the best of our knowledge, this is the first study to determine the relationship between the FRAIL scale and rehabilitation outcomes in the subacute rehabilitative setting. We conclude that the FRAIL scale is a useful and simple tool for hospital clinicians and administrators alike. Future research might consider focusing on the less frail patients,

implementing a frailty-specific inpatient exercise programme, monitoring rehabilitative progress after discharge, utilising a greater variety of rehabilitation outcome measures and using more comprehensive indicators of SES.

ACKNOWLEDGEMENTS

The co-author, Goh J, acknowledges support from NUS Start-up Grant number R-314-000-110-133.

REFERENCES

1. Morley JE. The new geriatric giants. *Clin Geriatr Med* 2017; 33:xi-xii.
2. Morley JE, Vellas B, van Kan GA, et al. Frailty consensus: a call to action. *J Am Med Dir Assoc* 2013; 14:392-7.
3. Woo J. Challenges of population ageing: putting frailty as a cornerstone of health and social care systems. *Eur Geriatr Med* 2018; 9:273-6.
4. Merchant RA, Chen MZ, Tan LWL, et al. Singapore Healthy Older People Everyday (HOPE) Study: prevalence of frailty and associated factors in older adults. *J Am Med Dir Assoc* 2017; 18:734.e9-e14.
5. Tan LF, Lim ZY, Choe R, Seetharaman S, Merchant R. Screening for frailty and sarcopenia among older persons in medical outpatient clinics and its associations with healthcare burden. *J Am Med Dir Assoc* 2017; 18:583-7.
6. Chong E, Ho E, Baldevarona-Llego J, et al. Frailty in hospitalized older adults: comparing different frailty measures in predicting short- and long-term patient outcomes. *J Am Med Dir Assoc* 2018; 19:450-7.e3.
7. Jiang SEJ, Han YYA, Tan XL, Goh J, Tan BY. Frailty in a community hospital in Singapore: prevalence and contributing factors. *Aging Med Healthcare* 2020; 11:39-46.

8. Fried LP, Tangen CM, Walston J, et al. Frailty in older adults: evidence for a phenotype. *J Gerontol A Biol Sci Med Sci* 2001; 56:M146-56.
9. Mitnitski AB, Mogilner AJ, Rockwood K. Accumulation of deficits as a proxy measure of aging. *ScientificWorldJournal* 2001; 1:323-36.
10. van Kan GA, Rolland Y, Bergman H, et al. The I.A.N.A Task Force on frailty assessment of older people in clinical practice. *J Nutr Health Aging* 2008; 12:29-37.
11. Dent E, Lien C, Lim WS, et al. The Asia-Pacific clinical practice guidelines for the management of frailty. *J Am Med Dir Assoc* 2017; 18:564-75.
12. Koh GC, Chen CH, Petrella R, Thind A. Rehabilitation impact indices and their independent predictors: a systematic review. *BMJ Open* 2013; 3:e003483.
13. Heinemann AW, Roth EJ, Cichowski K, Betts HB. Multivariate analysis of improvement and outcome following stroke rehabilitation. *Arch Neurol* 1987; 44:1167-72.
14. Shah S, Vanclay F, Cooper B. Efficiency, effectiveness, and duration of stroke rehabilitation. *Stroke* 1990; 21:241-6.
15. Kawryshanker S, Raymond W, Ingram K, Inderjeeth CA. Effect of frailty on functional gain, resource utilisation, and discharge destination: an observational prospective study in a GEM ward. *Curr Gerontol Geriatr Res* 2014; 2014:357857.
16. Haley MN, Wells YD, Holland AE. Relationship between frailty and discharge outcomes in subacute care. *Aust Health Rev* 2014; 38:25-9.
17. Rebagliati GAA, Sciumè L, Iannello P, et al. Frailty and resilience in an older population. The role of resilience during rehabilitation after orthopedic surgery in geriatric patients with multiple comorbidities. *Funct Neurol* 2016; 31:171-7.

18. Li Y, Zou Y, Wang S, et al. A pilot study of the FRAIL Scale on predicting outcomes in Chinese elderly people with type 2 diabetes. *J Am Med Dir Assoc* 2015; 16:714.e7-e12.
19. Wang HT, Fafard J, Ahern S, Vendittoli PA, Hebert P. Frailty as a predictor of hospital length of stay after elective total joint replacements in elderly patients. *BMC Musculoskelet Disord* 2018; 19:14.
20. Rockwood K, Song X, MacKnight C, et al. A global clinical measure of fitness and frailty in elderly people. *CMAJ* 2005; 173:489-95.
21. Gleason LJ, Benton EA, Alvarez-Nebreda ML, et al. FRAIL questionnaire screening tool and short-term outcomes in geriatric fracture patients. *J Am Med Dir Assoc* 2017; 18:1082-6.
22. Morley JE, Malmstrom TK, Miller DK. A simple frailty questionnaire (FRAIL) predicts outcomes in middle aged African Americans. *J Nutr Health Aging* 2012; 16:601-8.
23. Pampalon R, Hamel D, Gamache P. A comparison of individual and area-based socioeconomic data for monitoring social inequalities in health. *Health Rep* 2009; 20:85-94.
24. Chan CQH, Lee KH, Low LL. A systematic review of health status, health seeking behaviour and healthcare utilisation of low socioeconomic status populations in urban Singapore. *Int J Equity Health* 2018; 17:39.
25. Koh GC, Wee LE, Rizvi NA, et al. Socio-demographic and clinical profile of admissions to community hospitals in Singapore from 1996 to 2005: a descriptive study. *Ann Acad Med Singap* 2012; 41:494-510.
26. Ministry of Health, Singapore. Subsidies for government-funded intermediate long-term care services. Available at: <https://www.moh.gov.sg/cost-financing/healthcare->

- [schemes-subsidies/subsidies-for-government-funded-intermediate-long-term-care-services](#). Accessed June 1, 2020.
27. Ministry of Health, Singapore. Elderly and Continuing Care Division, Ministry of Health (Singapore). Healthcare services for the elderly. An information booklet for healthcare professionals. 1st ed. Singapore: Ministry of Health, 2004.
 28. Drubach DA, Kelly MP, Taragano FE. The Montebello rehabilitation factor score. *J Neuro Rehabil*. 1994;8:92-6. Available at: <https://ci.nii.ac.jp/naid/20000905515/>. Accessed June 1, 2020.
 29. Landi F, Bernabei R, Russo A, et al. Predictors of rehabilitation outcomes in frail patients treated in a geriatric hospital. *J Am Geriatr Soc* 2002; 50:679-84.
 30. Nolan M, Power D, Long J, Horgan F. Frailty and its association with rehabilitation outcomes in a post-acute older setting. *Int J Ther Rehabil* 2016; 23:33-40.
 31. Singh I, Gallacher J, Davis K, et al. Predictors of adverse outcomes on an acute geriatric rehabilitation ward. *Age Ageing* 2012; 41:242-6.
 32. Ng TP, Feng L, Nyunt MS, et al. Nutritional, physical, cognitive, and combination interventions and frailty reversal among older adults: a randomized controlled trial. *Am J Med* 2015; 128:1225-36.e1.
 33. Vaingankar JA, Chong SA, Abdin E, et al. Prevalence of frailty and its association with sociodemographic and clinical characteristics, and resource utilization in a population of Singaporean older adults. *Geriatr Gerontol Int* 2017; 17:1444-54.