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RESEARCH PAPER

Heterogeneity in functional status among moderately frail older adults: improving predictive performance using a modified approach of subgrouping the Clinical Frailty Scale

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Key summary points

Aims To establish if dependency in basic activities of daily living (bADL) amongst moderately frail older adults predict poorer health outcomes including mortality and institutionalisation. We also examined the utility of subgrouping category 6 of the Clinical Frailty Scale (CFS) by level of functional dependency to improve predictive performance.

Findings We observed a wider range in functional dependency among CFS 6 patients when compared to other frail categories. Incorporating CFS 6 subcategories based on bADL functional status increased predictive performance for longitudinal adverse outcomes compared with the original CFS scoring.

Message This study corroborates the heterogeneity of bADL functional status in CFS 6 individuals and validates the use of a modified approach to subgrouping the CFS via bADL dependency for improved predictive performance.

Abstract

Purpose Moderately frail individuals [Clinical Frailty Scale (CFS) 6] demonstrate heterogeneity in basic activities of daily living (bADL). We aimed to establish whether functional dependency in moderate frailty predicts poorer outcomes and examined the utility of subgrouping the CFS in predicting mortality and institutionalisation.

Methods We prospectively studied 201 hospitalised frail patients (89.5 ± 4.7 years, female 70.1%). We examined Katz Index (KI) against adverse outcomes in CFS6 ($n = 106$). We then compared predictive performances of a modified CFS version 1 (mCFS-1; category 6A: CFS6 and KI ≥ 2; 6B: CFS6 and KI ≤ 1) and modified CFS version 2 (mCFS-2; category 6A: CFS6 and KI ≥ 2; 6B1: CFS6, KI ≤ 1 and feeding independent; 6B2: CFS6, KI ≤ 1 and feeding dependent) against the CFS. Multivariate analysis was used to compare each tool against mortality and institutionalisation. Receiver operator characteristic analysis was performed to determine area under curve and optimal cut-points for each tool.

Results KI ≤ 1 in CFS6 was associated with higher 12-month mortality (39.3% vs. 15.6%, $p = 0.01$); amongst KI items, feeding dependent predicted 12-month mortality ($p < 0.05$). Using mCFS-1, category 6A did not increase 12-month mortality compared with category 5 (OR 1.83, 95% CI 0.52–6.47), unlike category 6B (OR 6.33, 95% CI 2.07–19.33). mCFS-2 produced higher mortality in category 6B1 (OR 5.19, 95% CI 1.30–20.69) and 6B2 (OR 6.92, 95% CI 2.14–22.35). Similar observations were seen for institutionalisation. Optimal cut-point for 12-month mortality was category 6 for CFS, and 6B and 6B1 for mCFS-1 and mCFS-2, respectively.

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Conclusion This study corroborates the heterogeneity of functional status in moderately frail individuals and validates the use of a modified approach to subgrouping the CFS6 via bADL functional status for improved predictive performance.

Keywords Geriatrics · Frailty · Acute · Risks · Outcomes · Inpatient

Introduction

Frailty is a multidimensional syndrome of reduced physiological functioning characterised by increased vulnerability to a myriad of adverse health outcomes, even when subjected to minor stressors [1]. Over the years, frailty has become an increasingly integral part of clinical practice and healthcare delivery [2, 3]. There are many tools which have been developed for frailty screening and identification. Amidst the array of frailty tools, the Clinical Frailty Scale (CFS) stands out as a simple-to-use, validated and reliable tool for frailty assessment [4–8].

Although the CFS was initially designed as a global synthesis assessment tool, it has rapidly evolved into an effective screening tool across various healthcare settings [2, 9]. The 9-point scale allows classification across the frailty continuum ranging from 1 (very fit) to 9 (terminally ill) with each category having a brief description and visual depiction. Frailty is diagnosed when individuals are categorised as CFS 5–8. The CFS is also a well-validated predictive tool for adverse health outcomes in older adults including mortality [4–7], institutionalisation [5–7], length of hospitalisation [10], risk of re-hospitalisation [10, 11], and peri-operative complications [12]. Given its widespread use, the tool has also been validated for administration through various methods including telephonic interviews [13], retrospective medical chart review [14], and via standardised algorithm [7].

Although there remains a paucity of data, patients in CFS 6 (moderately frail) appear to demonstrate a wider variation in rating of level of dependency in basic activities of daily living (bADL). Whilst there are clear demarcations for difficulties with instrumental ADLs (CFS 5) and dependence in all aspects of bADL [CFS 7 (severely frail) and 8 (very severely frail)], CFS 6 encompasses a heterogeneous in-between group with varying degrees of dependency in bADL. This is not a moot point, as increasing functional dependency in bADL has been shown to be a strong independent predictor of negative health outcomes [15–17]. Hence, given the variation in bADL functional ability within CFS 6, the current practice of treating CFS 6 as a single entity in frailty assessment may be inadequate and non-discriminatory in establishing risk estimates for negative health outcomes.

