

RESEARCH

Open Access



Prognostic value of frailty across age groups in emergency department patients aged 65 and above

Yunhyung Choi¹, Ho Sub Chung¹, Ji Yeon Lim², Keon Kim², Yoon Hee Choi³, Dong Hoon Lee¹ and Sung Jin Bae^{1*}

Abstract

Background The Clinical Frailty Scale (CFS) is widely utilized for risk stratification in emergency departments (EDs); however, its predictive value across various age groups remains unclear.

Methods In this retrospective multicenter study, we analyzed 6,310 patients in the ED aged ≥ 65 years, categorized into young-old (65–74 years, $n = 2,750$), middle-old (75–84 years, $n = 2,400$), and old-old (≥ 85 years, $n = 1,160$) groups. According to CFS, patients were categorized as robust (scores 1–3), pre-frail (score 4), or frail (scores 5–9). Multivariable logistic regression analyses were performed to evaluate the independent association between frailty categories and clinical outcomes (ICU admission and in-hospital mortality), adjusting for age, sex, and illness severity. Predictive performance was assessed using the area under the receiver operating characteristic curve (AUROC).

Results The predictive value of CFS varied significantly across age groups. In the young-old group, frail status was independently associated with increased ICU admission (adjusted odds ratio [aOR] 1.49, 95% confidence interval [CI] 1.076–2.062) and in-hospital mortality (aOR 3.232, 95% CI 1.738–6.009). The middle-old group demonstrated the strongest relationship with mortality for frail patients (aOR 5.361, 95% CI 2.872–10.007), but no significant association with ICU admission after adjustment. In the old-old group, neither pre-frail nor frail status significantly predicted outcomes. AUROC analysis showed the highest discriminative capability for ICU admission in the young-old group (0.616, 95% CI 0.597–0.634) and for mortality in the middle-old group (0.730, 95% CI 0.712–0.748), with reduced predictive value observed in the old-old group.

Conclusions The prognostic value of CFS varies significantly by age group, demonstrating the strongest performance in young-old patients and diminishing predictive value in the old-old group. These findings suggest the need for age-specific frailty assessment strategies in emergency care, with additional clinical indicators potentially necessary for risk stratification in the oldest patients.

Clinical trial number Not applicable.

Keywords Frailty, Clinical frailty scale, Emergency department, Older patients, Risk stratification

*Correspondence:

Sung Jin Bae
uzimuz85@gmail.com

¹Department of Emergency Medicine, College of Medicine, Chung-Ang University Gwangmyeong Hospital, Chung-Ang University, 110, Deokan-Ro, Gwangmyeong-Si, Seoul, Gyeonggi-Do 14353, Republic of Korea

²Department of Emergency Medicine, College of Medicine, Ewha Womans University Seoul Hospital, Ewha Womans University, 260, Gonghang-Daero, Gangseo-Gu, Seoul 07804, Republic of Korea

³Department of Emergency Medicine, College of Medicine, Ewha Womans University Mokdong Hospital, Ewha Womans University 1071, Anyangcheon-Ro, Yangcheon-Gu, Seoul 07985, Republic of Korea



Introduction

Emergency departments (EDs) are essential entry points for older adults with complex medical needs. The global aging population has led to a significant increase in ED visits, posing unprecedented challenges for emergency care delivery and resource allocation [1, 2]. In this context, frailty has emerged as a significant concern [3–5]. Traditionally, frailty research has defined older adults as individuals aged ≥ 65 years [6]. However, advances in modern healthcare and increased life expectancy have introduced greater diversity in health status and functional capacity within this age group, necessitating reconsideration of this threshold [7, 8].

Frailty—a multidimensional syndrome characterized by reduced physiological reserve and increased susceptibility to stressors—is a well-established prognostic indicator in older adults [9, 10]. The Clinical Frailty Scale (CFS)—a validated and widely used tool—offers a practical method for assessing frailty based on observable functional and cognitive characteristics [11, 12]. Studies consistently demonstrate that frail older patients experience worse clinical outcomes, including higher mortality rates, increased intensive care unit (ICU) admissions, and prolonged hospital stays [13–16]. Furthermore, frailty independently predicts adverse outcomes across various clinical contexts, from cardiovascular conditions to emergency abdominal surgery [17, 18]. However, while the prognostic value of frailty is widely recognized, its predictive utility across various age strata within the older adult population remains poorly understood, particularly in emergency care settings.

While the prognostic value of frailty in emergency care is well-established [19–21], a critical knowledge gap remains regarding its age-specific predictive capabilities. Therefore, this study aims to investigate the prognostic value of the CFS across three distinct age groups within the elderly population presenting to the ED: young-, middle-, and old-old (65–74, 75–84, and ≥ 85 years, respectively). Recent validation studies of frailty assessment tools in emergency care highlight the need for a more nuanced understanding of how the prognostic value of frailty might differ across age groups [22, 23]. By investigating the predictive capability of the CFS within these age strata, we hope to provide insights into the age-related effect of frailty on ED outcomes and contribute to the development of more precise risk stratification strategies for older adults. Ultimately, our findings could guide more effective and personalized care for elderly patients in the ED.

Methods

Study design and setting

In this retrospective cohort study, we analyzed data from patients aged ≥ 65 years who presented to the EDs of three

tertiary university hospitals in South Korea between August 1 and October 31, 2023. Data were obtained from the National Emergency Department Information System (NEDIS), a comprehensive nationwide database that collects real-time ED visit data to support research and inform policy decisions. The study protocol was approved by the Institutional Review Boards of all participating hospitals, and the requirement for informed consent was waived owing to the retrospective nature of the study.

Study population

The study included patients aged ≥ 65 years who presented to the EDs during the study period. We excluded patients who visited for non-medical purposes (such as certificate issuance) and those who were declared dead on arrival. Patients with uncertain outcomes due to discharge against medical advice or transfer to other facilities were excluded as their final clinical outcomes could not be accurately determined. Trauma patients were excluded because their outcomes are primarily influenced by injury-specific factors (mechanism, severity, anatomical location) rather than physiological reserve, requiring a different analytical approach. For analysis purposes, patients were stratified into three age categories: young-, middle-, and old-old (65–74, 75–84, and ≥ 85 years, respectively).

