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Frailty and other factors associated with early outcomes in middle-to older age trauma patients: A prospective cohort study

Tian-Shin Yeh, M.D.,Ph.D.[1,2,3,4], Jiunn-Horng Kang, M.D.,Ph.D. [5,6,7,8,9], Thomas J. Littlejohns, Ph.D.[10], Chia-Chieh Wu, M.S.[11,12], Jin-Hua Chen, Ph.D.[13,14,15], Krisna Piravej, M.D.[16,17], Wen-Ta Chiu, M.D.,Ph.D.[18,19], Carlos Lam, M.D.,Ph.D.[11,12]*

[1] Department of Physical Medicine and Rehabilitation, School of Medicine, College of Medicine, Taipei Medical University, Taipei, Taiwan

[2] Department of Physical Medicine and Rehabilitation, Wan Fang Hospital, Taipei Medical University, Taipei, Taiwan

[3] Department of Epidemiology and Nutrition, Harvard T. H. Chan School of Public Health, Harvard University, Boston, MA, USA

[4] Department of Physical Medicine and Rehabilitation, National Taiwan University Hospital, Taipei, Taiwan; Department of Physical Medicine and Rehabilitation, College of Medicine, National Taiwan University, Taipei, Taiwan

[5] Department of Physical Medicine and Rehabilitation, Taipei Medical University Hospital, Taipei, Taiwan

[6] Department of Physical Medicine and Rehabilitation, School of Medicine, College of Medicine, Taipei Medical University, Taipei, Taiwan

[7] Graduate Institute of Nanomedicine and Medical Engineering, College of Biomedical Engineering, Taipei Medical University, Taipei, Taiwan

[8] International Ph.D. Program in Medicine, College of Medicine, Taipei Medical University, Taipei, Taiwan

[9] Professional Master Program in Artificial Intelligence in Medicine, College of Medicine, Taipei Medical University, Taipei, Taiwan

[10] Nuffield Department of Population Health, University of Oxford, Oxford, UK

[11] Emergency Department, Wan Fang Hospital, Taipei Medical University, Taipei, Taiwan

[12] Department of Emergency, School of Medicine, College of Medicine, Taipei Medical University, Taipei, Taiwan

[13] Graduate Institute of Data Science, College of Management, Taipei Medical University, Taipei, Taiwan

[14] Institutional Research Center, Office of Data Science, Taipei Medical University, Taipei, Taiwan

[15] Biostatistics Center, Department of Medical Research, Wan Fang Hospital, Taipei Medical University, Taipei, Taiwan

[16] Department of Rehabilitation Medicine, Faculty of Medicine, Chulalongkorn University, Bangkok, Thailand

[17] Department of Chula Neuroscience Center, King Chulalongkorn Memorial Hospital, Bangkok, Thailand

[18] Graduate Institute of Injury Prevention and Control, College of Public Health, Taipei Medical University, Taipei, Taiwan

[19] AHMC Health System, Alhambra, CA, USA

*Corresponding author

Carlos Lam, M.D, Ph.D.

Emergency Department, Wan Fang Hospital, Taipei Medical University. No.111, Section 3, Xinglong Road, Taipei 11696, Taiwan.

E-mail address: lsk@w.tmu.edu.tw

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Abstract

Objectives: To prospectively investigate associations of frailty and other predictor variables with functional recovery and health outcomes in middle-aged and older patients with trauma.

Design: Single-centre prospective cohort study.

Setting: Emergency department of Wan Fang Hospital in Taiwan.

Participants: Trauma patients aged 45 and older.

Measurements: Frailty was assessed with the Clinical Frailty Scale (CFS). Injury mechanisms, pre-existing diseases, and fracture locations were recorded at baseline. The primary outcome was functional recovery assessed using the Barthel Index (BI). Secondary outcomes were new care needs, unscheduled return visits, and falls three months postinjury.

Results: A total of 588 participants were included in the final analysis. For every one-point increase in the CFS, the multivariable-adjusted odds ratio (OR, 95% confidence interval [CI]) of failure to retain the preinjury BI was 1.34 (1.16–1.55); associations were consistent across levels of age and injury severities. Significant joint associations of frailty and age with poor functional recovery were observed. CFS was also associated with new care needs (OR for every one-point increase, 1.36, 95% CI 1.17–1.58), unscheduled return visits (OR 1.26, 95% CI 1.04–1.51), and falls (OR 1.23, 95% CI 1.01–1.51). Other variables associated with failure to retain preinjury BI included road traffic accident and presence of hip fracture.

