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Low falls and inpatient complications increase risk for longer length of stay in older persons admitted following trauma

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Abstract

Background Older adults make up 33% of all trauma admissions in Australia despite comprising 17% of the population with rates rising faster for older age groups compared to any other age group. A high proportion of older adults admitted to hospital following trauma are frail and have increased rates of hospital acquired complications, resulting in poorer outcomes as well as increased resource utilisation and cost to the healthcare system. Length of Stay (LOS) is an important outcome for hospitals, contributing to resource utilisation and patient flow. This study aimed to determine factors associated with the primary outcome of LOS in older persons admitted with trauma at a major trauma centre as targets for improvement.

Methods Ethics approval was obtained to collect data on all adult trauma admissions ≥ 1 day in patients aged 65 years and over. Patients were included in the Trauma in older persons (TOPS) database if they otherwise met criteria for the pre-existing trauma registry maintained by the hospital's trauma service. Admissions between January 2022 and January 2023 were included. Univariable negative binomial regression identified variables associated with LOS with p-values ≤ 0.1 which were then included in a multivariable regression model. Significance was taken as p-value ≤ 0.05.

Results 1250 admissions ≥ 1 day and alive at discharge were included in the primary analysis. The median LOS was 7 (4–13) days. In the multivariable model, delirium (Incidence Rate Ratio (IRR) = 1.41, 95%CI = 1.25–1.59), inpatient fall (IRR = 1.46, 95%CI = 1.15–1.86), pneumonia (IRR = 1.28, 95%CI = 1.08–1.53), thromboembolism (IRR = 1.43, 95%CI = 1.05–1.96), blood transfusion (IRR = 1.34, 95%CI = 1.17–1.53) and unplanned intensive care admission (IRR = 1.52, 95%CI = 1.08–2.14) were all associated with increased LOS. Low fall mechanism was high risk for longer LOS (IRR = 1.26, 95%CI = 1.11–1.43).

Conclusions After controlling for available factors, inpatient complications and patients admitted following low falls were identified as high risk for increased LOS and may represent areas for targeted quality improvement for older adults admitted following trauma.

Keywords Geriatric trauma, Length of stay, Falls, Low fall, Hospital acquired complications

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Introduction

Trauma related injuries are a major cause of hospitalisation in older Australians, with rates rising significantly after the age of 65 years [1]. In 2021–2022 in Australia, 33% of injury related hospitalisations were in people aged over 65 years, with falls being the most common mechanism of injury [1]. This age group are also at greatest risk of mortality making up over half of all injury related deaths [1]. Although rates of injury related hospitalisations have increased across all age groups, rates have increased disproportionally in the over 65s over the decade prior to 2016–2017 [2]. Injury represents a significant burden on the healthcare system, contributing 8.5% of the total burden of disease across Australia in 2015, with the majority of the cost to the system being for inpatient and emergency room care [3]. Hospital care for patients over 60 represents 36% of injury related expenditure [3]. The major contributor to inpatient healthcare relates to the length of stay (LOS) [4]. The average LOS for older persons hospitalised due to falls in Australia was 10 days in 2016-17, representing 8% of all patient-days [5].

Older persons with trauma have more comorbidities and increased rates of frailty than younger persons and therefore have a reduced physiological reserve in the face of a traumatic insult and can derive significant injury and morbidity even from minor trauma. Consequently, they are at increased risk of complications including infections, thromboembolic phenomena and organ failure and worse outcomes which contribute to longer LOS [6].

The role of a major trauma service in managing the increasing demographic of older patients particularly with low impact trauma is still unclear and has been highlighted as an area of limited research [7]. Models integrating geriatric services into trauma centre care for this population with the aim of improving outcomes, including by reducing LOS have been posited as potential improvement mechanisms [8–10]. Identification of older persons admitted with trauma most at risk of poorer outcomes and therefore likely to benefit from targeted interventions will allow for improved efficiency and resource allocation. The aims of this study were to identify factors associated with the primary outcome of LOS, with secondary outcomes of mortality and functional decline, in older persons 65 years and older admitted with trauma.