Data collection

Demographic information was extracted from the NEDIS database, including age and sex. Initial vital signs recorded in the ED—such as systolic and diastolic blood pressure, pulse rate, respiratory rate, and body temperature—were also obtained. Mental status was evaluated using the Alert/Verbal/Painful/Unresponsive (AVPU) scale, with altered mental status defined as any state other than Alert (V, P, or U). Additionally, data on mental status and Korean Triage and Acuity Scale (KTAS) levels were collected. The KTAS is a standardized five-level triage tool adapted from the Canadian Triage and Acuity Scale and implemented nationally in South Korea since 2016. It categorizes patients from level 1 (most urgent, requiring immediate life-saving intervention) to level 5 (non-urgent), based on presenting complaints, vital signs, pain scale, and mechanism of injury. For this study, we dichotomized KTAS into urgent (levels 1–3) and non-urgent (levels 4–5) categories based on clinical relevance. ED outcomes were recorded, including discharge, admission to general wards or ICU, and death, as well as length of stay in the ED and hospital. Final hospital outcomes, including in-hospital mortality or discharge, were also documented.

Frailty assessment was performed using the Korean version of the CFS (CFS-K) [24]. Upon ED arrival,

physicians or nurses interviewed patients or their caregivers to determine the CFS score. Based on these scores, patients were categorized into three groups for primary analyses: robust (scores 1–3), pre-frail (score 4), or frail (scores 5–9). Additionally, for predictive performance evaluation using ROC curve analysis, the CFS was analyzed as a continuous variable to determine optimal cut-off values for clinical screening purposes.

Outcomes

The primary outcomes of this study were ICU admission and in-hospital mortality. These outcomes were selected to represent distinct aspects of emergency care - resource utilization decisions and patient survival, respectively. We analyzed these outcomes independently across different age groups to understand the relationship between frailty and age-specific clinical outcomes. Secondary outcomes included ED length of stay (LOS), hospital LOS, and general ward admission rates. ED LOS was defined as the time from ED arrival to ED departure (either discharge or admission), and hospital LOS was calculated from the time of hospital admission to discharge or death.

Statistical analysis

Continuous variables are presented as means with standard deviations or as medians with interquartile ranges when the data are not normally distributed. The normality of the distribution was assessed using the Shapiro–Wilk test. For normally distributed continuous variables, comparisons between age groups were conducted using ANOVA, while non-normally distributed variables, such as ED LOS and hospital LOS, were compared using the Kruskal–Wallis test. Categorical variables are expressed as frequencies with percentages and compared using chi-square tests.

Multivariable logistic regression analyses were performed to evaluate the independent predictive value of frailty for ICU admission and in-hospital mortality, adjusting for age, sex, and severity of illness using KTAS categories (urgent vs. non-urgent). Adjusted odds ratios (aOR) and their corresponding 95% confidence intervals (CI) were presented separately for each age group. Additionally, to evaluate the discriminative performance of frailty status as a prognostic tool, we calculated the area under the receiver operating characteristic curves (AUROC) with 95% confidence intervals for each outcome and age group. Optimal cut-off values were determined using the Youden index ($J = \text{sensitivity} + \text{specificity} - 1$), which identifies the point that maximizes both sensitivity and specificity simultaneously. This method was selected to provide a balanced approach to diagnostic accuracy in emergency settings. Receiver operating characteristic (ROC) curves and AUROC values were

generated using MedCalc Statistical Software. Statistical significance was set at $p < 0.05$. All other statistical analyses were conducted using SPSS version 26.0 (IBM Corp., Armonk, NY).

Although a priori sample size calculation was not conducted due to the retrospective design of this study, a post-hoc power analysis demonstrated that our sample size provided sufficient statistical power ($> 99\%$) to detect even small effect sizes (OR approximately 1.5 or higher) at a significance level of 0.05.

Results

General and clinical characteristics

In total, 6,310 patients were included and categorized into three age groups (Fig. 1): young-, middle-, and old-old ($n = 2,750$, 2,400, and 1,160, respectively). The mean age was 69.21 ± 2.81 , 79.36 ± 2.90 , and 88.88 ± 3.42 years in young-, middle-, and old-old groups, respectively ($p < 0.001$). Furthermore, the female proportion increased with age, with 51.5%, 53.5%, and 63.6% respectively ($p < 0.001$, Table 1).

Initial vital signs showed significant differences across the age groups. Systolic blood pressure decreased with age, with values of 141 ± 28 , 138 ± 28 , and 137 ± 30 mmHg, respectively ($p < 0.001$). Diastolic blood pressure also decreased with age, with values of 78 ± 16 , 73 ± 16 , and 70 ± 16 mmHg, respectively ($p < 0.001$). Respiratory rate (20 ± 2 , 20 ± 2 , and 20 ± 2 breaths/min, respectively, $p < 0.001$) and body temperature (36.9 ± 0.9 °C, 37 ± 0.9 °C, and 37 ± 0.9 °C, respectively, $p = 0.048$) also differed significantly, while pulse rate did not differ significantly among the groups.

The proportion of patients with altered mental status (non-alert) increased with age (4.9%, 8.2%, and 12.1%, respectively, $p < 0.001$). Higher acuity KTAS categories (levels 1–3) were more frequent in the older groups, with frequencies of 84.7%, 89.2%, and 91.3%, respectively ($p < 0.001$). ED LOS also increased with age: 180 (116–264), 208 (137–306), and 230 (151.8–327) min, respectively ($p < 0.001$). Admission rates rose significantly with age—with 40.7%, 51.5%, and 55.3%, respectively ($p < 0.001$)—as did in-hospital mortality (2.0%, 4.0%, and 6.8%, respectively, $p < 0.001$). The proportion of frail patients (CFS 5–9) increased significantly with age, with 21.1%, 40.6%, and 64.1%, respectively ($p < 0.001$).

Frailty and clinical outcomes

The association between frailty status and clinical outcomes varied across age groups, with the most consistent patterns observed in the young-old group (65–74 years). In this group, all outcomes demonstrated a clear, stepwise increase with frailty severity. ICU admission rates rose progressively from 7.2% in robust individuals to 10.3% in pre-frail and 17.2% in frail individuals ($p < 0.001$). General