Conclusion: Frailty was significantly associated with poor functional and health outcomes

regardless of injury severity in middle-aged and older patients with trauma. Injury mechanisms and fracture locations were also significant predictors of functional recovery postinjury.

Keywords: frailty, injury, functional recovery, middle-to older age, Clinical Frailty Scale

Introduction

Trauma is a leading cause of death and disability worldwide [1]. Medical advances have led to a considerable reduction in posttraumatic mortality [2]. However, poor recovery following trauma may result in long-term disability and considerable productivity and health-care costs [3]. Older individuals are particularly vulnerable and are at higher risk of poor health and functional recovery after injury because of multiple pre-existing conditions, low physiological reserve, and complicated medication use [4]. With the rapid aging of the global population, the number of older patients with trauma has been increasing substantially. Specifically, the mean age of patients with major trauma increased from approximately 40 years in 2000 to approximately 60 years in 2019 [4]. The identification of factors associated with post-trauma recovery in middle-aged and older patients with trauma could help to improve the prognoses of such patients.

Frailty refers to the accelerated decline of physiological reserve and failures of homeostatic mechanisms in multiple systems; even a minor stressor event can exert detrimental effects on individuals with frailty [5]. Emerging evidence has shown that frailty may be an important predictor of mortality [6], length of hospital stay [7], functional status [8], medical complications, and discharge destination for geriatric inpatients with major trauma [9]. However, to our knowledge, the joint associations of frailty and age is unclear and whether frailty also plays an important role in middle-aged adults and outpatients with

minor trauma has not been extensively studied. Furthermore, few studies have investigated the associations of injury mechanisms with functional or other health outcomes [10]. Therefore, the present study prospectively examined the role of preinjury frailty and other possible predictor variables on functional and health outcomes in a cohort of middle-aged and older patients with trauma.

Materials and Methods

Study design and participants

The Post Traumatic Recovery Cohort-Taiwan (PTRC-Taiwan) is a prospective cohort study conducted at the emergency department (ED) of Wan Fang Hospital in Taiwan from 28 August 2020 to 31 March 2022 [11]. Wan Fang Hospital is an affiliate teaching hospital of Taipei Medical University in the southern area of Taipei City, covering a population of approximately 400,000 people. This 733-bed hospital is accredited as an advanced emergency responsibility hospital in Taiwan, providing advanced treatment to patients with major injuries. The ED of the hospital treats more than 60,000 patients annually.

The research physician and nurse practitioners in the ED initially selected eligible patients. The research assistant then obtained the patients' written consent and interviewed them. This study included individuals aged >45 who arrived at the ED within 48 hours of their injury. We excluded patients who relied heavily on others, were non-Taiwanese

residents, had been discharged against medical advice or transferred to other hospitals, had incomplete interviews, or had previous study enrollment.

During the recruitment period, 742 patients were screened in the ED; of these patients, 10 did not meet the inclusion criteria, 59 declined to participate, and 3 declined to follow up after completing the interview. Thus, 670 patients were enrolled in this study. Subsequently, 9 patients died during hospitalisation. Therefore, 661 patients were followed up by telephone three months after discharge from the hospital or ED. During the telephone interviews, trained research assistants obtained information from the patients regarding their current physical function, frailty status, and other outcome variables.

After excluding 57 patients who did not respond to the follow-up and 16 who died before the telephone follow-up, we included 588 patients in the final analysis (Supplementary Figure S1). This study was approved by the Joint Institutional Review Board of Taipei Medical University (approval no. N202002099), and written informed consent was obtained from all the participants.

Data collection

The data were collected from the patients' initial interviews, electronic medical records, and follow-up telephone interviews. A trained research assistant collected information on patients' demographic characteristics, histories of preexisting diseases, and injury

mechanisms through initial face-to-face interviews in the ED. The patients' Barthel index (BI) and Clinical Frailty Scale (CFS) scores before injury were recorded to obtain their baseline data.