Against this backdrop, we performed a secondary analysis study of our original prospective study to determine if bADL functional ability (as represented by Katz Index total score and individual items) in moderately frail (CFS 6) older adults predicts outcomes of mortality and institutionalisation at initial hospitalisation and at 6- and 12-month follow-up. Using bADL functional ability to sub-categorise CFS 6, we studied how the expanded CFS 6 categories compared against mild (CFS 5) and severe (CFS 7–8) frailty in predicting mortality and institutionalisation. We also examined the predictive performance of the modified approach of subgrouping CFS 6 by bADL functional ability to predict outcomes compared with CFS.

Methods

Study design and eligibility criteria

We previously reported diagnostic and predictive performance of the CFS against the "gold-standard" Frailty Index [5, 6]. We also validated a standardised approach in administration of the CFS using a simple algorithm (CFS-A) [7]. This study examined the same population of 210 older adults who were consecutively admitted in 2015 to the Department of Geriatric Medicine, Tan Tock Seng Hospital, Singapore. In addition to our original study's exclusion criteria, which were (1) previous recruitment in an earlier admission, (2) terminal illness (life expectancy less than a year), (3) patient identified as "dangerously ill" (typically a label used for patients who have hemodynamic instability, requiring close monitoring with or without the need for high dependency or critical care) for more than 72 h from day of admission, (4) absence of caregiver for consent in patients who lack mental capacity, and (5) current resident in a community hospital or nursing home, we further excluded individuals who were not frail. Hence, a total of 201 participants were included for analysis in this study as they were diagnosed as frail (CFS category 5–8) by two independent raters using the CFS-A approach [7].

Data on patient demographics, cognitive function, admitting diagnosis, functional status (Katz index), burden of comorbidities [modified Charlson's Comorbidity Index (CCI)] and severity of illness (modified severity of illness index) were gathered [18, 19]. Further details of the original study methods have been described previously [5].

Written informed consent was obtained from the patient or a legally acceptable representative (in individuals who lack capacity for consenting). Ethics approval was obtained from the Domain Specific Review Board of the National Healthcare Group, Singapore.

Examining Katz Index (KI) and adverse health outcomes in CFS 6

A total of 106 moderately frail (CFS 6) individuals were examined by comparing individual KI items (bathing, toileting, transfer, dressing, continence, and feeding) and total KI scores (0–6) against the outcomes of mortality and institutionalisation at initial hospitalisation, 6 and 12 months post enrolment. We then examined independent associations between each individual KI items against the aforementioned outcomes of interest.

Modified approach of subgrouping the CFS 6 category

Following subgroup analyses, and with the knowledge that feeding dependence and lower KI scores portend poorer outcomes, we propose two variations of a modified approach to subgroup CFS 6 (Appendix 1). Modified CFS version 1 (mCFS-1) involved separating CFS 6 into two sub-categories: (1) CFS 6A—category 6 with a total KI of 2–6, and (2) CFS 6B—category 6 with a total KI of 0–1. Modified CFS version 2 (mCFS-2) involved separating CFS 6 into three sub-categories: (1) CFS 6A—category 6 with a total KI of 2–6, (2) CFS 6B1—category 6, total KI of 0–1, and feeding independent, and (3) CFS 6B2—category 6, total KI of 0–1, and feeding dependent.

Outcome measures

All-cause mortality (as primary outcome) and institutionalisation were gathered via patients' electronic medical records and telephonically at initial hospitalisation, 6- and 12-month follow-up. Institutionalisation was captured as a composite outcome as participants who died during the specified period were counted as a case. This well-accepted method, which was performed in our original study [6, 7], allows us to make the assumption that institutionalisation had occurred in all mortality cases. We also examined and compared CFS, mCFS-1, and mCFS-2 in their predictive performance for the aforementioned outcomes of interest.

Statistical analyses

Data were captured using standardised data collection forms and entered into an electronic database. We expressed continuous variables as means (standard deviation) or medians (interquartile range), whilst categorical variables were expressed as counts and percentages. Univariate analysis was performed using Chi-square or Fisher Exact test for counts; Kruskall–Wallis test (for non-parametric data), and analysis of variance (ANOVA; for parametric data) were performed to compare baseline characteristics between three groups of frail patients—CFS 5, 6, and 7–8.