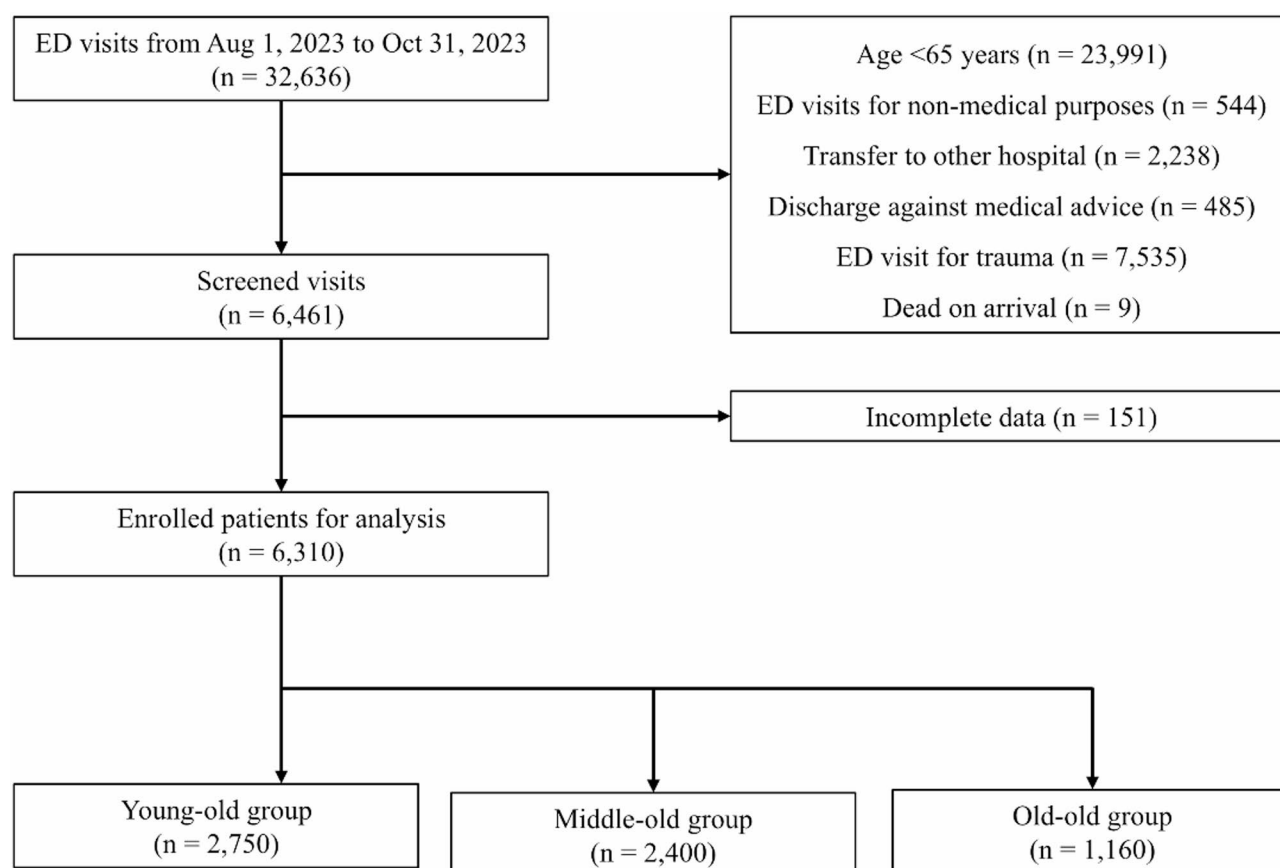


Fig. 1 Flow chart of participant selection. ED: emergency department

ward admission showed a similar pattern, increasing from 26.2% in robust individuals to 34.6% in pre-frail and 41.4% in frail individuals ($p < 0.001$). Similarly, in-hospital mortality increased from 1.1% in robust individuals to 2.6% in pre-frail and 4.0% in frail patients ($p < 0.001$). ED LOS also showed a significant upward trend (robust: 160.0 (110.0–240.0), pre-frail: 199.0 (131.0–291.5), and frail: 221.0 (143.0–320.5) min, $p < 0.001$), as did hospital LOS (7.0 (4.0–12.0), 8.0 (5.0–14.0), and 9.0 (6.0–17.25) days, $p < 0.001$, Table 2).

In the middle-old group (75–84 years), most outcomes showed significant associations with frailty, though the patterns were less consistent than in the young-old group. ICU admission rates were higher in frail patients (17.2%) compared to robust (10.2%) and pre-frail individuals (8.8%) ($p < 0.001$). General ward admission rates were similar between robust (35.6%) and pre-frail patients (35.5%) but higher in frail patients (43.4%) ($p < 0.001$). In-hospital mortality showed a more pronounced increase with frailty severity, from 1.3% in robust to 2.4% in pre-frail and 7.2% in frail patients ($p < 0.001$). Both ED LOS and hospital LOS increased with frailty severity ($p < 0.001$).

In the old-old group (≥ 85 years), the relationship between frailty and clinical outcomes exhibited more variable patterns. ICU admission rates were highest among frail patients (16.3%) and robust individuals (15.5%), while pre-frail patients had lower rates (12.2%) ($p < 0.001$). General ward admission was highest in frail patients (43.1%) compared to robust (35.9%) and pre-frail individuals (31.6%) ($p = 0.006$). Similarly, in-hospital mortality rates were 5.4%, 3.1%, and 8.2% in robust, pre-frail, and frail patients, respectively ($p < 0.001$). ED LOS and hospital LOS continued to show significant associations with frailty status ($p < 0.001$), though with less consistent patterns than in younger patient groups.

Effect of frailty on intensive care unit admission and in-hospital mortality

The prognostic value of frailty showed differences across age groups (Tables 3 and 4). In the young-old group, frailty was independently associated with increased ICU admission, with significantly higher odds observed in frail patients (aOR: 1.49; 95% CI: 1.076–2.062, $p = 0.016$) after adjusting for age, sex, and triage urgency. However, pre-frail status did not show statistical significance in the multivariable model (aOR: 1.151; 95% CI: 0.792–1.672,

