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Original Study

Health Services Use and Functional Recovery Following Blunt Trauma in Older Persons — A National Multicentre Prospective Cohort Study

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A B S T R A C T

Objective: Frailty is associated with morbidity and mortality in older injured patients. However, for older blunt-trauma patients, increased frailty may not manifest in longer length of stay at index admission. We hypothesized that owing to time spent in hospital from readmissions, frailty would be associated with less total time at home in the 1-year postinjury period.

Design: Prospective, nationwide, multicenter cohort study.

Setting and Participants: All Singaporean residents aged ≥55 years admitted for blunt trauma with an Injury Severity Score (ISS) or New Injury Severity Score (NISS) ≥10 from March 2016 to July 2018.

Methods: Frailty (by modified Fried criteria) was assessed at index admission, based on questions on preinjury weight loss, slowness, exhaustion, physical activity, and grip strength at the time of recruitment. Low time at home was defined as >14 hospitalized days within 1 year postinjury. The contribution of planned and unplanned readmission to time at home postinjury was explored. Functional trajectory (by Barthel Index) over 1 year was compared by frailty.

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Results: Of the 218 patients recruited, 125 (57.3%) were male, median age was 72 years, and 48 (22.0%) were frail. On univariate analysis, frailty [relative to nonfrail: odds ratio (OR) 3.45, 95% confidence interval (CI) 1.33−8.97, $P = .01$] was associated with low time at home. On multivariable analysis, after inclusion of age, gender, ISS, intensive care unit admission, and surgery at index admission, frailty (OR 5.21, 95% CI 1.77−15.34, $P < .01$) remained significantly associated with low time at home in the 1-year postinjury period. Unplanned readmissions were the main reason for frail participants having low time at home. Frail participants had poorer function in the 1-year postinjury period.

Conclusions and Implications: In the year following blunt trauma, frail older patients experience lower time at home compared to patients who were not frail at baseline. Screening for frailty should be considered in all older blunt-trauma patients, with a view to being prioritized for postdischarge support.

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Frailty is characterized by the cumulation of deficits,[1,2] resulting in a reduction in physiologic reserve,[3−6] and has been associated with fall risk,[7] reduced quality of life,[4,5,7] functional decline,[8,9] readmissions,[1,6,7,10,11] in-hospital complications,[5] prolonged hospital stays,[6,9] increased health care costs, and overall mortality.[2,4,5,8,10−14] As such, there has been growing awareness of frailty as a risk factor for morbidity and mortality in older injured patients. Frailty screening methods previously used in community settings or elective surgical patients have been adapted for emergency surgery and trauma patients.[3,4,7−9,15]

However, increased frailty may not manifest in longer length of stay (LOS) at index admission in older blunt-trauma patients. In our analysis of baseline data collected from the national multicenter prospective cohort study of blunt-trauma patients aged ≥55 years, we found that frailty was paradoxically associated with a reduced adjusted LOS at index admission.[16] Other authors have shown that a shorter hospital stay can be followed by a lengthier stay in post-acute care facilities.[17]

Time at home is a patient-centered outcome[2,6,18−23] of increasing interest in older patient populations, validated in different settings, including stroke,[23] surgery,[19,20] geriatrics and palliative care,[24] with a clear correlation with both patient experience and quality of life.[25] Time at home takes into consideration time spent outside hospitals, an outcome that matters to patients, especially those who have chronic disease and frequent hospitalizations.[6] As a proxy of health care utilization, it overcomes some limitations of the traditional endpoint quality measures, such as length of hospital stay at index admission.

We hypothesize that in the 1-year follow-up period postinjury, frailty is associated with less time at home owing to the increased risk and duration of readmission.[11] We examine the effect of frailty on time at home postinjury, as well as its effect on change in functional status over time.

Methods

Study Population and Data Collection

Singapore is a rapidly aging Asian nation with a life expectancy at birth of 83.1 years and a population of 5.6 million, of whom 24.6% are 55 years and older, compared to 17.3% worldwide.[11,26]

In this prospective, nationwide, multicenter cohort study of Singaporean residents (citizens or permanent residents), patients admitted via the emergency department were screened via the Singapore National Trauma Registry offices in each participating public hospital. Injury Severity Score (ISS), New Injury Severity Score (NISS), Abbreviated Injury Scale (AIS), and Revised Trauma Score (RTS) data were drawn from National Trauma Registry offices at the respective study sites. Demographics (age, gender, race, housing type, and employment status) were drawn from the National Trauma Registry and verified in the questionnaire.