The principal investigator (C.L.) reviewed the patients' electronic medical records and retrieved their trauma data after they were discharged from the hospital or ED. The information retrieved included the locations, patterns, and types of injuries and the patients' injury severity scores (ISSs). The ISS is widely used in trauma medicine to evaluate injury severity [12]. The evaluation involves assigning an Abbreviated Injury Scale (AIS) grade to each of the six body regions (head & neck, face, thorax, abdomen, extremities, and external) using a scale of 1 (minor) to 6 (untreatable). The ISS was determined by summing the squares of the highest AIS from the three most severe regions (1 to 75). An ISS > 9 indicates a moderate injury that requires hospitalization or intensive care [13]. The research assistants retrieved other clinical data from electronic medical records, including the Glasgow Coma Scale (GCS) score, mortality, and body mass index (BMI).

To observe the patients' functional changes, we collected the BI through telephone interviews three months postdischarge from the hospital or ED. The patients were also surveyed for other outcome parameters during the follow-up period. We used standardised formats to collect data, ensuring consistency in data quality.

Outcome parameters

The primary outcome parameter in the current study was functional status assessed by the BI. Comprising 10 items, the BI evaluates a range of activities encompassing self-care tasks like feeding, grooming, toilet use, bathing, dressing, bladder and bowel control, as well as mobility activities including transfer, walking, and climbing stairs. The BI score ranges from 0 (total dependence) to 100 (complete independence) [14]. Follow-up BI scores at three months post-discharge from the hospital or ED were obtained through a telephone interview, which has been shown reliable [15].

Other outcome parameters included new care needs, unscheduled return visits, and falls within the follow-up period. New care needs included personal living assistance, nursing home care, round-the-clock care, safety measures, housekeeping assistance, and meal preparation [16].

Candidate predictor variables

During the interviews in the ED, we collected the following demographic variables: sex, age, employment status, marital status, current living status, and educational level. Employment status was categorised as employed, homemaker, retired, and unemployed. Marital status was categorised as single, married, divorced, and widowed. Current living status was divided into living alone, living with family, and institutional living. Educational

level had five categories: ≤6 years, 7–9 years, 10–12 years, 13–15 years, and more than 16 years. The BMI was collected and calculated to determine the patients' obesity status.

The preexisting diseases selected for analysis included hypertension, diabetes mellitus, heart failure, chronic kidney disease, chronic liver disease, chronic obstructive pulmonary disease (COPD), stroke, anaemia, hip fracture, Parkinson's disease, and dementia [17]. These conditions were identified through the patients' self-reports and the hospital's electronic medical records.

The preinjury frailty status of each participant was assessed using the validated Chinese version of the CFS, which was significantly associated with various geriatric assessments, such as hand grip, physical performance, nutrition status, and depression [18]. The CFS is widely utilised in both research and clinical practice, and has been considered a promising tool for screening frailty [19]. It examines specific domains such as comorbidity, function, and cognition to generate a frailty score ranging from 1 (very fit) to 9 (a status of terminally ill). Injury mechanisms were categorised as falls, road traffic accidents, and others. Variables of injury types included traumatic intracranial haemorrhage, upper extremity fracture, lower extremity fracture, hip fracture, pneumothorax, hemothorax, rib fracture, thoracic spine fracture, and lumbar spine fracture.

Statistical analysis

Continuous variables are presented as median and interquartile ranges (IQRs), while categorical variables are presented as frequencies and percentages. Pearson's chi-squared test and Fisher's exact test were used to assess categorical variables, and the Mann-Whitney test was used for the continuous variables. To evaluate the associations of sociodemographic characteristics, preexisting diseases, preinjury frailty, and injury characteristics with the outcome parameters within the follow-up period, we first performed univariate analysis. Sex, age, and other candidate predictor variables with a *P*-value of <0.2 in the univariate analysis were considered for inclusion in a stepwise selection model [20]. The final multivariate model was derived through stepwise selection.

We initially treated the BI at three months post-discharge as a continuous variable and adjusted for baseline BI along with other variables in the multivariate model. In this model, we found that higher preinjury CFS was significantly associated with a poorer BI score at three months post-discharge. Considering the clinical importance of functional recovery in middle-to older age trauma patients, we further conducted the analysis exploring the odds of failure to retain preinjury BI at three months post-discharge using a multiple logistic regression model. In this analysis, BI difference was calculated by subtracting the BI score at three months post-discharge from the preinjury baseline BI score, and any decrease in the BI score was considered a failure to retain the preinjury BI status [21-24]. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated. In addition, because a reduction of 10 points