Focusing on category 6, we compared KI total and item scores against the outcomes of mortality and institutionalisation. We then performed logistic regression analysis, adjusting for age, gender, comorbidities, and severity of illness, to investigate the independent association between dependency in individual KI items and the adverse outcomes of interest.

Following subgroup analyses, we performed univariate analysis comparing the CFS, mCFS-1, and mCFS-2 against mortality and institutionalisation. Logistic regression analyses, adjusting for age, gender, comorbidities, and severity of illness, were performed to compare predictive performances of each tool against mortality and institutionalisation. We also performed receiver operating curve analysis to determine area under curve (AUC) and optimal cut-point for each tool using Youden's Index (*J*).

Statistical analysis was performed using SPSS V19.0 (SPSS, Inc., Chicago, IL, USA), and STATA V12.0 (Stata Corp, College Station, TX, USA) assuming a two-sided test at 5% level of significance.

Results

Baseline characteristics

A total of 201 participants were examined in this study. Of these, 60 (29.9%), 106 (52.7%), and 35 (17.4%) patients were rated as CFS 5, 6, and 7–8, respectively. The mean age of our study participants was 89.5 ± 4.7 years, with predominance of females ($n = 141$, 70.1%) and Chinese ethnicity ($n = 164$, 81.6%) (Table 1). Four participants were lost to follow-up resulting in a total of 197 patients for follow-up analyses.

Age, gender, ethnicity, and severity of illness were similar between CFS groups. We observed significantly higher comorbidities, dementia, and delirium as frailty severity increased. Total CCI score was significantly higher in CFS 6 [CCI 3.0 (2.0–4.0)] compared to CFS 5 [CCI 2.0 (1.0–3.0)] or CFS 7–8 [CCI 2.0 (2.0–4.0)] ($p < 0.001$).

We observed a wider range in functional dependency among CFS 6 patients [KI 1 (0–3)], when compared to CFS 5 [KI 6 (6–6)] and 7–8 [KI 0 (0–0)]. CFS 6 had the widest range of dependency in individual domains of KI, ranging from 40 (37.7%) for feeding to 89 (84.0%) for bathing.

bADL dependency and adverse outcomes (CFS 6)

Amongst 106 patients who are moderately frail (CFS 6), we observed a statistically significant association between dependency in feeding and mortality at 6-month (35.0% vs.

Table 1 Baseline characteristics: comparison between CFS categories

Baseline characteristics ($n=201$)	CFS 5 ($n=60$)	CFS 6 ($n=106$)	CFS 7–8 ($n=35$)	p value
Age (mean ± SD)	88.5 ± 4.3	89.8 ± 4.5	90.1 ± 5.4	0.155
Race, Chinese (%)	55 (91.7)	82 (77.4)	27 (77.1)	0.309
Gender, Male (%)	20 (33.3)	30 (28.3)	10 (28.6)	0.780
Comorbidities				
CCI (median, IQR)	2 (1–3)	3 (2–4)	2 (2–4)	0.025
CCI class (%)				
Low	6 (10.0)	9 (8.5)	0 (0.0)	0.079
Medium	30 (50.0)	38 (35.8)	20 (57.1)	
High	20 (33.3)	41 (38.7)	9 (25.7)	
Very high	4 (6.7)	18 (17.0)	6 (17.1)	
Severity of Illness Index (%)				
Level 1	1 (1.7)	1 (0.9)	0 (0.0)	0.095
Level 2	50 (83.3)	79 (74.5)	21 (60.0)	
Level 3	9 (15.0)	26 (24.5)	14 (40.0)	
Activities of daily living				
Median Katz index (median, IQR)	6 (6–6)	1 (0–3)	0 (0–0)	< 0.001
Dependency in:				
Bathing (%)	0 (0.0)	89 (84.0)	35 (100)	< 0.001
Toileting (%)	0 (0.0)	83 (78.3)	35 (100)	< 0.001
Transfer (%)	0 (0.0)	83 (78.3)	35 (100)	< 0.001
Dressing (%)	0 (0.0)	81 (76.4)	35 (100)	< 0.001
Continence (%)	1 (1.7)	69 (65.1)	35 (100)	< 0.001
Feeding (%)	0 (0.0)	40 (37.7)	35 (100)	< 0.001
Cognitive function				
AMT (median, IQR)	6 (4–8)	3 (0–7)	0 (0–0)	< 0.001
Dementia (%)	12 (20.0)	54 (50.9)	28 (80.0)	< 0.001
Delirium on admission (%)	6 (10.0)	25 (23.6)	11 (31.4)	0.028
Admitting diagnosis				
Sepsis (%)	34 (56.7)	62 (58.5)	22 (62.9)	0.838
Fall/syncope/seizure (%)	11 (18.3)	15 (14.2)	2 (5.7)	0.229
Delirium/dementia (%)	1 (1.7)	5 (4.7)	4 (11.4)	0.106
Other medical (%)	14 (23.3)	21 (19.8)	4 (11.4)	0.363
Surgical (%)	0 (0.0)	3 (2.8)	3 (8.6)	0.060