Inclusion criteria were as follows: age ≥55 years, admitted for ≥48 hours after blunt injury, survived the index hospitalization, and with an ISS or New Injury Severity Score ≥10, or an Organ Injury Scale ≥3 (refer to Supplementary Material 1 for further details).

For patients unable to respond appropriately to questionnaires, their caregivers were approached for the caregiver questionnaire arm of the study. Patients and caregivers were not approached if the primary attending physician did not agree to the study team approaching the patient or caregiver, if the patient was not expected to survive the admission, or if the patient could not give consent and there was no caregiver.

At the time of study initiation, there were 6 public hospitals in Singapore receiving adult trauma conveyed by ambulance. All 6 hospitals contributed data to the study, with recruitment taking place from March 2016 to July 2018, and 1-year follow-up completed in July 2019.

Frailty and Other Covariates

Modified Fried criteria (MFC)[4] has been used in studies of both elective and emergency surgical populations.[3−5,7,9] Patients were considered frail if they scored 3 or more of the following 5 criteria, using a questionnaire on preinjury baseline status completed during the index admission, and available in 3 of the 4 official languages in Singapore[27]: (1) unintentional weight loss (≥5 kg in the last year), (2) slowness [slow walking speed, based on the question "Do you find it difficult to walk 200 to 300 meters (1 bus stop to another)?", as a substitute for the Timed Up and Go], (3) exhaustion (present if answered "yes" to at least 1 of the 2 questions from the Center for Epidemiological Studies−Depression Scale, "I felt that everything I did was an effort"/"I could not 'get going'"),[28] (4) weakness (grip strength),[18] and (5) low physical activity.[26,28] Grip strength was measured with a dynamometer at the time of recruitment,[26] and physical activity was assessed via the Global Physical Activity Questionnaire,[29] both validated locally. Seventy-nine patients (36.2%) were unable to perform grip strength assessments at baseline, almost all due to cognitive impairment and not being able to understand the dynamometer instructions. These patients were included in the study and scored for frailty based on the other components of frailty.

Cognitive impairment, associated with physical frailty and correlated with poor outcomes,[30−32] was assessed via the Mini Mental State Examination.[33] Patients who were unable to complete any part of the Mini Mental State Examination were included in the study as a category of "unable to perform," and a cutoff of 24 was used to categorize the patients who were able to attempt the Mini Mental State Examination (cognitive impaired vs not impaired).[16] Patient demographics, Charlson Comorbidity Index,[34] injury characteristics, and inpatient management details were recorded at index admission.

Outcomes

The outcome of interest in this analysis was time at home, dichotomized into high time at home (defined as ≤14 acute hospital admission days over the 1-year postinjury period) and low time at home (>14 acute hospital admission days in the 1-year period postinjury period).[19] This included admissions to rehabilitation facilities such as community hospitals and excluded nonhospital admissions such as emergency department and specialist clinic visits. A reduction in time at home of >14 days in 1 year is shown to be negatively associated with patient-centered functional outcomes.[35] We examined the association between the outcome of interest and frailty (MFC)[4] and other covariates: demographics, comorbidities, mechanism of injury, injury severity, treatment characteristics at index admission [intensive care unit (ICU) admission, surgery], social isolation (defined by patients staying alone), and cognitive impairment. We explored the relative contribution of planned (scheduled, intentional) vs unplanned (unscheduled, unexpected) readmissions to time at home in the 1-year period postinjury. For patients who declined further study visits after the first follow-up visit, readmission data and death data were obtained from the recruiting institution's medical records, as agreed to in the consent form.

In addition, we explored change in functional status (by Barthel Index) between the frail, prefrail, and nonfrail groups. Barthel Index was collected during in-person follow-up interviews, conducted at the following time points: at recruitment (to reflect preinjury baseline function), 3 months postinjury, 6 months postinjury, and 12 months postinjury. The postinjury follow-ups were conducted regardless of whether patients were still admitted for the index injury.

Statistical Analysis

Patient characteristics at baseline were summarized by median (interquartile range) or frequency (%) as appropriate. Chi-square and Mann-Whitney *U* were used to compare categorical and continuous variables between the low and high time at home groups. Predictors significantly different ($P < .05$) were analyzed with univariate and multivariable logistic regression. Variables not statistically significant but which were clinically meaningful in studies of long-term outcome (age and gender)[5] were retained in the multivariable model.

For patients who completed the 12-month follow-up, functional status by Barthel Index was charted over time.

The following sensitivity analyses were performed: incorporation of physiological measures of injury severity that were not significant on univariate analysis (RTS), incorporation of clinically meaningful interaction terms in the model, and exclusion of participants who died during the study follow-up period.

Stata, version 15.1, was used. The first author's Institutional Review Board granted ethical approval for this study (SingHealth IRB Reference 2015/2590).