Methods

This observational cohort study was conducted at the Royal Melbourne Hospital (RMH), a level one trauma service with an integrated geriatrician led Trauma in Older Persons (TOPS) service. The RMH trauma registry is a prospectively collected database of all trauma related admissions to RMH and includes all patients regardless of age, who are admitted with a principal diagnosis of injury (excluding isolated hip fractures) and have a LOS ≥ 24 h or who died (regardless of LOS), all patients who receive a trauma team activation or who are pregnant regardless of LOS. The TOPS database was established based on this registry for patients 65 years and older to collect geriatric specific data as outlined by variables of interest. The cohort for this study was defined by inclusion in the TOPS database with LOS greater to or equal to one day. Patients were excluded if they had no LOS outcome data. Data entry for the TOPS database was commenced in January 2022 and 12 months' worth of admissions were available for inclusion at the time of analysis in January 2023.

Data was collated in a REDCaps data base [11, 12] and inputted predominantly by a research assistant from chart review of the electronic medical record. Posited variables for this study were identified based on review of the literature and included in the REDCaps form if not already being collected.

The primary outcome of this study was LOS of the primary acute admission as measured by the incidence rate ratio (IRR) (i.e. the relative increase or decrease in length of stay in those with and without the covariate). Secondary outcomes were the relative odds of mortality during the acute admission and functional decline, defined as a discharge to destination other than home or other private residence or a decrease in Katz activity index score on discharge from acute admission, compared to admission.

Variables of interest included patient demographics including age (as a continuous variable), sex, premorbid functional status (using the Katz activity index), baseline gait, living situation, polypharmacy (≥ 5 medications), anticoagulation, comorbidity (using the Charlson Comorbidity Index (CCI)), diagnosis of dementia and non-English speaking background (NESB). Injury and management factors were low fall mechanism (including fall from standing height), admitting unit (trauma, orthopaedic, general medicine or other), surgery during admission, and complications (delirium, urinary tract infection (UTI), pneumonia, venous thromboembolism (VTE), myocardial infarction (MI), need for blood transfusion, pressure injury, inpatient fall, and unplanned intensive care unit (ICU) admission based on previous studies [13]).

Descriptive statistics for the cohort included number and proportion (%) for categorical variables, mean with standard deviations for continuous and normally distributive data, and median with interquartile ranges for continuous, non-normally distributive variables or nominal variables as appropriate.

For the primary outcome of LOS, only cases who survived the acute admission were included in the analysis. Variables were assessed for association in univariable negative binomial regression analyses to account for