AMT abbreviate mental test, *CCI* Charlson's comorbidity index, *CFS* clinical frailty scale, *IQR* interquartile range, *SD* standard deviation

13.6%, $p=0.01$) and 12-month (42.5% vs. 21.2%, $p=0.02$) follow-up (Table 2). We also found that median total KI at baseline was significantly higher in surviving patients at 6 months [KI 1 (0–3) vs. 1 (0–1), $p=0.02$] and 12 months [KI 2 (0–3) vs. 1 (0–1), $p=0.036$). When CFS 6 was further categorised into KI 0–1 ($n=61$) and KI 2–6 ($n=45$), patients in the former group had a higher incidence of all-cause mortality at 6 months (31.1% vs. 8.9%, $p=0.008$) and 12 months (39.3% vs. 15.6%, $p=0.01$) (Table 3).

In logistic regression analysis adjusted for age, gender, comorbidities, and severity of illness, we observed that feeding dependent was independently associated with mortality at 6 months (Odds Ratio (OR) 3.13, 95% Confidence Interval (CI) 1.18–8.30, $p=0.022$) and 12 months (OR 2.66, 95% CI 1.06–6.68, $p=0.038$) (Appendix 2). We also observed independent associations between dependency in bathing (OR 8.69, 95% CI 1.05–71.74, $p=0.045$) and dressing (OR 3.87 (95% CI 1.01–14.84), $p=0.049$) with 6-month institutionalisation.

Predictive performances of mCFS-1 and mCFS-2

We compared CFS against mCFS-1 and mCFS-2 in predicting incident mortality and institutionalisation. In univariate

Table 2 Association between individual Katz Index items and negative health outcomes among CFS 6 patients

Premorbid Katz Index (independent)		Mortality			Institutionalisation or mortality[a]		
		Initial hospitalisation ($n=106$)	6 months ($n=106$)	12 months ($n=106$)	Initial hospitalisation ($n=106$)	6 months ($n=105$)[b]	12 months ($n=105$)[b]
Feeding	Yes	2/66 (3.0%)	9/66 (13.6%)*	14/66 (21.2%)*	6/66 (9.1%)	14/65 (21.5%)	21/65 (32.3%)
	No	3/40 (7.5%)	14/40 (35.0%)*	17/40 (42.5%)*	4/40 (10.0%)	15/40 (37.5%)	18/40 (45.0%)
Continence	Yes	2/37 (5.4%)	6/37 (16.2%)	8/37 (21.6%)	5/37 (13.5%)	10/36 (27.8%)	12/36 (33.3%)
	No	3/69 (4.3%)	17/69 (24.6%)	23/69 (33.3%)	5/69 (7.2%)	19/69 (27.5%)	27/69 (39.1%)
Dressing	Yes	0/25 (0.0%)	2/25 (8.0%)	5/25 (20.0%)	1/25 (4.0%)	3/24 (12.5%)	7/24 (29.2%)
	No	5/81 (6.2%)	21/81 (25.9%)	26/81 (32.1%)	9/81 (11.1%)	26/81 (32.1%)	32/81 (39.5%)
Transfer	Yes	1/23 (4.3%)	3/23 (13.0%)	5/23 (21.7%)	3/23 (13.0%)	5/22 (22.7%)	8/22 (36.4%)
	No	4/83 (4.8%)	20/83 (24.1%)	26/83 (31.3%)	7/83 (8.4%)	24/83 (28.9%)	31/83 (37.3%)
Toileting	Yes	0/23 (0.0%)	3/23 (13.0%)	5/23 (21.7%)	2/23 (8.7%)	5/22 (22.7%)	8/22 (36.4%)
	No	5/83 (6.0%)	20/83 (24.1%)	26/83 (31.3%)	8/83 (96%)	24/83 (28.9%)	31/83 (37.4%)
Bathing	Yes	0/17 (0.0%)	1/17 (5.9%)	3/17 (17.6%)	0/17 (0.0%)	1/17 (5.9%)*	4/17 (23.5%)
	No	5/89 (5.6%)	22/89 (24.7%)	28/89 (31.5%)	10/89 (11.2%)	28/88 (31.8%)*	35/88 (39.8%)