Results

Out of the 220 patients recruited, 2 were found in retrospect not to have met criteria for the study (1 died before discharge and 1 had too low an ISS), leaving a final cohort of 218 participants (Supplementary Figure 1). Of the remaining 218 participants, 116 (57.4%) were male, the median age was 72 years [interquartile range (IQR) 66–83 years], and 48 (22.0%) were frail. More than two-thirds (148 participants, 67.9%) completed the 1-year follow-up. Sixty-four (31.7%) participant questionnaires were answered by surrogates, not the patients themselves. Low fall patients (defined as ≤0.5 m) had the highest proportion of frailty (44, 27.3%), followed by higher-level fallers (3, 21.4%) and motor vehicle accidents (1, 2.3%) ($P < .01$).[5] At least half of the participants in all 3 categories of mechanism of injury were prefrail at baseline: low fall (98, 60.9%), high fall (7, 50.0%), and motor vehicle injury (35, 81.4%) (Table 1).

More than one-third of patients (85, 39.0%) were severely or critically injured (ISS ≥16), with the remainder moderately injured (ISS 10–15). The proportion of anatomical polytrauma patients (AIS ≥3 for 2 or more ISS regions) was 11.9% (26 patients). In terms of pattern of injury, a significant head injury (head and neck AIS score ≥3) was the most common (123, 56.4%), followed by extremity (56, 25.7% extremity AIS score ≥3) and thorax injuries (45, 20.6%, thorax AIS score ≥3). A higher proportion of critically injured (ISS ≥25) and severely injured patients (ISS 16–24) had a head AIS score of ≥3 (26, 96.3% and 44, 85.9% respectively), compared to the moderately injured (ISS 10–15) (53, 39.9%).

One hundred sixteen (53.2%) patients experienced low time at home in the year postinjury. These patients had more emergency department visits and unplanned readmissions. However, both groups (high vs low time at home) had similar numbers of outpatient physician visits, and no differences in planned readmissions (Table 1). Ten (4.6%) participants experienced both unplanned readmission and death.

On univariate analysis, frailty by MFC (relative to nonfrail) was significantly associated with low time at home [odds ratio (OR) 3.45, 95% confidence interval (CI) 1.33–8.97, $P = .01$; Table 2]. High injury severity (ISS 16–24 relative to ISS 10–15: OR 1.93, 95% CI 1.03–3.63, $P = .04$; ISS ≥25 relative to ISS 10–15: OR 2.80, 95% CI 1.15–6.85, $P = .02$), and need for ICU at index admission (OR 3.92, 95% CI 1.62–9.48, $P < .01$) was also associated with low time at home. Surgery performed at index admission was associated with high time at home at 1 year (OR 0.40, 95% CI 0.23–0.70, $P < .01$) (Table 2).

Eleven patients (5.1%) also experienced a Clavien-Dindo complication of grade 3 and above (requiring reintervention or ICU)[36] during the index hospitalization. All 11 patients underwent surgery at the index admission, with a long LOS at the index admission (median 44 days, IQR 30–61 days, compared to the 207 patients without complications, median 11 days, IQR 6–19, $P < .001$ on Mann Whitney *U* test), but were not at higher risk of unplanned readmission within the study period (4, 36.4%, compared to the patients without complications, 51, 24.6%; $P = .36$ on chi-square). As all 11 patients had low time at home owing to the index hospitalization, and there were none in the high time at home group, this factor could not be included in the multivariable model.

On multivariable analysis incorporating age and gender (Table 2), frailty (MFC) (OR 5.21, 95% CI 1.77–15.34, $P < .01$) still had a statistically significant association with low time at home, as did age (OR 1.03, 95% CI 1.00–1.06, $P = .05$), injury severity (ISS 16–24 relative to ISS 10–15: OR 2.30, 95% CI 1.13–4.71, $P = .02$), and need for intensive care at index admission (OR 3.30, 95% CI 1.20–9.06, $P = .02$). Surgery at index admission was associated with high time at home (OR 0.34, 95% CI 0.18–0.64, $P < .01$).

None of the sensitivity analyses (incorporating RTS, analysis without those who died during the study period, addition of interaction terms between ISS and surgery, ISS and frailty, frailty and surgery, mechanism of injury and surgery, and ISS and ICU) affected the reported associations, nor did they improve the area under the receiving operating characteristic curve.

Frail patients had many more total hospitalized days in the postinjury year compared to the nonfrail patients, with prefrail patients in-between (Figure 1). Functional independence, as seen from the Barthel Index, decreased over the 1-year follow-up period for the frail patients more than for the prefrail (intermediate) and nonfrail, although, for patients who completed the follow-up, all 3 groups showed improvement in function from the 3-month point onward, when function was the worst (Figure 2).