Table 1 Demographic characteristics of patients

Variable	Total (n = 6,310)	Young-old age (n = 2,750)	Middle-old age (n = 2,400)	Old-old age (n = 1,160)	p-value
Age (years) ^a	76.69 ± 7.95	69.21 ± 2.81	79.36 ± 2.90	88.88 ± 3.42	< 0.001
Sex ^b					< 0.001
Male	2,871 (45.5)	1,333 (48.5)	1,116 (46.5)	422 (36.4)	
Female	3,439 (54.5)	1,417 (51.5)	1,284 (53.5)	738 (63.6)	
Systolic Blood Pressure (mmHg) ^a	139 ± 29	141 ± 28	138 ± 28	137 ± 30	< 0.001
Diastolic Blood Pressure (mmHg) ^a	75 ± 16	78 ± 16	73 ± 16	70 ± 16	< 0.001
Pulse rate (beats/min) ^a	87 ± 20	87 ± 21	87 ± 20	87 ± 20	0.417
Respiratory rate (breath/min) ^a	20 ± 2	20 ± 2	20 ± 2	20 ± 2	0.001
Body temperature (°C) ^a	37 ± 0.9	36.9 ± 0.9	37 ± 0.9	37 ± 0.9	0.048
Mental status ^b					< 0.001
Alert	5,839 (92.5)	2,615 (95.1)	2,204 (91.8)	1,020 (87.9)	
Verbal response	264 (4.2)	74 (2.7)	111 (4.6)	79 (6.8)	
Painful response	198 (3.1)	59 (2.1)	79 (3.3)	60 (5.2)	
Unresponsive	9 (0.1)	2 (0.1)	6 (0.3)	1 (0.1)	
KTAS ^b					< 0.001
Level 1	23 (0.4)	7 (0.3)	9 (0.4)	7 (0.6)	
Level 2	1,004 (15.9)	375 (13.6)	394 (16.4)	235 (20.3)	
Level 3	4,501 (71.3)	1,946 (70.8)	1,738 (72.4)	817 (70.4)	
Level 4	709 (11.2)	372 (13.5)	239 (10.0)	98 (8.4)	
Level 5	73 (1.2)	50 (1.8)	20 (0.8)	3 (0.3)	
ED outcomes					
ED LOS ^c	198 [129–291]	180 [116–264]	208 [137–306]	230 [151.8–327]	< 0.001
Discharge ^b	3,315 (52.5)	1,632 (59.3)	1,164 (48.5)	519 (44.7)	< 0.001
Admission ^b	2,995 (47.5)	1,118 (40.7)	1,236 (51.5)	641 (55.3)	
Hospital LOS ^c	8.5 [5–15]	8 [5–14]	9 [6–16]	15 [9–25]	< 0.001
GW admission ^b	2,240 (74.8)	848 (75.8)	930 (75.2)	462 (72.1)	0.191
ICU admission ^b	755 (25.2)	270 (24.2)	306 (24.8)	179 (27.9)	
In-hospital mortality ^b	228 (3.6)	54 (2)	95 (4.0)	79 (6.8)	< 0.001
Frailty					< 0.001
Clinical Frailty Scale (CFS) ^c	4 [3–6]	3 [2–4]	4 [3–6]	5 [4–7]	< 0.001
Robust (CFS 1–3) ^b	2,815 (44.6)	1,702 (61.9)	893 (37.2)	220 (19)	
Pre-frail (CFS 4) ^b	1,196 (19)	468 (17)	532 (22.2)	196 (16.9)	
Frail (CFS 5–9) ^b	2,299 (36.4)	580 (21.1)	975 (40.6)	744 (64.1)	

^a The values are given as mean ± standard deviation^b The values are given as number (%)^c The values are given as median [interquartile range]

KTAS: Korean Triage and Acuity Scale; ED: Emergency department; LOS: length of stay; GW: General ward; ICU: intensive care unit

Boldface type indicates statistical significance ($p < 0.05$)

$p = 0.462$). For in-hospital mortality in this age group, both pre-frail (aOR: 2.107; 95% CI: 1.011–4.389, $p = 0.047$) and frail statuses (aOR: 3.232; 95% CI: 1.738–6.009, $p < 0.001$) independently predicted significantly higher risk compared to robust patients.

In the middle-old group, the multivariable analysis showed that frail status did not independently predict ICU admission after adjustment (aOR: 1.25; 95% CI: 0.931–1.678, $p = 0.138$), while pre-frail status also showed no significant association (aOR: 0.774; 95% CI: 0.528–1.133, $p = 0.188$). Regarding mortality in this age group, frail status demonstrated a strong independent predictive association (aOR: 5.361; 95% CI: 2.872–10.007, $p < 0.001$),

while pre-frail status was not significantly predictive (aOR: 1.77; 95% CI: 0.799–3.92, $p = 0.159$).

In the old-old group, multivariable analysis could not be performed for the association between frailty categories and either ICU admission or mortality outcomes because the univariate analysis did not show statistically significant associations for CFS categories.

Predictive performance of clinical frailty scale by age groups

Table 5; Fig. 2 show the predictive performance of CFS varied based on age group and clinical outcomes. For ICU admission (Fig. 2A), the young-old group showed

Table 2 Frailty and clinical outcomes by age group

Young-old group				
	Robust	Pre-Frail	Frail	p-value
ICU admission ^a	122 (7.2)	48 (10.3)	100 (17.2)	<0.001
In-hospital mortality ^a	19 (1.1)	12 (2.6)	23 (4.0)	<0.001
GW admission ^a	446 (26.2)	162 (34.6)	240 (41.4)	<0.001
ED LOS ^b	160.0 [110.0–240.0]	199.0 [131.0–291.5]	221.0 [143.0–320.5]	<0.001
Hospital LOS ^b	7.0 [4.0–12.0]	8.0 [5.0–14.0]	9.0 [6.0–17.25]	<0.001
Middle-old group				
	Robust	Pre-Frail	Frail	p-value
ICU admission ^a	91 (10.2)	47 (8.8)	168 (17.2)	<0.001
In-hospital mortality ^a	12 (1.3)	13 (2.4)	70 (7.2)	<0.001
GW admission ^a	318 (35.6)	189 (35.5)	423 (43.4)	<0.001
ED LOS ^b	189.0 [122.0–271.0]	204.5 [140.75–283.25]	234.0 [152.0–344.0]	<0.001
Hospital LOS ^b	8.0 [5.0–13.0]	9.0 [5.0–15.0]	11.0 [6.0–19.0]	<0.001
Old-old group				
	Robust	Pre-Frail	Frail	p-value
ICU admission ^a	34 (15.5)	24 (12.2)	121 (16.3)	<0.001
In-hospital mortality ^a	12 (5.4)	6 (3.1)	61 (8.2)	<0.001
GW admission ^a	79 (35.9)	62 (31.6)	321 (43.1)	0.006
ED LOS ^b	226.0 [143.0–304.0]	197.0 [129.75–293.0]	239.5 [161.0–343.0]	<0.001
Hospital LOS ^b	8.0 [5.0–13.0]	9.5 [6.0–18.0]	9.5 [6.0–15.0]	<0.001

^a The values are given as number (%)^b The values are given as median [interquartile range]

GW: General ward; ICU: intensive care unit; ED: Emergency department; LOS: length of stay

Boldface type indicates statistical significance ($p < 0.05$)

the highest discriminative ability (AUROC 0.616, 95% CI 0.597–0.634) with a cut-off value of 3, achieving balanced sensitivity and specificity (54.81% and 63.71%, respectively). The middle-old group demonstrated slightly lower

performance (AUROC 0.596) despite a higher cut-off value of 5, while the old-old group showed no significant predictive value (AUROC 0.533, $p = 0.163$). When analyzing the entire patient cohort, the overall discriminative ability was moderate (AUROC 0.605, 95% CI 0.593–0.617). Pairwise comparison of ROC curves revealed no statistically significant differences between the overall cohort and both young-old ($p = 0.609$) and middle-old groups ($p = 0.671$), while there was a significant difference when compared to the old-old group ($p = 0.005$).