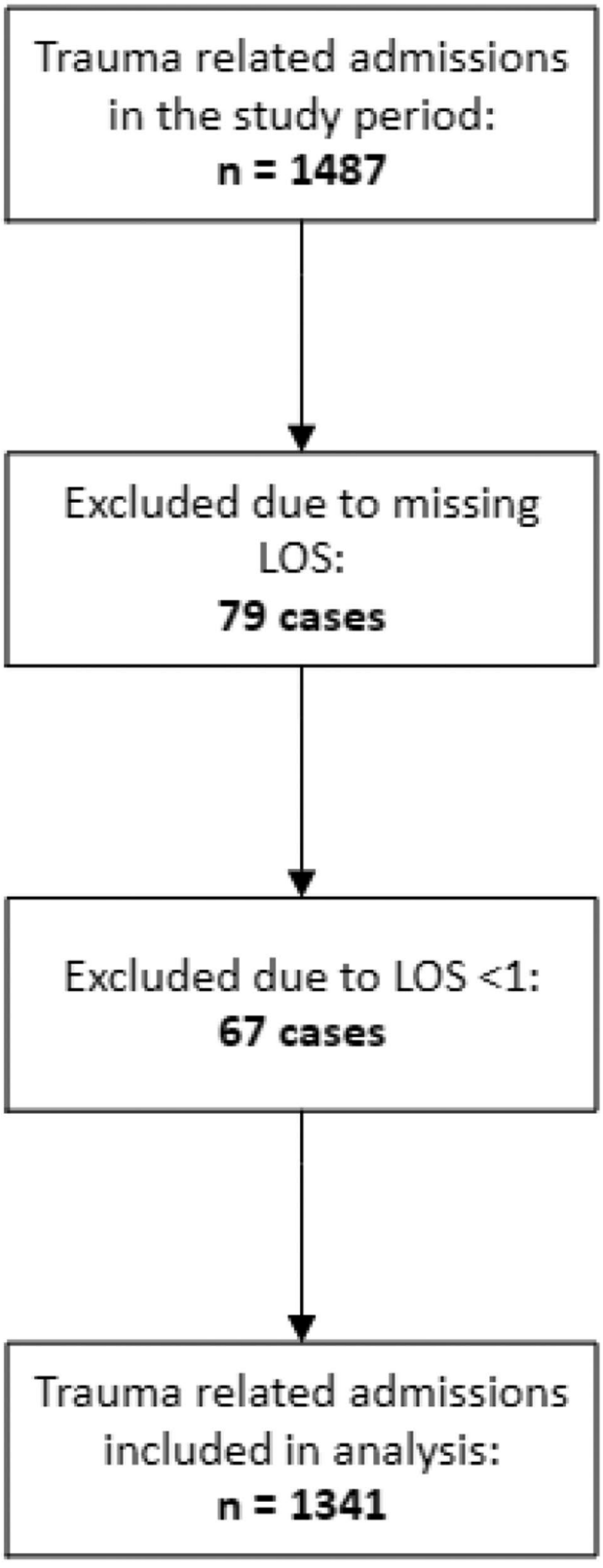

Fig. 1 Flow diagram of total number of admissions included in analysis after exclusion criteria applied

skewness and over dispersion [14]. Variables associated with p-values of ≤ 0.1 in univariable analysis were then included in a multivariable model to control for confounders. All analyses maximised the number of cases analysed by including all cases where the minimum data was available for each analysis. Significance was taken to be p-value of ≤ 0.05 in this exploratory study. Adjustment was not made for multiple comparisons.

This was repeated for secondary outcomes of mortality (using the whole cohort) and functional decline (in patients alive at discharge from acute admission and with functional decline outcome data) using binomial logistic regression. Variable inflation factor (VIF) scores were reviewed to assess for collinearity in the multivariate models. All statistical analysis was performed using R version 4.2.0 (R Foundation for Statistical Computing, R Core Team) [15].

This project was undertaken as part of the Evaluation of Outcomes of a New Model of Care: Trauma Older Persons Service Project. Ethics and clinical governance were approved by the Royal Melbourne Human Research Ethics committee: HREC/72,410/MH-2021.

Results

There were 1487 trauma related admissions entered into the TOPS data base over the 12-month study period. After 146 cases were excluded due to having missing LOS data (79 cases) or LOS of less than 1 day (67 cases), the final cohort consisted of 1341 admissions (Fig. 1).

Summary data for the final cohort are presented in Table 1. The mean age was 78 years, and 53.3% were female. Median LOS was seven days (IQR 4–13). Ninety-one patients did not survive the acute admission resulting in a crude mortality rate of 6.8%. Most patients were from home with others (57.5%) followed by living home alone (32.1%); 9.0% were from residential aged care facilities (RACF). The most common initial admitting unit was trauma (46.3%), followed by orthopaedics (23.8%) and general medicine (20.8%). Two thirds of patients (64.1%) were admitted with the injury mechanism being a low fall. Patients were mostly independent with mobility with or without a gait aid (91.3%) and independent with personal activities of daily living (ADLs) with a median Katz activity index of six (IQR 5.25-6). A total of 45.1% of cases required surgery during the acute admission. On discharge, 48% of patients returned to their previous residence. Functional decline as defined in this study was seen in 71.2% of cases and the Katz activity index on discharge decreased by two points compared to admission. The rate of any complication in this cohort was 46.1%, with the most common complication being delirium (26.2%) followed by blood transfusion (20.6%) and pneumonia (10.7%).