Table 1
Characteristics of Study Participants (N = 218)

	All Patients (N = 218)	High Time at Home (n = 102)	Low Time at Home (n = 116)	*P* Value
Demographics				
Age, y, median (IQR)	73 (66–83)	72.5 (64–81)	74.5 (66–85)	.20
Sex				
Male	125 (57.3)	63 (61.8)	62 (53.5)	.22
Female	93 (42.7)	39 (38.2)	54 (46.5)	
Ethnicity				
Chinese	184 (84.4)	87 (85.3)	97 (83.6)	.78
Malay	23 (10.5)	12 (10.8)	12 (10.3)	
Indian	11 (5.1)	4 (3.9)	7 (6.0)	
Housing type				
1–2 room public	25 (11.5)	9 (8.8)	16 (13.8)	.56
3-room public	46 (21.1)	23 (22.6)	23 (19.8)	
4-room public	69 (31.6)	33 (32.3)	36 (31.0)	
5-room public	47 (21.6)	25 (24.5)	22 (19.0)	
Private	31 (14.2)	12 (11.8)	19 (16.4)	
Employment status				
Full-time	54 (24.8)	32 (31.4)	22 (19.0)	.14
Part-time	17 (7.8)	9 (8.8)	8 (6.9)	
Homemaker	29 (13.3)	11 (10.8)	18 (15.5)	
Retired	118 (54.1)	50 (49.0)	68 (58.6)	
Highest level of education				
None	27 (12.4)	10 (9.8)	17 (14.7)	.45
Primary	89 (40.8)	47 (46.1)	42 (36.2)	
Secondary	78 (35.8)	34 (33.3)	44 (37.9)	
Tertiary	24 (11.0)	11 (10.8)	13 (11.2)	
Living arrangements				
Not alone	196 (89.9)	95 (93.1)	101 (87.1)	.14
Alone	22 (10.1)	7 (6.9)	15 (12.9)	
Interviewee				
Patient	148 (67.9)	74 (72.6)	74 (63.8)	.17
Surrogate (patient unable to answer)	70 (32.1)	28 (27.4)	42 (36.2)	
Injury characteristics				
ISS				
10–15	133 (61.0)	72 (70.6)	61 (52.6)	**.02**
16–24	58 (26.6)	22 (21.6)	36 (31.0)	
≥25	27 (12.4)	8 (7.8)	19 (16.4)	
ISS regions with AIS of ≥3				
Head and neck AIS ≥3	123 (56.4)	55 (53.9)	68 (58.6)	.49
Face AIS ≥3	2 (0.9)	1 (1.0)	1 (0.9)	.93
Thorax AIS ≥3	45 (20.6)	24 (23.5)	21 (18.1)	.32
Abdomen or pelvis AIS ≥3	14 (6.4)	6 (5.9)	8 (6.9)	.76
Extremities AIS ≥3	56 (25.7)	22 (21.6)	34 (29.3)	.19
External AIS ≥3	0	0	0	—
Anatomical polytrauma,[18] AIS ≥3 in at least 2 ISS regions	26 (11.9)	10 (9.8)	16 (13.8)	.37
RTS				
<7.841 (abnormal)	12 (5.5)	5 (4.9)	7 (6.0)	.71
7.841 (normal)	206 (94.5)	97 (95.1)	109 (94.0)	
Mechanism of injury				
Low fall, ≤0.5 m	161 (73.9)	73 (71.6)	88 (75.9)	.61
High fall, >0.5 m	14 (6.4)	6 (5.9)	8 (6.9)	
Motor vehicle injury	43 (19.7)	23 (22.6)	20 (17.2)	
Treatment characteristics at index admission				
Surgery performed	87 (39.9)	29 (28.4)	58 (50.0)	**<.01**
ICU admission	33 (15.1)	7 (6.9)	26 (22.4)	**<.01**
Complications	11 (5.1)	0 (0)	11 (9.5)	**<.01**
Frailty, function, and comorbidity				
Nonfrail, MFC = 0	30 (13.8)	19 (18.6)	11 (9.5)	**.03**
Prefrail, MFC 1–2	140 (64.2)	67 (65.7)	73 (62.9)	
Frail, MFC ≥3	48 (22.0)	16 (15.7)	32 (27.6)	
MFC components				
Slowness	39 (17.9)	12 (11.8)	27 (23.3)	**.03**
Exhaustion	57 (26.2)	26 (25.5)	31 (26.7)	.84
Weight loss	48 (22.0)	20 (19.6)	28 (24.1)	.40
Low physical activity	112 (51.4)	48 (47.1)	64 (55.2)	.23
Weakness[*]	105 (48.2)	46 (45.1)	59 (50.9)	.42
Functional independence, Barthel Index <80 (dependent)	25 (11.5)	11 (10.8)	14 (12.1)	.77
MMSE score				
Unable to perform MMSE	80 (36.7)	37 (36.3)	43 (37.1)	.71
MMSE <24	56 (25.7)	24 (23.5)	32 (27.6)	
MMSE ≥24	82 (37.6)	41 (40.2)	41 (35.3)	