For in-hospital mortality (Fig. 2B), the CFS demonstrated superior overall discrimination than that of ICU admission prediction. The middle-old group demonstrated the best performance (AUROC 0.730, 95% CI 0.712–0.748) with a cut-off value of 4, showing high sensitivity (73.68%) and moderate specificity (60.74%). The young-old group also showed good discrimination (AUROC 0.673) with a lower cut-off value of 3, while the old-old group maintained significant but decreased predictive capability (AUROC 0.628) with a higher cut-off value of 6. For the entire patient cohort, the CFS showed good overall discriminative ability for mortality prediction (AUROC 0.712, 95% CI 0.700–0.723). Pairwise comparison of ROC curves revealed no statistically significant differences between the overall cohort and both young-old ($p = 0.337$) and middle-old groups ($p = 0.573$), but a significant difference was observed when compared to the old-old group ($p = 0.035$), further supporting the finding that the prognostic value of frailty diminishes in the oldest patients.

Discussion

This study offers novel insights into the age-dependent variability of the prognostic value of frailty among older patients in the ED. The main finding was that the predictive performance of CFS varied significantly by age group. In the young-old group, frailty exhibited a clear relationship with worse outcomes, with frail status independently predicting increased ICU admission and both pre-frail and frail statuses significantly associated with higher in-hospital mortality. This aligns with findings from previous research indicating that the severity of frailty is associated with higher mortality and resource utilization in elderly populations [25]. In the middle-old group, a different pattern emerged. While frailty was not independently associated with ICU admission after adjustment for confounders, it strongly predicted in-hospital mortality with frail patients showing more than five times higher odds of mortality compared to robust patients. However, the pre-frail status did not demonstrate significant predictive value for either outcome in this age group. Most notably, in the old-old group, frailty categories showed no significant associations with either ICU admission or mortality in univariate analysis,

Table 3 Predictors of ICU admission by age group

Variable	Univariate analysis ^a		Multivariate analysis ⁺		
	ICU (-) group	ICU (+) group	p-value	aOR	p-value
Young-old group	n = 2,480	n = 270			
Age (years)	69.17 ± 2.81	69.54 ± 2.82	0.044	1.010 (0.961–1.061)	0.689
Sex; Male	1,170 (47.2)	163 (60.4)	< 0.001	1.642 (1.242–2.173)	0.001
Urgent Triage (KTAS ≤ 3)	2,061 (83.1)	267 (98.9)	< 0.001	13.885 (4.401–43.808)	< 0.001
CFS					
Robust (Reference)	1,580 (63.7)	122 (45.2)			
Pre-Frail	420 (16.9)	48 (17.8)	0.028	1.151 (0.792–1.672)	0.462
Frail	480 (19.4)	100 (37.0)	< 0.001	1.49 (1.076–2.062)	0.016
Middle-old group	n = 2,094	n = 306			
Age (years)	79.32 ± 2.88	79.67 ± 3	0.048	1.023 (0.979–1.070)	0.309
Sex; Male	968 (46.2)	148 (48.4)	0.484	-	
Urgent Triage (KTAS ≤ 3)	1,838 (87.8)	303 (99.0)	< 0.001	10.039 (3.181–31.678)	< 0.001
CFS					
Robust (Reference)	802 (38.3)	91 (29.7)			
Pre-Frail	485 (23.2)	47 (15.4)	0.403	0.774 (0.528–1.133)	0.188
Frail	807 (38.5)	168 (54.9)	< 0.001	1.25 (0.931–1.678)	0.138
Old-old group	n = 981	n = 179			
Age (years)	88.92 ± 3.48	88.66 ± 3.07	0.355	-	
Sex; Male	350 (35.7)	72 (40.2)	0.245	-	
Urgent Triage (KTAS ≤ 3)	880 (89.7)	179 (100)	0.996	-	
CFS					
Robust (Reference)	186 (19)	34 (19)		-	
Pre-Frail	172 (17.5)	24 (13.4)	0.346	-	
Frail	623 (63.5)	121 (67.6)	0.774	-	

ICU: intensive care unit; aOR: Adjusted odds ratio; KTAS: Korean Triage and Acuity Scale; CFS: Clinical frailty scale

Boldface type indicates statistical significance ($p < 0.05$)^a Data are presented as mean (standard deviation) or number (%)⁺ Data in parentheses indicate adjusted odds ratios (95% confidence intervals), derived from multivariate logistic regression for variables with a p-value < 0.05 in univariate analysis

precluding their inclusion in multivariable models. This suggests that in the oldest patients, the prognostic value of frailty assessment diminishes, potentially because other factors may have greater influence on clinical outcomes in this population. This finding challenges the traditional approach of treating older adults as a homogeneous group, highlighting the increasing complexity of the relationship between frailty and clinical outcomes as people age and the need for age-stratified approaches to geriatric assessment in emergency settings.

While previous studies have established the general prognostic value of CFS in ED settings, they have generally analyzed older adults as a single group [15, 26, 27], with few studies stratifying the results by age group. This stratification is essential as aging is a heterogeneous process, and the effect of frailty on clinical outcomes may vary significantly between age groups. The stepwise progression of adverse outcomes with increasing frailty in our young-old group aligns with previous findings [21, 28]. However, the observed diminishing predictive value in the old-old group presents a novel perspective, suggesting that the traditional understanding of the influence

of frailty may not apply uniformly across age groups [7, 29]. The pairwise comparison of ROC curves in our study offers additional evidence for this age-dependent variability. The finding that there were no statistically significant differences between the overall cohort's predictive performance and that of young-old and middle-old groups, but significant differences when compared to the old-old group for both ICU admission and mortality outcomes, further strengthens our conclusion that the prognostic value of frailty truly diminishes in patients aged 85 and above. This consistent pattern across both outcome measures suggests that this is not merely a statistical artifact but represents a clinically meaningful phenomenon that warrants consideration in emergency care. Our findings are consistent with those of a recent meta-analysis on frailty, which highlights frailty as a major determinant of ICU admission and mortality. Conversely, it also suggests the need for further investigation into standardized measurements and age-related trends across the spectrum of advanced age [13, 17, 19, 30]. Such evidence underscores the importance of developing more nuanced, age-specific