from the baseline BI score has been considered a substantial functional decline [25, 26], we conducted a sensitivity analysis using a 10-point reduction in the BI as the outcome variable. We also performed stratified analyses to examine whether the association between frailty and failure to retain preinjury BI at three months post-discharge differed by age (<65 vs ≥ 65 years) and injury severity (ISS<9 vs ≥ 9). Because preinjury CFS and age are two of the most important predictor variables for functional recovery post-injury, we further explored their combined impact by creating new composite categories: Frailty was categorised as non-frail (CFS score 1–4) or frail (CFS score 5–9) [27] and age was categorised using the cutoffs of 65 and 85 years, which were used to define older adults [6] and the oldest-old [28], respectively--these age groups often exhibit distinct physiological and functional changes [29]; the resulting categories of the combined variable are as follows: 'Reference: Non-frail and aged < 65', 'non-frail and aged 65–84', 'non-frail and aged 85+', 'frail and aged < 65', 'frail and aged 65–84', and 'frail and aged 85+'.

For all other outcome parameters, we constructed multiple logistic regression models using the same aforementioned stepwise selection process, and ORs and 95% CIs were calculated. The collinearity of all the predictor variables within multiple regression models was assessed using variance inflation factors; two-sided P <0.05 was considered statistically significant. All statistical analyses were performed using SAS software (version 9.4; SAS Institute, Cary, NC, USA).

Results

Patient characteristics

In total, 588 patients (59.9% of which were women) completed the follow-up three months after injury (Table 1). The median age was 72 years (IQR = 20) and the median ISS of the patients was 5 (IQR = 7). Participants who failed to retain their preinjury BI status were older and predominantly female, less likely to live with a family and more likely to reside in a facility, less likely to be married and more likely to be widowed, more likely to be retired or unemployed, more likely to experience fall-related injuries, and sustain hip fractures or lumbar spine fractures, and more likely to be frail.

Primary outcome - BI at three months postdischarge from the hospital or ED

The results of the univariate analysis revealed that patients' age, employment status, marital status, current living status, educational level, preexisting conditions (including hypertension, diabetes mellitus, heart failure, chronic kidney disease, stroke, anaemia, history of hip fracture, Parkinson's disease, and dementia), BMI, preinjury BI and CFS scores, injury mechanism, GCS score, and injury types (upper extremity, lower extremities, and hip fracture) were significantly associated with BI at three months postdischarge from the hospital or ED ($P<0.05$).

Subsequently, sex, age, and other independent variables with $P < 0.2$ from univariate analysis were considered for inclusion in a stepwise selection model, which then yielded the final multivariable models. During the initial analysis, the BI score at three months post-discharge was treated as a continuous variable. In this model, elevated preinjury CFS (β = -2.77, 95%CI = -3.90, -1.63) and increased age (β = -0.25, 95%CI = -0.39, -0.11) were associated with a lower BI score at three months post-discharge, whereas higher preinjury BI score (β = 0.68, 95%CI = 0.58, 0.78) was associated with a higher BI score three months post-discharge (Supplementary Table S1). Other variables that remained in this final multivariate model include marital status, employment, hip fracture, diabetes mellitus, chronic kidney disease, and GCS score, all of which had significant associations with the BI score at three months post-discharge.

We then used a multiple logistic regression model, constructed using the same aforementioned stepwise selection process, to calculate the ORs for failure to retain preinjury BI status. The variables in this multiple regression model are shown in Table 2. Frailty was significantly associated with failure to retain preinjury BI status, the multivariate-adjusted OR (95% CI) for every one-point increase in CFS was 1.34 (1.16–1.55). The odds of failure to retain preinjury BI status increased with age, OR for every five years increase in age=1.24, 95% CI 1.10–1.39. Compared to married patients, the widowed patients had a higher risk of this parameter (OR 1.90, 95% CI 1.18–3.06). Road traffic accidents were associated with a

higher risk of poor functional recovery compared with falls or other injury mechanisms (compared with other injury mechanisms, the OR for road traffic accidents was 3.33, 95% CI 1.28–8.70 and OR for falls was 2.98, 95% CI 1.20–7.41). Finally, the risk was also significantly increased among patients with hip fractures (OR 2.25, 95%CI 1.31–3.88). Stratified analysis indicated that the results were similar across age and injury severity groups (Supplementary Figure S2). The sensitivity analysis examining the odds of a 10-point reduction in the BI from baseline showed similar results (Supplementary Table 2).

Figure 1 shows the ORs of failure to retain preinjury BI across various combinations of frailty and age. Compared with non-frail patients aged <65, the OR (95% CI) was 3.21 (1.39–7.42) for frail patients aged 65 to 84, 4.69 (1.86–11.81) for non-frail patients whose age was 85 years or older, and 6.99 (2.81–17.39) for frail patients whose age was 85 years or older.