(*continued on next page*)

Table 1 (*continued*)

	All Patients (N = 218)	High Time at Home (n = 102)	Low Time at Home (n = 116)	*P* Value
CCI				
0	67 (30.7)	36 (35.3)	31 (26.7)	.40
1	51 (23.4)	24 (23.5)	27 (23.3)	
2	31 (14.2)	15 (14.7)	16 (13.8)	
≥3	69 (31.7)	27 (26.5)	42 (36.2)	
Healthcare utilization				
Number of patients experiencing ≥1 planned readmission	19 (8.7)	7 (6.9)	12 (10.3)	.36
Number of patients experiencing ≥1 unplanned readmission	55 (25.2)	9 (8.8)	46 (39.7)	**<.001**
Hospitalized days 1 y postinjury, median days (IQR)	16 (8–38)	7.5 (5–10)	35.5 (21.5–60)	**<.001**
Outpatient doctor visits within 1 y of injury, median visits (IQR)	5.5 (2–11)	6 (2–12)	5 (2–10.5)	.46
Emergency department visits within 1 y of injury, median visits (IQR)	1 (0–3)	1 (0–2)	2 (1–4)	**<.01**
Death within 1 y of injury	16 (7.3)	4 (3.9)	12 (10.3)	.07

CCI, Charlson Comorbidity Index; MMSE, Mini Mental State Examination.
Unless otherwise noted, values are n (%). Boldface indicates statistical significance.
*Seventy-nine patients (36.2%) were unable to perform grip strength assessments at baseline, almost all due to cognitive impairment and not being able to understand dynamometer instructions.

Discussion

In this prospective national multicenter cohort study of older blunt-trauma patients, frailty was associated with low time at home in the 1-year postinjury period, as well as with functional decline. This finding contrasts with our earlier reported observation of the baseline data showing that frailty was associated with a shorter LOS at index admission.[16] Taken together, the findings suggest that older patients who are frail at baseline continue to accumulate deficits[1] over the 1-year period postinjury, manifesting in low time at home and functional decline. A short LOS after moderate blunt injury in older frail patients does not preclude them from eventually spending low time at home owing to readmission in the first-year postinjury, likely because of functional decline and the reduced capacity of recovery observed in older trauma patients.[3,37]

The epidemiology of injury in our prospective cohort study (head injury with AIS ≥3 most common, followed by chest and extremity injuries), as well as the high proportion of low falls with high injury severity, is similar to that reported in the literature on older trauma patients.[5,13,37,38] Although other authors have reported a higher proportion of physiological derangement in older patients,[39] we had few patients with abnormal physiology on presentation (by RTS score), similar to a national registry–based study of survivors of the index admission.[5] Similarly, the relatively low 1-year mortality we observed may be due to selection criteria of only recruiting survivors of the index admission, as well as difficulties faced in recruiting more severely injured participants, especially if they were admitted critically ill and caregivers were under stress.

In our baseline study, frail patients were less likely to undergo surgery, which was one explanation for a shorter LOS at index admission.[16] Having surgery at the index admission for the initial injury was associated with a longer length of stay at the index admission in our baseline study. Yet, at 1 year, surgery was independently associated with lower time at home. Hence, although surgery increases the LOS at index admission, it is associated with lower time at home at 1 year. It is difficult to distinguish from our data as to whether this phenomenon can be attributed to frail patients having a pattern of injury that is different from the prefrail or nonfrail that is less amenable to surgery, or whether this is due to patient and surgeon choices for surgery, based on their preinjury frailty. Our sensitivity analysis (there was no significant interaction between frailty and surgery, and adding this interaction did not change findings) suggests that there may not be a clear-cut answer, and further studies designed to examine postinjury surgical decision making are indicated.