CFS clinical frailty scale, *IQR* interquartile range, *SD* standard deviation

*$p<0.05$

[a]Participants who died during the specified period were counted as a case

[b]1 patient excluded from 6- and 12-month analyses due to loss to follow-up

Table 3 Association between Katz Index scores and negative health outcomes among CFS 6 patients

Premorbid Katz Index		Mortality			Institutionalisation or mortality[a]		
		Initial hospitalisation ($n=106$)	6 months ($n=106$)	12 months ($n=106$)	Initial hospitalisation ($n=106$)	6 months ($n=105$)[b]	12 months ($n=105$)[b]
Total score	0	2/35 (5.7%)	11/35 (31.4%)	14/35 (40.0%)	3/35 (8.6%)	12/35 (34.3%)	15/35 (42.9%)
	1	2/26 (7.7%)	8/26 (30.8%)	10/26 (38.5%)	2/26 (7.7%)	8/26 (30.8%)	11/26 (42.3%)
	2	0/14 (0.0%)	0/14 (0.0%)	0/14 (0.0%)	2/14 (14.3%)	3/14 (21.4%)	3/14 (21.4%)
	3	1/8 (12.5%)	1/8 (12.5%)	2/8 (25.0%)	2/8 (25.0%)	2/8 (25.0%)	3/8 (37.5%)
	4	0/6 (0.0%)	2/6 (33.3%)	2/6 (33.3%)	0/6 (0.0%)	2/6 (33.3%)	2/6 (33.3%)
	5	0/13 (0.0%)	1/13 (7.7%)	2/13 (15.4%)	1/13 (7.7%)	2/12 (16.7%)	4/12 (33.3%)
	6	0/4 (0.0%)	0/4 (0.0%)	1/4 (25.0%)	0/4 (0.0%)	0/4 (0.0%)	1/4 (25.0%)
Grouped by score	Katz 0–1	4/61 (6.6%)	19/61 (31.1%)*	24/61 (39.3%)*	5/61 (8.2%)	20/61 (32.8%)	26/61 (42.6%)
	Katz 2–6	1/45 (2.2%)	4/45 (8.9%)*	7/45 (15.6%)*	5/45 (11.1%)	9/44 (20.5%)	13/44 (29.5%)

CFS clinical frailty scale, *IQR* interquartile range, *SD* standard deviation

*$p<0.05$

[a]Participants who died during the specified period were counted as a case

[b]1 patient excluded from 6- and 12-month analyses due to loss to follow-up

analysis, all three tools showed significant association with mortality at 6 and 12 months (both $p<0.001$) and with institutionalisation at initial hospitalisation ($p<0.05$), 6 months ($p<0.001$) and 12 months ($p<0.001$). For both mCFS-1 and mCFS-2, there was an increase in mortality and institutionalisation moving from CFS 5 through CFS 6 stages to CFS 7–8 at 6- and 12-month follow-up (Table 4).

We next performed logistic regression analysis, adjusting for age, gender, comorbidities, and severity of illness (Table 5). When taken as a whole, CFS 6 had a fourfold

Table 4 Comparison between CFS, mCFS-1, and mCFS-2 against incident mortality and institutionalisation

Frailty category		Mortality			Institutionalisation or mortality[a]		
		Initial hospitalisation ($n=201$) (%)	6 months ($n=201$) (%)	12 months ($n=201$) (%)	Initial hospitalisation ($n=201$) (%)	6-month ($n=197$)[b] (%)	12-month ($n=197$)[b] (%)
Clinical Frailty Scale (CFS)	5	0/60 (0.0)	3/60 (5.0)†	5/60 (8.3)†	0/60 (0.0)*	4/57 (7.0)†	6/57 (10.5)†
	6	5/106 (4.7)	23/106 (21.7)†	31/106 (29.2)†	10/106 (9.4)*	29/105 (27.6)†	39/105 (37.1)†
	7–8	3/35 (8.6)	16/35 (45.7)†	21/35 (60.0) †	3/35 (8.6)*	18/35 (51.4)†	22/35 (62.9)†
Modified CFS Version 1 (mCFS-1)	5	0/60 (0.0)	3/60 (5.0)†	5/60 (8.3)†	0/60 (0.0)*	4/57 (7.0)†	6/57 (10.5)†
	6A	1/45 (2.2)	4/45 (8.9)†	7/45 (15.6)†	5/45 (11.1)*	9/44 (20.5)†	13/44 (29.5)†
	6B	4/61 (6.6)	19/61 (31.1)†	24/61 (39.3)†	5/61 (8.2)*	20/61 (32.8)†	26/61 (42.6)†
	7–8	3/35 (8.6)	16/35 (45.7) †	21/35 (60.0) †	3/35 (8.6)*	18/35 (51.4)†	22/35 (62.9)†
Modified CFS Version 2 (mCFS-2)	5	0/60 (0.0)	3/60 (5.0)†	5/60 (8.3)†	0/60 (0.0)*	4/57 (7.0)†	6/57 (10.5)†
	6A	1/45 (2.2)	4/45 (8.9)†	7/45 (15.6)†	5/45 (11.1)*	9/44 (20.5)†	13/44 (29.5)†
	6B1	1/21 (4.8)	5/21 (23.8)†	7/21 (33.3)†	1/21 (4.8)*	5/21 (23.8)†	8/21 (38.1)†
	6B2	3/40 (7.5)	14/40 (35.0)†	17/40 (42.5)†	4/40 (10.0)*	15/40 (37.5)†	18/40 (45.0)†
	7–8	3/35 (8.6)	16/35 (45.7)†	21/35 (60.0) †	3/35 (8.6)*	18/35 (51.4) †	22/35 (62.9)†