Secondary outcomes - new care needs, unscheduled return visits, and falls

In the multiple logistic regression analyses of new care needs, a higher preinjury CFS score was associated with a significant increase in the risk of having new care needs (OR 1.36, 95% CI 1.17–1.58 for every one-point increase in CFS) (Table 3). Road traffic accidents were associated with a higher risk than falls (compared with other injury mechanisms, OR 2.67, 95% CI 1.20–5.96 and OR 2.18, 95% CI 1.01–4.68, respectively). Hip fracture was also a significant risk factor (OR 2.02, 95% CI 1.07–3.81).

We also found preinjury CFS score (OR 1.26, 95% CI 1.04–1.51 for every one-point increase in CFS) and lumbar spine fracture (OR 3.11, 95% CI 1.15–8.38) were associated with an increased risk of unscheduled return visits (Supplementary Table S3).

In addition, patients with higher preinjury CFS scores were more likely to experience falls subsequently (OR 1.23, 95% CI 1.01–1.51 for every one-point increase in CFS). Other risk factors associated with increased risk of falls included Parkinson's disease (OR 3.18, 95% CI 1.25–8.10) and rib fracture (OR 3.03, 95% CI 1.49–6.15) (Supplementary Table S4).

Discussion

The findings of the current study revealed that frailty, assessed using the CFS, was significantly associated with poor early functional recovery, new care needs, unscheduled return visits, and subsequent falls in the examined middle-aged and older patients with trauma. These associations persisted even after adjustment for age, sex, marital status, employment status, injury mechanism, and fracture location. We also observed significant joint associations of frailty and older age with poor functional recovery. In addition, we determined that falls, road traffic accidents, and hip fractures were associated with higher risks of poorer function and new care needs postinjury.

To our knowledge, the current study is among the few prospective studies investigating the relationship between frailty and post-injury functional recovery as measured by the BI.

Our results showed a significant association—the odds of failure increased by 34% to retain pre-injury BI for every one-point increase in the CFS, equivalent to being more than 7 years younger. The BI is among the most frequently used tools to assess disability, independence, and physical function [30], which are crucial parameters for the care of middle-aged and older patients. However, literature prospectively examining the association between frailty and BI recovery remained scarce. A recent prospective study reported that among 218 patients with trauma admitted to an ED, frail patients (defined by modified Fried criteria) were more functionally dependent compared with the prefrail and non-frail group during the year after blunt trauma [31]. Another prospective study that examined 188 geriatric patients with trauma admitted to a trauma centre identified frailty (determined by the Vulnerable Elders Survey score) as the major predictor of postinjury functional status [8]. Our results showed frailty as an important predictor for both inpatients and outpatients, and across injury severities and age. Furthermore, the combination of frailty and advanced age significantly elevated the risk of poor functional recovery: the odds of failure to retain preinjury BI for those who were frail and aged 65 to 84 was 3.21 times the odds of those who were non-frail and below the age of 65, and the OR further increased to 6.99 for frail patients greater than 85 years of age. More than 18% of our study participants were over the age of 85, reflecting society's rapidly growing population of the oldest-old [32], among whom frailty is even more common [5]. Findings from the current study highlighted frailty and age as two of the most

important factors associated with functional recovery postinjury.

Other variables significantly associated with lower odds of BI recovery include old age, widow status, injury mechanisms, and hip fracture. Among the examined injury mechanisms, road traffic accidents were associated with the highest risk of poor BI recovery three months after injury. Road traffic injuries not only lead to high mortality and injury rates, but it has also been linked to chronic pain and substantial psychological consequences, such as depression, posttraumatic stress disorder, and anxiety [33], any of which can adversely affect functional recovery [34]. With the aging of the population in Taiwan and the heavy use of motorcycles for commuting, the impact of road traffic injuries on older adults is becoming increasingly prominent [35]; the same situation is observed in multiple developing countries [36]. Therefore, reducing the incidence of traffic accidents among older adults and improving the functional recovery of older patients with injury are crucial for injury prevention and control. Fall was another injury mechanism significantly associated with poor BI recovery in this study. Falls in the geriatric population often lead to severe consequences, such as hip fractures, femoral fractures, and head injuries, all of which are important predictors of long-term mortality and functional dependence [37]. Even if falls do not result in severe health conditions, patients may develop a fear of falling [38], which in turn may exert a detrimental effect on balance, functional performance, and future fall risk [39]. Also, we noticed that preinjury BI score, the GCS, and major comorbidities, including diabetes mellitus and

chronic kidney disease, were significantly associated with BI at three months post-discharge; these results were consistent with previous literature showing these variables as predictors of poor outcomes [40, 41].