In our baseline study, a positive correlation was seen between ISS and length of stay, contrary to other studies that observed no correlation between ISS and RTS and length of stay.[40] In the analysis of our follow-up data, ISS also contributed to a 2- to 3-fold increase in risk of low time at home, when analyzed by conventional bands of injury severity (ISS 10–15 moderate injury, 16–24 severe, ≥25 critical). When compared to the reported effect of ISS on the readmission risk in other papers[11,41] (OR 1.01–1.02 for every 1-point

Table 2
Risk Factors for Low Time at Home 1 Year Postinjury

Risk Factors	Univariate			Multivariate		
	OR	95% CI	*P* Value	OR	95% CI	*P* Value
Demographics						
Age	1.02	0.99–1.04	.16	1.03	1.00–1.06	**.05**
Male (ref: female)	0.71	0.41–1.22	.22	0.80	0.43–1.50	.49
ISS						
10–15	1 (ref)					
16–24	1.93	1.03–3.63	**.04**	2.30	1.13–4.71	**.02**
≥25	2.80	1.15–6.85	**.02**	1.54	0.55–4.37	.41
Treatment characteristics at index admission						
ICU admission	3.92	1.62–9.48	**<.01**	3.30	1.20–9.06	**.02**
Surgery performed	0.40	0.23–0.70	**<.01**	0.34	0.18–0.64	**<.01**
Frailty by MFC						
Nonfrail MFC = 0	1 (ref)					
Prefrail MFC = 1–2	1.88	0.83–4.24	.13	2.10	0.85–5.19	.11
Frail MFC ≥3	3.45	1.33–8.97	**.01**	5.21	1.77–15.34	**<.01**

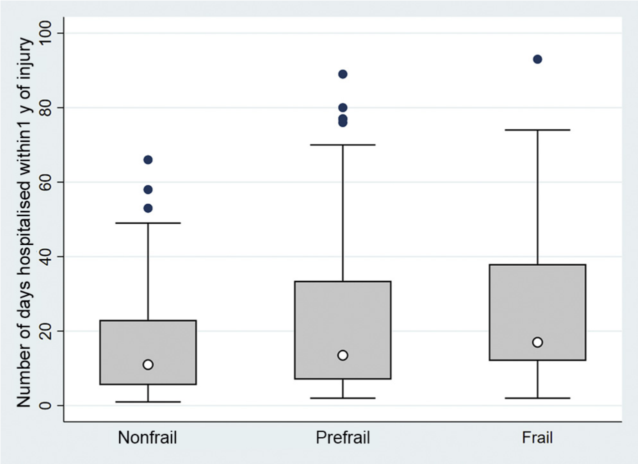

Fig. 1. Days hospitalized within 1 year of injury, nonfrail vs prefrail vs frail.

increase in ISS), this is slightly higher than expected. This could mean that readmission as an outcome measure on its own may underestimate the impact of injury severity on eventual total time at home at 1 year. Although the highest band of injury severity (ISS ≥25 critical) was not statistically significant in multivariable analysis and had a lower effect size than ISS 16–24 (severe), this was likely due to collinearity with ICU admission, which was also included in the multivariable model. Older trauma patients experiencing ICU admission may also benefit from postdischarge support, especially if they are frail or prefrail.

We found no statistically significant association between Charlson Comorbidity Index and time at home, suggesting that multimorbidity alone was not a major contributor to hospitalized days postinjury in our study population. Large population-based studies of trauma patients have shown that adding the Charlson Comorbidity Index score does not improve mortality prediction.[42]

Our study included patients with at least moderately severe injury regardless of anatomical region. Specific types of anatomical injury more commonly studied in the literature (eg, head injury, extremity injury[43–45]), were not independently associated with low time at home. Nevertheless, in our study, the highest ISS-injured patients were mostly patients with significant head injury, as were the majority of patients admitted to ICU. Hence, the association of ICU admission (which is also a surrogate for injury severity) and overall ISS with low time at home is likely driven by more severe head injuries.

Frail patients may have a pre-existing support system in place prior to their injury, because of their premorbid disability or dependence, contributing to reduced LOS at the index admission. Regardless of factors contributing to LOS at index admission, our follow-up study shows that frail patients have continued hospitalization needs postdischarge. One contributory factor could be their worsening functional trajectory, as demonstrated by the deterioration of frail participants' Barthel Index over the 1-year postinjury period.

Of the patients who completed the follow-up period, the functional trajectory (by Barthel Index) was worst at the 3-month point, before gradually improving over time at the 6-month and then the 12-month point. Although this trend was seen for both frail and nonfrail patients, the drop in function was more marked for the frail patients, with prefrail patients in between. Although there would be a survival bias to this group of patients who completed the study, support for expected functional decline postinjury would be one aspect of multidisciplinary care that could be addressed in future studies.