* $p<0.05$, † $p<0.001$ (Fisher Exact test)

[a]Participants who died during the specified period were counted as a case

[b]4 patients excluded from 6- and 12-month analyses due to loss to follow-up

increase in mortality at 6 and 12 months compared to CFS 5. When CFS 6 was stratified into subcategories, CFS 6A did not increase mortality at 6 and 12 months compared with CFS 5 (OR 1.64 and 1.83, respectively), unlike CFS 6B (OR 7.13 and 6.33, respectively) in mCFS-1. Further delineation of CFS 6B in mCFS-2 revealed differences in mortality in 6B1 (OR 5.16 and 5.19, respectively) and 6B2 (OR 8.18 and 6.92. respectively). Similarly, CFS 6 increased institutionalisation by around fivefold at 6 and 12 months. In mCFS-1 model, CFS 6B significantly increased institutionalisation (OR 5.85 and 6.16, respectively) more than CFS 6A (OR 3.27 and 3.55, respectively). Again, further categorisation of CFS 6B in mCFS-2 revealed differences in institutionalisation in 6B1 (OR 3.89 and 5.44, respectively) and 6B2 (OR 6.99 and 6.55, respectively). Our results were similar when we ran a separate regression model substituting comorbidities with underlying dementia when adjusting for cofounders.

Lastly, AUC for CFS, mCFS-1 and mCFS-2 against incident mortality at 12 months was 0.72 (95% CI 0.65–0.78, $p<0.001$), 0.76 (95% CI 0.69–0.81, $p<0.001$), and 0.76 (95% CI 0.70–0.82, $p<0.001$), respectively (Table 6). Optimal cut-point was 6 for CFS (sensitivity 91.2%, specificity 38.2%) and 6B for either mCFS-1 or mCFS-2 (sensitivity 79.0%, specificity 64.6%). Fairly similar AUC and optimal cut-point results were noted for institutionalisation at 12 months. However, results for institutionalisation at initial hospitalisation and 6 months were largely inconsistent.

Discussion

In this retrospective cohort study of hospitalised oldest old adults, we found that moderately frail (CFS 6) patients have greater heterogeneity in functional status compared to other frail categories. This in turn resulted in a wider range of risk estimates for adverse health outcomes of mortality and institutionalisation at 6 and 12 months, such that patients with KI ≥ 2 have lower mortality risk which approximate that of CFS 5, whereas those with KI ≤ 1 and feeding dependent are at greatest risk. Incorporating CFS 6 subcategories based on bADL functional status increased predictive performance for longitudinal adverse outcomes compared with the original CFS scoring. To our knowledge, this is the first study to report these findings.

Findings in this study are consistent with an earlier study which reported that disability in bADLs is a strong predictor of survival amongst centenarians [20]. A recent study reported an adjusted hazard ratio per disability increment in KI of 1.6 among hospitalised patients aged 83 years and above [21]. Notably, an ordered hierarchy of ADL has been previously reported, with feeding being the easiest and bathing the most difficult [22]. Thus, loss of independence in feeding represents a more advanced state of bADL functional dependency which would portend poorer outcomes. A study of 418 older adults who underwent videofluoroscopic swallow for dysphagia reported that malnutrition and frailty were positively correlated with severe dysphagia,

Table 5 Multivariate analyses comparing CFS, mCFS-1, and mCFS-2 against incident mortality and institutionalisation