Another crucial consequence of functional decline is the need for care, which can be a major change in a patient's life and may affect their autonomy, self-esteem, and dignity [42]. We determined that preinjury frailty, road traffic accidents, falls, and hip fractures were associated with higher odds of having new care needs after injury. Patients discharged from emergency general surgery were reported to have fluctuating functional statuses and to transition back and forth among functional independence, chronic home care use, nursing home admission, and death; the need for chronic home care peaked approximately three months after discharge [43]. Nonetheless, the return of functional independence is quite likely, provided that early interventions are given [43]. Acute rehabilitation [44] with adequate nutritional strategies [45] has been shown to considerably benefit patients with trauma. Our results identified patients at higher risk for needing new care, which provides an opportunity for early intervention to facilitate prognosis in these high-risk groups.

Next, frailty was significantly associated with higher odds of subsequent falls and unscheduled return visits regardless of age or injury severity. Patients with frailty exhibited decreased muscle strength and mass [46], high stride time variability [47], and decreased gait speed [48]. These characteristics may increase the likelihood of falls, which can be a reason

for unscheduled revisits. Moreover, patients with frailty often have multiple comorbidities and medication use [49], these factors further increase the risk of unplanned readmission. Lumbar spine fracture, which in severe cases may be accompanied by spinal cord injuries leading to various adverse consequences [50, 51], was also associated with unscheduled return visits. Our results are consistent with those of previous studies reporting frailty as a risk factor for falls in community-dwelling middle-aged and older individuals [52] and unscheduled readmissions in patients with cardiovascular diseases [53]. Our findings suggest that frailty is a crucial predictor of these adverse outcomes in patients with trauma. Frailty can be reversed through adequate intervention, such as physical therapy and nutritional support [54]. Our findings highlight the importance of the active and early management of frailty to reduce the likelihood of adverse outcomes after injury.

The current study had several strengths. First, because this study was a prospective cohort study, the associations observed were unlikely to have been caused by to reverse causation. Second, the participants included both inpatients and outpatients, which enabled us to investigate the relationships between multiple risk factors and the aforementioned adverse outcomes across patients with different levels of injury severity. Third, we included patients of a wide age range, from middle-aged to older adults; this feature enabled us to perform a relatively comprehensive examination of associations among multiple age groups.

This study also had some limitations. First, our participants were recruited from a single

hospital; therefore, sampling bias may have occurred. Second, some potential confounding factors—such as information regarding nutritional factors, and alcohol or substance use—were not determined or collected. Finally, interventions following injury were not analysed in the present study.

Conclusions

Preinjury frailty, injury mechanisms, and fracture locations were significant predictors of postinjury functional and health outcomes; these present findings were consistent across age and injury severity. The screening and identification of frailty and other risk factors in the ED are crucial for the prevention of the subsequent risks of poor functional recovery, the need for new care, unscheduled return visits, and falls. Clinicians should make efforts to provide adequate early interventions, such as rehabilitation and nutrition support, to improve patients' frailty statuses. Moreover, physicians should take extra precautions to prevent adverse outcomes after injury in patients with the aforementioned risk factors.

Author contributions

TSY, JHK, and CL designed the study and analysis, interpreted the data, and revised and edited the manuscript. CCW, JHK, and CL participated in patient enrollment and data collection. CCW performed the statistical analyses. TSY, JHK, TJL, JHC, KP, WTC, and CL assisted with interpreting the results. TSY and CL wrote the manuscript. The final version of the manuscript was read and approved by all contributing authors.

Data statement

The data has not been previously presented orally or by poster at scientific meetings. The data used or generated in this study are available from the corresponding author upon reasonable request.

Disclosure/conflict of interest

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Figure legends

Figure 1. OR (95%CI) of failure to retain preinjury BI at three months post-discharge across various combinations of frailty and age. Sex, marital status, employment status, injury mechanism, frailty, hip fracture, and lumbar spine fracture were adjusted in the multivariable model. BI, Barthel Index; CI, confidence interval; OR, odds ratio.