These findings have real-world implications. Increased LOS is often used to identify patients at high risk of postdischarge readmission or death.[46] Hence, pathways that only screen patients after a certain number of days in hospital may miss these frail older blunt-trauma patients. Instead, according to the findings of our study, screening

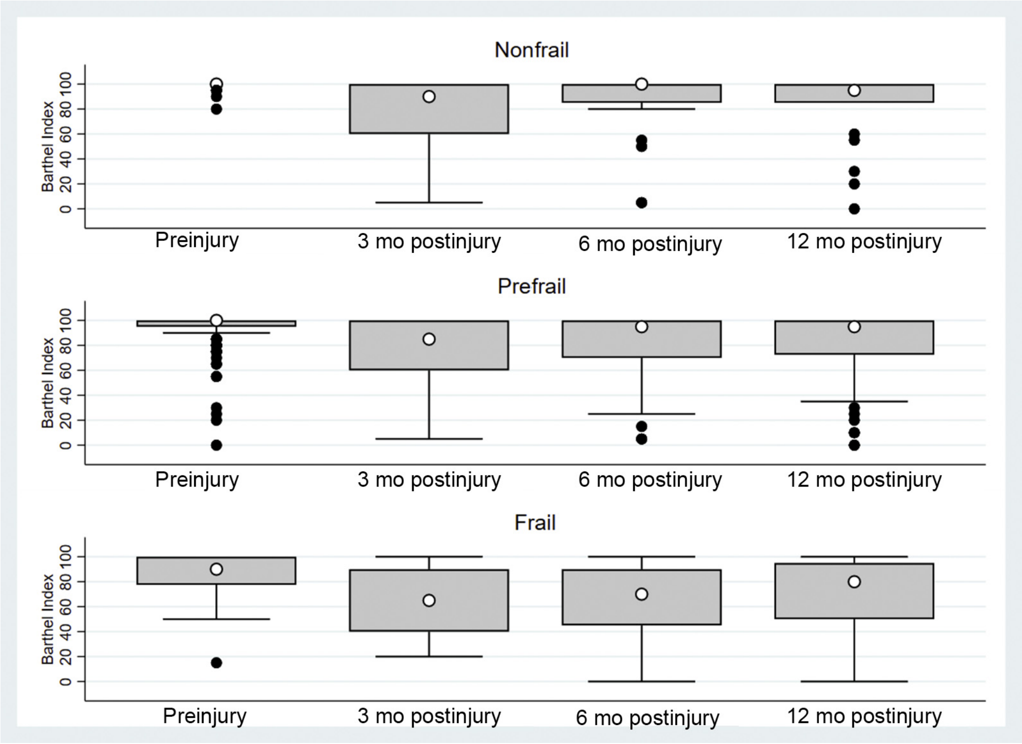

Fig. 2. Change in functional status (by Barthel Index) over 12 months postinjury, nonfrail vs prefrail vs frail.

for frailty for older blunt-trauma patients should be considered, even if they have a short LOS at index admission. This would enable additional intervention or postdischarge support, reducing unplanned readmission,[6,46,47] which occurred in almost one-third of our study participants.

None of the sociodemographic factors (ethnicity, housing, employment, education, living alone) were statistically associated with high time at home. However, this could reflect participation bias, as patients living alone or who did not have a caregiver may have been less willing to participate in the study.

The strength of our study was in its national multicenter prospective study design, the capture of sociodemographic factors that may affect time at home, as well as the inclusion of patients who were not able to answer questions themselves, as almost one-third of participant responses in this study were obtained from their surrogate. This is an advantage over scoring systems that require participants to be cognitively and physically able to do so themselves.[9,15]

As our study was a prospective cohort study, the 1-year follow-up period gave enough time to show that the prefrail patients were also at increased risk of low time at home. This highlights the importance of considering as many dimensions of frailty as practically feasible to identify both frail and prefrail as high-risk groups, rather than relying on one single “screen” test.

Limitations

Given the proportion of participants not contactable at the end of the study, one potential limitation of our study was underestimation of readmission for patients readmitted to private hospitals not participating in the study. As we limited our participants to Singapore residents, the possibility that patients were readmitted to hospitals outside of Singapore was low.

Owing to the timing of the inception of this study and the time taken to complete study recruitment, several frailty scores that have since been reviewed or validated in literature, including scores specific to the trauma population and/or surgical patients,[8,15] were not used in this study. Nevertheless, we hope that screening for high-risk patients in older blunt-trauma patients will be useful, regardless of choice of frailty screening tool.

Conclusions and Implications

In the year following blunt trauma, frail older patients experience low time at home and functional decline. Screening for frailty and prefrailty should be considered in all older blunt-trauma patients to improve prioritization for postdischarge support.