Table 4 Predictors of in-hospital mortality by age group

Variable	Univariate analysis ^a		Multivariate analysis ⁺		
	In-hospital mortality (-)	In-hospital mortality (+)	p-value	aOR	p-value
Young-old group	n = 2,696	n = 54			
Age (years)	69.19 ± 2.81	70.43 ± 2.83	0.002	1.153 (1.043–1.274)	0.005
Sex; Male	1,298 (48.1)	35 (64.8)	0.017	2.007 (1.138–3.541)	0.016
Urgent Triage (KTAS ≤ 3)	2274 (84.3)	54 (100)	0.993	-	
CFS					
Robust (Reference)	1,683 (62.4)	19 (35.2)			
Pre-Frail	456 (16.9)	12 (22.2)	0.023	2.107 (1.011–4.389)	0.047
Frail	557 (20.7)	23 (42.6)	< 0.001	3.232 (1.738–6.009)	< 0.001
Middle-old group	n = 2,305	n = 95			
Age (years)	79.33 ± 2.89	80.08 ± 3.01	0.014	1.066 (0.991–1.147)	0.085
Sex; Male	1,057 (45.9)	59 (62.1)	0.002	2.056 (1.34–3.155)	0.001
Urgent Triage (KTAS ≤ 3)	2,048 (88.9)	93 (97.9)	0.014	5.829 (1.42–23.919)	0.014
CFS					
Robust (Reference)	881 (38.2)	12 (12.6)			
Pre-Frail	519 (22.5)	13 (13.7)	0.132	1.77 (0.799–3.92)	0.159
Frail	905 (39.3)	70 (73.7)	< 0.001	5.361 (2.872–10.007)	< 0.001
Old-old group	n = 1,081	n = 79			
Age (years)	88.85 ± 3.37	89.25 ± 4.05	0.312	-	
Sex; Male	395 (36.5)	27 (34.2)	0.647	-	
Urgent Triage (KTAS ≤ 3)	981 (90.7)	78 (98.7)	0.040	0.7951 (1.094–57.771)	0.040
CFS					
Robust (Reference)	208 (19.2)	12 (15.2)			
Pre-Frail	190 (17.6)	6 (7.6)	0.237		
Frail	683 (63.2)	61 (77.2)	0.180		

aOR: Adjusted odds ratio; KTAS: Korean Triage and Acuity Scale; CFS: Clinical frailty scale

Boldface type indicates statistical significance ($p < 0.05$)^a Data are presented as mean (standard deviation) or number (%)⁺ Data in parentheses indicate adjusted odds ratios (95% confidence intervals), derived from multivariate logistic regression for variables with a p-value < 0.05 in univariate analysis**Table 5** Cut-off value, AUROC, sensitivity and specificity for predict prognosis by age

	Cut-off value	AUROC (95% CI)	Sensitivity, % (95% CI)	Specificity, % (95% CI)	p-value-
Young-old group					
For predict ICU admission	3	0.616 (0.597–0.634)	54.81 (48.7–60.9)	63.71 (61.8–65.6)	< 0.001
For predict in-hospital mortality	3	0.673 (0.655–0.690)	64.81 (50.6–77.3)	62.43 (60.6–64.3)	< 0.001
Middle-old group					
For predict ICU admission	5	0.596 (0.576–0.616)	44.12 (38.5–49.9)	73.30 (71.4–75.2)	< 0.001
For predict in-hospital mortality	4	0.730 (0.712–0.748)	73.68 (63.6–82.2)	60.74 (58.7–62.7)	< 0.001
Old-old group					
For predict ICU admission	6	0.533 (0.054–0.562)	36.31 (29.3–43.8)	69.83 (66.8–72.7)	0.163
For predict in-hospital mortality	6	0.628 (0.600–0.656)	51.90 (40.4–63.3)	70.40 (67.6–73.1)	< 0.001

AUROC: Area under the ROC curve, ICU: Intensive care unit

approaches to frailty assessment and risk stratification in emergency care.

The attenuated predictive capability of CFS in the old-old group can be attributed to several interrelated factors. First, the old-old group may exhibit a narrower range of physical and cognitive function, with a higher proportion of individuals already exhibiting significant deficits. This could further diminish the discriminative power of the CFS in this population. Second, the clinical presentation

and manifestations of frailty may shift in the old-old group, making the CFS less sensitive in this age group. Third, physiological changes can complicate the interaction between frailty and other comorbidities, making it challenging to isolate the independent influence of frailty on outcomes.

Our study highlights the need for age-specific frailty assessment in the ED. The findings suggest that the CFS can be effectively utilized to guide clinical

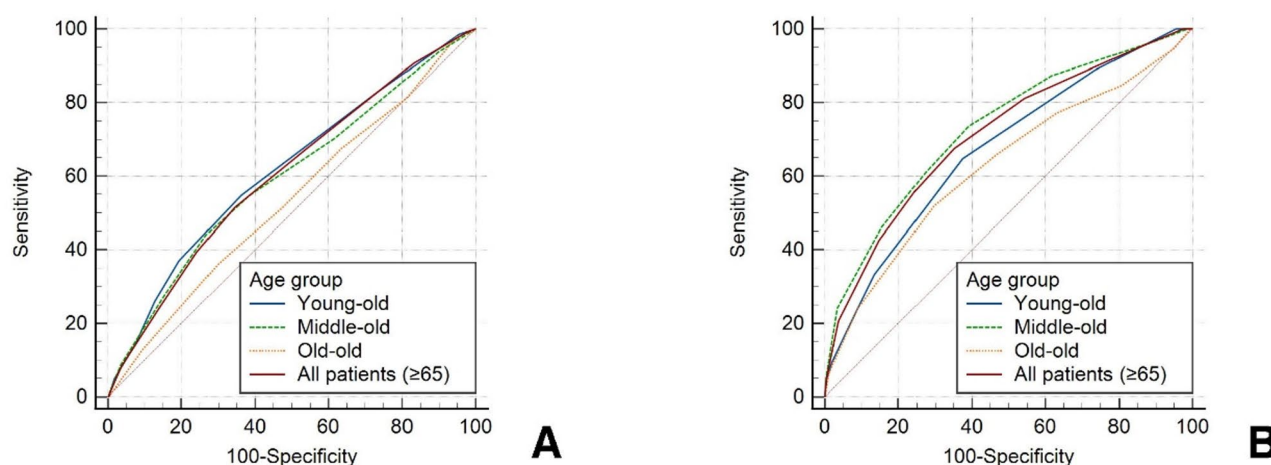


Fig. 2 Comparison of the AUROC curves by age group. **A.** for predicting ICU admission; and **B.** for predicting in-hospital mortality. AUROC: area under the receiver operating characteristic

decision-making, particularly for young-old and middle-old patients, where the relationship between frailty and outcomes is most pronounced. Conversely, for the old-old group, frailty assessment should be complemented with other clinical and functional indicators to ensure accurate risk stratification. Integrating age-specific vulnerability assessments into the triage protocol can enhance resource allocation by identifying patients who require intensive monitoring or early intervention. Additionally, it can reduce healthcare costs through more intensive interventions for patients at the highest risk of adverse events [31, 32]. This stratified approach to frailty assessment could optimize patient care and resource utilization in the ED setting.