Frailty category		Mortality			Institutionalisation or mortality[b]		
		Initial hospitalisation ($n=201$)	6 months ($n=201$)	12 months ($n=201$)	Initial hospitalisation ($n=201$)	6 months ($n=197$)[c]	12 months ($n=197$)[c]
		Adjusted OR (95% CI)			Adjusted OR (95% CI)		
Clinical Frailty Scale (CFS)	5	–[a]	Ref	Ref	–[a]	Ref	Ref
	6	Ref	4.30 (1.20–15.46)*	3.90 (1.36–11.16)*	Ref	4.59 (1.49–14.11)*	4.83 (1.84–12.67)*
	7–8	2.16 (0.46–10.14)	14.08 (3.56–55.80)†	16.35 (4.85–55.10)†	1.05 (0.26–4.27)	13.23 (3.80–46.05)†	15.16 (4.80–47.91)†
		Adjusted OR (95% CI)			Adjusted OR (95% CI)		
Modified CFS Version 1 (mCFS-1)	5	–[a]	Ref	Ref	–[a]	Ref	Ref
	6A	Ref	1.64 (0.34–7.92)	1.83 (0.52–6.48)	Ref	3.27 (0.92–11.57)	3.55 (1.19–10.52)*
	6B	2.39 (0.24–23.93)	7.13 (1.90–26.83)*	6.33 (2.07–19.33)*	0.68 (0.17–2.77)	5.85 (1.79–19.10)*	6.16 (2.19–17.38)*
	7–8	3.97 (0.38–42.12)	14.57 (3.66–57.96)†	17.03 (5.02–57.84)†	0.85 (0.18–4.14)	13.47 (3.86–46.97)†	15.51 (4.89–49.19)†
		Adjusted OR (95% CI)			Adjusted OR (95% CI)		
Modified CFS Version 2 (mCFS-2)	5	–[a]	Ref	Ref	–[a]	Ref	Ref
	6A	Ref	1.64 (0.34–7.91)	1.83 (0.52–6.47)	Ref	3.26 (0.92–11.55)	3.54 (1.19–10.51)*
	6B1	1.54 (0.09–27.81)	5.16 (1.05–25.50)*	5.19 (1.30–20.69)*	0.33 (0.03–3.17)	3.89 (0.89–16.92)	5.44 (1.51–19.57)*
	6B2	2.94 (0.27–32.17)	8.18 (2.08–32.18)*	6.92 (2.14–22.35)*	0.95 (0.21–4.25)	6.99 (2.04–23.98)*	6.55 (2.19–19.63)*
	7–8	3.98 (0.38–42.37)	14.46 (3.64–57.42)†	16.93 (4.99–57.44)†	0.86 (0.17–4.20)	13.39 (3.84–46.64)†	15.47 (4.88–49.03)†

CFS Clinical Frailty Scale, *CI* confidence interval, *OR* odds ratio, *Ref* reference

Adjusted for age, gender, comorbidities, and severity of illness

[a]No case of mortality or institutionalisation in CFS category 5 at initial hospitalization

*$p<0.05$

†$p<0.001$

[b]Participants who died during the specified period were counted as a case

[c]4 patients excluded from 6- and 12q-month analyses due to loss to follow-up

irrespective of age [23]. Additionally, dependency in feeding has been shown to be a powerful predictor of poorer outcomes including mortality [24]. Our findings, along with the aforementioned studies, support the utility of supplementing KI and feeding dependency into the CFS matrix to improve its predictive performance.

Earlier studies reported that amongst older adults who are hospitalised or admitted to the intensive care unit, the mildly frail (CFS 5) had better outcomes than the moderately or severely frail, even in the oldest old [25, 26]. Our study adds to this body of evidence by demonstrating that CFS 6 represents a heterogeneous group with different prognosis depending on the underlying bADL functional status. Specifically, moderately frail hospitalised older adults with better functional abilities (categorised as CFS 6A in mCFS-1 or mCFS-2) may potentially benefit from more aggressive interventions, including critical care, as they appear to share similar survival outcomes with CFS 5 patients up to 12-month follow-up. In contrast, in moderately frail hospitalised older adults with impairment across bADLs (categorised as CFS 6B), feeding dependency can further differentiate the prognosis, such that those who are feeding independent (categorised as CFS 6B1) have around one-third the mortality and institutionalisation risks compared with CFS 7, vis-à-vis one-half the risks in those who are feeding dependent (categorised as CFS 6B2).