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Supplementary Material 1. Measures of Injury Severity

Definitions

AIS: The Abbreviated Injury Scale (AIS)[1] is a detailed injury code for each injury. It includes anatomical detail of the injury, as well as a severity score from 1 (minor) to 6 (untreatable), with a scale of ≥3 being considered serious.

Polytrauma: Polytrauma[2] is defined as having AIS scores of ≥3 in at least 2 body regions.

ISS and NISS: The Injury Severity Score (ISS)[3] and New Injury Severity Score (NISS)[4] are 2 different composite injury scores drawn from the total AIS-scored injuries that a patient sustains. ISS standardizes grouping of injuries by anatomy into 6 ISS regions (head and neck, thorax, abdomen and pelvis, musculoskeletal, and skin). Only the most severe injury from each ISS region is used to score ISS. ISS is the sum of the squares of the top 3 most severely injured ISS regions. NISS does not group injuries by anatomy. NISS is the sum of the square of AIS for the top 3 injuries *regardless* of region.

OIS: The Organ Injury Scale (OIS)[5] was designed to reflect the impact of a specific organ injury on ultimate patient outcomes.

RTS: The Revised Trauma Score (RTS)[6] is a weighted sum of coded variable values, factoring in the patient's Glasgow Coma Scale (GCS), systolic blood pressure, and respiratory rate. A normal RTS score is 7.841, any score below that would be abnormal.

In our study, almost all the patients with injuries that could be scored by OIS had sustained rib fractures that also met ISS/NISS inclusion criteria, with only 1 patient sustaining an OIS III injury (jejunal laceration).

These trauma severity scoring systems are widely reported for benchmarking in trauma databases and are regularly used in literature.

Scoring Examples

Here are some examples of patients meeting the inclusion criteria in our study, featuring the 3 most common injured body regions (head, thorax, and extremities):

1. Intracranial bleeding (usually an AIS of ≥3) and contusion of another body part;
2. ≥3 rib fractures (OIS 2, AIS 3, ISS and NISS of 9) and contusion of another body part;
3. Multiple closed fractures (closed femur fracture AIS 3 and closed radial head fracture AIS 2 would give an ISS of 9 ($3^2 = 9$) but an NISS of 13 ($3^2 + 2^2 = 13$), because they are both considered extremity injuries)

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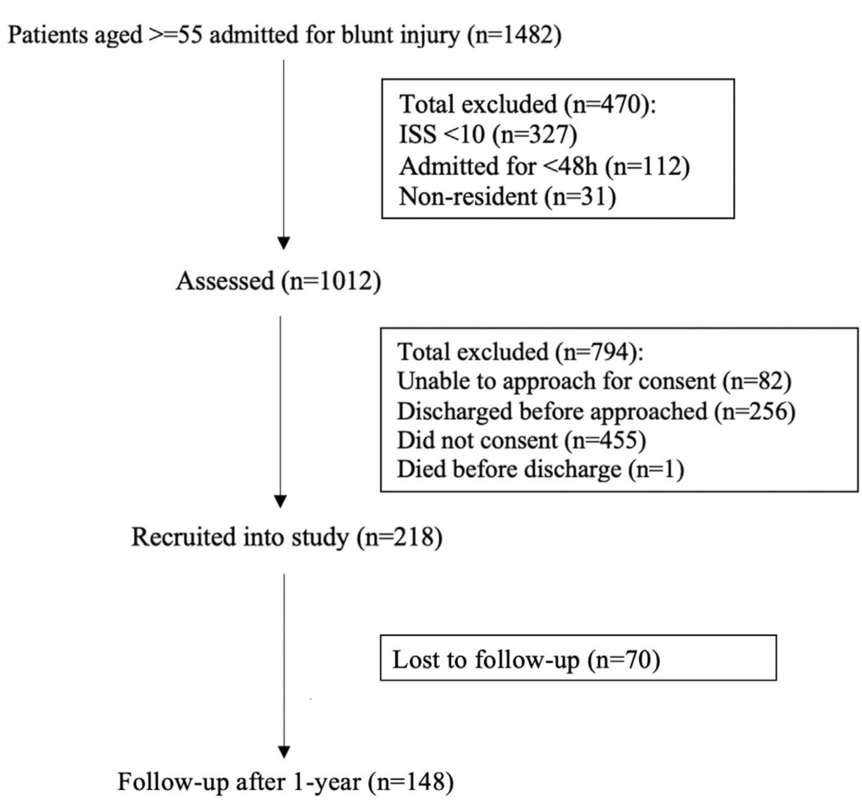

Supplementary Fig. 1. Participant recruitment flowchart.