Strengths and limitations

The key strengths of this study lie in its multicenter design and large sample size, enhancing the generalizability of the findings. Additionally, the age-stratified analysis offers valuable insights into the age-specific effect of frailty on ED outcomes. However, some limitations warrant consideration. The retrospective design may introduce selection bias, and the single-country setting may limit the generalizability of the results to other healthcare systems. The reliance on the CFS, which involves subjective clinical judgment, could affect inter-rater reliability. Also, we used the widely accepted classification of robust, pre-frail, and frail based on CFS scores, but did not further differentiate between mild-moderate frailty (CFS 5–6) and severe-terminal frailty (CFS 7–9). This additional stratification might have revealed more nuanced patterns, particularly in the old-old group where the prevalence of frailty was significantly higher. Such subgroup analysis could potentially provide greater insight into the diminishing predictive value of CFS in the oldest patients and will be an important direction for future

research. Furthermore, the study did not investigate other frailty-related measures, such as sarcopenia and cognitive impairment, which might influence outcomes. Future research should focus on developing age-specific frailty assessment tools and investigating additional prognostic factors particularly relevant to the oldest-old population. Additionally, prospective studies are needed to validate these findings and explore whether age-stratified intervention strategies could enhance outcomes for older patients with ED.

Conclusion

This study shows that the prognostic value of frailty varies significantly across age groups among older patients in the ED. While the CFS showed strong predictive ability for adverse outcomes in young-old patients (65–74 years), its performance became more nuanced in middle-old patients (75–84 years) and showed diminished predictive value in the old-old group (≥ 85 years). These findings challenge the traditional one-size-fits-all approach to frailty assessment in emergency care, highlighting the need for age-specific strategies. Our findings suggest that emergency physicians should consider age-specific patterns when using frailty to guide clinical decision-making, potentially enabling more personalized and effective care for older patients in the ED.

Acknowledgements

We would like to acknowledge our ED staffs for their support.

Author contributions

D.H.L. was responsible for the research supervision and project management; S.J.B. conceptualized the study topic; Y.C., H.S.C., J.Y.L., K.K., and Y.H.C. conducted the research. The data was then curated by Y.C. and D.H.L., with further contributions to the study methods from Y.C. and S.J.B. The formal analysis was performed by Y.C. and S.J.B., with Y.C. creating the figures and tables and writing the main manuscript. S.J.B. revised the manuscript and added comments.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Data availability

The data sets used in this study are available from the corresponding author on reasonable request.

Declarations

Human ethics approval and consent to participate

Not applicable.

Institutional review board

The present study was conducted in accordance with the guidelines of the Declaration of Helsinki and approved by the Institutional Review Board (IRB) of each participating hospital. The study was approved by Ewha Womans University Seoul Hospital (IRB No. 2024-04-013, 22 April 2024) and Ewha Womans University Mokdong Hospital (IRB No. 2024-01-007-005, 12 April 2024), and Chung-Ang University Gwangmyeong Hospital (IRB No. 2402-139-020, 6 March 2024).

Informed consent

Owing to the difficulty in relocating patients, the requirement for informed consent was waived for retrospectively collected clinical data.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Received: 1 February 2025 / Accepted: 29 May 2025