Our study findings are salient in light of the current COVID-19 pandemic, when there is intense interest in reliable assessment tools to inform patient prioritisation for scarce intensive care resource. A recent multicentre study of patients admitted to hospital with COVID-19 found that frailty better predicted mortality compared to age or comorbidity [27]. Yet, findings from a single-site study of hospitalised patients aged 70 and above suggest that frailty was

Table 6 AUC comparing CFS, mCFS-1 and mCFS-2 in predicting incident mortality and institutionalisation

Adverse outcomes	Initial hospitalisation		6 months		12 months	
	AUC (95% CI)	Ideal cut off category (Sn%, Sp%)	AUC (95% CI)	Ideal cut off category (Sn%, Sp%)	AUC (95% CI)	Ideal cut off category (Sn%, Sp%)
Mortality						
CFS	0.70 (0.63–0.76)*	≥6 (100, 31.1)	0.71 (0.64–0.77)†	≥6 (92.9, 35.9)	0.72 (0.65–0.78)†	≥6 (91.2, 38.2)
mCFS-1	0.74 (0.67–0.80)†	≥6B (87.5, 53.9)	0.76 (0.69–0.81)†	≥6B (83.3, 61.6)	0.76 (0.69–0.81)†	≥6B (79.0, 64.6)
mCFS-2	0.75 (0.68–0.81)†	≥6B1 (87.5, 53.9)	0.76 (0.70–0.82)†	≥6B1 (83.3, 61.6)	0.76 (0.70–0.82)†	≥6B1 (79.0, 64.6)
Institutionalisation or mortality[a,b]						
CFS	0.65 (0.58–0.72)*	≥6 (100, 31.9)	0.70 (0.63–0.76)†	≥6 (92.2, 36.3)	0.71 (0.64–0.77)†	≥6 (91.0, 39.2)
mCFS-1	0.64 (0.57–0.70)*	≥6A (100, 31.9)	0.72 (0.66–0.78)†	≥6B (74.5, 60.3)	0.73 (0.66–0.79)†	≥6B (71.6, 63.1)
mCFS-2	0.65 (0.58–0.71)*	≥6A (100, 31.9)	0.73 (0.66–0.79)†	≥6B2 (64.7, 71.2)	0.73 (0.66–0.79)†	≥6B1 (71.6, 63.1)

AUC area under the operator curve; CFS, clinical frailty scale; CI, confidence interval; Sn, sensitivity; Sp, specificity

*$p < 0.05$

†$p < 0.001$

[a]Participants who died during the specified period were counted as a case

[b]4 patients excluded from 6- and 12-month analyses due to loss to follow-up

not a good discriminator of prognosis in COVID-19 [28]. Nonetheless, we advise that frailty is but one component of a multi-pronged person-centred approach to assist prognostication and to guide meaningful conversations on goals of care, i.e. to set goals of care rather than shift the goalpost of care [29, 30].

This study had a number of limitations. First, the exclusion of dangerously ill patients likely contributed to the overall low inpatient mortality rate, and limits generalisability of our study findings. Second, four participants were lost to follow-up and were excluded from 6- and 12-month analyses. Even so, we were able to determine their mortality status by accessing local hospital electronic medical records. Third, whilst it is reassuring that the modified CFS discriminated predictive performance in our population of hospitalised oldest old adults, future studies across the age range of older adults and in different study settings are required to ascertain the generalisability of our results. Fourth, our assessment of bADL was limited to the KI and we are unable to examine whether the use of other instruments such as the Barthel index would produce better results. Nevertheless, a study of 86 centenarians (mean age 102 ± 1 years) found that KI performed similarly to the Barthel index in predicting 360-day mortality [20]. Therefore, the ease of use of the KI is an advantage when used to derive a quick assessment of CFS score. And lastly, we acknowledge that despite the clear definitions in place to categorise patients as CFS 6 using the CFS-A, our data show that there remains great variability in function, with some CFS 6 participants having KI scores of 0 (fully dependent) or 6 (fully independent). This reflects the fact that there remains variability in scoring the CFS in actual practice, and hence, the added approach of including bADLs may help to address this concern.

In conclusion, this study corroborates the heterogeneity in bADL functional status with downstream impact on predictive performance of risk estimates of mortality and institutionalisation among hospitalised older adults with moderately frailty. Other indicators including a KI score of 1 or less and dependency in feeding should be taken into account to better prognosticate and aid clinical decision-making in moderately frail individuals. Taken together, our study validates the use of a modified approach in sub-grouping CFS 6 via bADL functional status for improved predictive performance.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethics approval Ethics approval for the study was obtained from the National Healthcare Group (NHG) Domain Specific Review Board (DSRB). The procedures used in this study adhere to the tenets of the Declaration of Helsinki.

Consent to participate and publication Written consent was obtained from patients or a legally acceptable representative (if patients lack mental capacity for consenting) for participation in the study and publication of data.

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