Published online: 02 July 2025

References

1. Tarabay R, Perry A, Al Aridi R, Malone M. Can an emergency department adequately address an older adult who has complex needs? *J Geriatric Emerg Med*. 2021;2(3). <https://doi.org/10.17294/2694-4715.1015>.
2. Hwang U, Shah MN, Han JH, Carpenter CR, Siu AL, Adams JG. Transforming emergency care for older adults. *Health Affairs (Millwood)*. 2013;32(12):2116–21. <https://doi.org/10.1377/hlthaff.2013.0670>.
3. Fried LP, Cohen AA, Xue QL, Walston J, Bandeen-Roche K, Varadhan R. The physical frailty syndrome as a transition from homeostatic symphony to cacophony. *Nat Aging*. 2021;1(1):36–46. <https://doi.org/10.1038/s43587-020-00017-z>.
4. Cesari M, Prince M, Thiagarajan JA, De Carvalho IA, Bernabei R, Chan P, et al. Frailty: an emerging public health priority. *J Am Med Dir Assoc*. 2016;17(3):188–92. <https://doi.org/10.1016/j.jamda.2015.12.016>.
5. Cesari M, Calvani R, Marzetti E. Frailty in older persons. *Clin Geriatr Med*. 2017;33(3):293–303. <https://doi.org/10.1016/j.cger.2017.02.002>.
6. Fried LP, Tangen CM, Walston J, Newman AB, Hirsch C, Gottdiener J et al. Frailty in older adults: evidence for a phenotype. *The journals of gerontology series A: biological sciences and medical sciences*. 2001;56(3):M146–57. <https://doi.org/10.1093/gerona/56.3.m146>.
7. Santoni G, Angleman S, Welmer AK, Mangialasche F, Merengoni A, Fratiglioni L. Age-Related variation in health status after age 60. *PLoS ONE*. 2015;10(6):e0130024. <https://doi.org/10.1371/journal.pone.0120077>.
8. Thygesen LC, Christensen K, Rørth M, Sørensen HT, Vandenbroucke JP, Westendorp RGJ. Tipping Points—Do the prognostic values of Multimorbidity and functional status vary with age? *Clin Epidemiol*. 2021;13:853–7. <https://doi.org/10.2147/CLEP.S325348>.
9. Chen X, Mao G, Leng SX. Frailty syndrome: an overview. *Clin Interv Aging*. 2014;9:433–41. <https://doi.org/10.2147/CIA.S45300>.
10. De Biasio JC, Mittel AM, Mueller AL, Ferrante LE, Kim DH, Shaefi S. Frailty in critical care medicine: A review. *Anesth Analg*. 2020;130(6):1462–73. <https://doi.org/10.1213/ANE.0000000000004665>.
11. Church S, Rogers E, Rockwood K, Theou O. A scoping review of the clinical frailty scale. *BMC Geriatr*. 2020;20(1):393. <https://doi.org/10.1186/s12877-020-01801-7>.
12. Rockwood K, Song X, MacKnight C, Bergman H, Hogan DB, McDowell I, et al. A global clinical measure of fitness and frailty in elderly people. *Can Med Assoc J*. 2005;173(5):48995. <https://doi.org/10.1503/cmaj.050051>.
13. Bruno RR, Wernly B, Bagshaw SM, van den Boogaard M, Darvall JN, De Geer L, et al. The clinical frailty scale for mortality prediction of old acutely admitted intensive care patients: a meta-analysis of individual patient-level data. *Ann Intensive Care*. 2023;13(1):37. <https://doi.org/10.1186/s13613-023-01132-x>.
14. Thompson MQ, Fatema NEZ, Tucker GR, Khalid A, Huang Y, Smyth CR, et al. Frailty in general medicine patients receiving geriatric medicine Liaison services is predictive of adverse outcomes. *Australas J Ageing*. 2024. <https://doi.org/10.1111/ajag.13374>.
15. Fehlmann CA, Nickel CH, Cino E, Al-Najjar Z, Langlois N, Eagles D. Frailty assessment in emergency medicine using the clinical frailty scale: a scoping review. *Intern Emergency Med*. 2022;17(8):2407–18. <https://doi.org/10.1007/s11739-022-03042-5>.
16. Juma S, Taabazuing MM, Montero-Odasso M. Clinical frailty scale in an acute medicine unit: a simple tool that predicts length of stay. *Can Geriatr J*. 2016;19(2):34–9. <https://doi.org/10.5770/cgj.19.196>.
17. Prendiville T, Leahy A, Gabr A, Ahmad F, Afilalo J, Martin GP, et al. Clinical frailty scale as a predictor of adverse outcomes following Aortic valve replacement: a systematic review and meta-analysis. *Open Heart*. 2023;10(2):e002354. <https://doi.org/10.1136/openhrt-2023-002354>.
18. Tan HL, Chia S, Nadkarni NV, Ang SY, Seow DCC, Wong TH. Frailty and functional decline after emergency abdominal surgery in the elderly: A prospective cohort study. *World J Emerg Surg*. 2019;14(1):62. <https://doi.org/10.1186/s13017-019-0280-z>.
19. Koay WJ, Leahy A, Barry L, Condon J, Egan A, Prendiville T, et al. Systematic review and Meta-Analysis of diagnostic and predictive accuracy of the clinical frailty scale in older adults in emergency department. *Age Ageing*. 2024;53(Supplement4):afae005. <https://doi.org/10.1093/ageing/afae178.005>.
20. Lin JW, Lin PY, Wang TY, Chen YJ, Yen DH, Huang HH. The association between frailty evaluated by clinical frailty scale and mortality of older patients in the emergency department: A prospective cohort study. *Clin Interv Aging*. 2024;19:1383–92. <https://doi.org/10.2147/cia.s472991>.
21. Fernando SM, Guo KH, Lukasik M, Rochweg B, Cook DJ, Kyremanteng K, et al. Frailty and associated prognosis among older emergency department patients with suspected infection: A prospective, observational cohort study. *Can J Emerg Med*. 2020;22(5):687–91. <https://doi.org/10.1017/cem.2020.377>.
22. Lorna AF, Shamis KRBAD. Screening for frailty in older emergency department patients: the utility of the survey of health, ageing and retirement in Europe frailty instrument. *QJM*. 2018;111(3):151–4. <https://doi.org/10.1093/qjmed/hcx242>.
23. YÜcel M, Altuncu YA, ÖZÇete E, Kilavuz A, Karbek Akarca F. Comparison of clinical frailty scale and Edmonton frail scale in older adults presenting to the emergency department. *Turkish J Geriatr*. 2024;27(1):108–17. <https://doi.org/10.29400/tjgeri.2024.384>.
24. Ko RE, Moon SM, Kang D, Cho J, Chung CR, Lee Y, et al. Translation and validation of the Korean version of the clinical frailty scale in older patients. *BMC Geriatr*. 2021;21(1):47. <https://doi.org/10.1186/s12877-021-02008-0>.
25. Han L, Clegg A, Doran T, Fraser L. The impact of frailty on healthcare resource use: A longitudinal analysis using the clinical practice research datalink in England. *Age Ageing*. 2019;48(5):665–71. <https://doi.org/10.1093/ageing/afz088>.
26. Elliott A, Taub N, Banerjee J, Aijaz F, Jones W, Teece L, et al. Does the clinical frailty scale at triage predict outcomes from emergency care for older people? *Ann Emerg Med*. 2021;77(6):620–7. <https://doi.org/10.1016/j.annemergmed.2020.09.006>.
27. Kaeppli T, Rueegg M, Dreher-Hummel T, Brabrand M, Kabell-Nissen S, Carpenter C, et al. Validation of the clinical frailty scale for prediction of Thirty-Day mortality in the emergency department. *Ann Emerg Med*. 2020;76(3):291–300. <https://doi.org/10.1016/j.annemergmed.2020.03.028>.
28. Rueegg M, Nissen SK, Brabrand M, Kaeppli T, Dreher T, Carpenter C, et al. The clinical frailty scale predicts 1-year mortality in emergency Department patients aged 65 years and older. *Acad Emerg Med*. 2022;29(5):572–80. <https://doi.org/10.1111/acem.14460>.
29. Jacobs JM, Maaravi Y, Cohen A, Bursztyn M, Ein-More E, Stessman J. Changing profile of health and function from age 70 to 85 years. *Gerontology*. 2012;58(4):313–21. <https://doi.org/10.1159/000335238>.

30. Wu C. Embracing complexity: new horizons in frailty research. *Lancet Reg Health - Western Pac.* 2023;34:100791. <https://doi.org/10.1016/j.lanwpc.2023.100791>.
31. Hinson JS, Martinez DA, Cabral S, George K, Whalen M, Hansoti B, et al. Triage performance in emergency medicine: A systematic review. *Ann Emerg Med.* 2019;74(1):140–52. <https://doi.org/10.1016/j.annemergmed.2018.09.022>.
32. Tam HL, Chung SF, Lou CK. A review of triage accuracy and future direction. *BMC Emerg Med.* 2018;18(1):58. <https://doi.org/10.1186/s12873-018-0215-0>.

Publisher's note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.