Table 1 Cohort summary of the included cases

	n	Statistic
Total included cases	1341	
Age (mean (SD))	1341	78.10 (14.1)
Sex - Male (%)	1341	626 (46.7)
NESB - YES (%)	1339	249 (18.6)
Initial Unit (%)	1341	
Trauma		621 (46.3)
General Medicine		279 (20.8)
Orthopaedic		319 (23.8)
Other		122 (9.1)
Mobility (%)	1316	
Independent, nil aid		774 (58.8))
Assistance		53 (4.0)
Independent with aid		427 (32.4)
Non Ambulant		12 (0.9)
Supervision		50 (3.8)
Usual Residence (%)	1322	
Home Alone		425 (32.1)
Home with Others		760 (57.5)
RACF		119 (9.0)
SRS		18 (1.4)
Independent ADL		
Bathing (%)	1304	1053 (80.8)
Dressing (%)	1303	1119 (85.9)
Toileting (%)	1304	1201 (92.1)
Transferring (%)	1305	1218 (93.3)
Continence (%)	1305	1119 (85.7)
Feeding (%)	1303	1257 (96.5)
Katz Score (median [IQR])	1302	6.00 [5.25, 6.00]
Low Fall (%)	1338	858 (64.1)
Complications		
Delirium (%)	1338	350 (26.2)
UTI (%)	1337	84 (6.3)
Pneumonia (%)	1338	143 (10.7)
VTE (%)	1337	33 (2.5)
MI (%)	1338	18 (1.3)
Transfusion (%)	1338	275 (20.6)
Pressure Injury (%)	1338	37 (2.8)
Fall (%)	1338	55 (4.1)
Unplanned ICU (%)	1338	29 (2.2)
Any Complication (%)	1337	617 (46.1)
Polypharmacy (%)	1326	908 (68.5)
Anticoagulated (%)	1327	269 (20.3)
Dementia (%)	1341	1181 (88.1)
CCI (median [IQR])	1330	1.00 [0.00, 2.00]
Surgery (%)	1329	599 (45.1)
Katz Score on Discharge (median [IQR])*	1200	4.00 [2.00, 6.00]
Discharge Destination (%)*	1247	
Previous Residence		598 (48.0)
Brain Injury Rehab		9 (0.7)
GEM		149 (11.9)
New RACF		55 (4.4)
Other		91 (7.3)
Other Private Residence		18 (1.4)
Rehabilitation		214 (17.2)
Rehabilitation in the Home		113 (9.1)
LOS (median [IQR])*	1250	7.00 [4.00, 13.00]
Functional Decline (%)*	1218	867 (71.2)
Inpatient Mortality (%)	1341	91 (6.8)

*alive at discharge

Results of the univariable analysis on the primary outcome are displayed in Table 2. Age, sex, being admitted to orthopaedics or an "other" unit, being from supported residential service or RACF accommodation, low fall mechanism, inpatient complications, polypharmacy, comorbidity, dementia or requiring surgery were all associated with increased LOS with p values of 0.10 or lower. Female sex, being from RACF, or being dependent for toileting, transferring or feeding, were associated with decreased LOS.

After adjustment in the multivariable model, patient related factors including age remained significantly associated with LOS (IRR = 1.01, p = < 0.001) albeit with small effect size and being female had a 10% lower LOS compared to males (IRR = 0.90, $p = 0.036$). Being from home with others had a reduced LOS compared with being from home alone (IRR 0.89, $p = 0.033$) and those from RACF had 59% lower LOS (IRR = 0.41, p = < 0.001). Patients admitted following a low fall had a 26% longer LOS (IRR = 1.26, p = < 0.001). Polypharmacy was associated with a 23% increased LOS (IRR = 1.23, p = < 0.001) and having a diagnosis of dementia a 50% increased LOS (1.48, p = < 0.001). ADLs including toileting, feeding, and transferring were not associated with LOS after adjustment.

Being admitted to a unit other than trauma, orthopaedics, or general medicine, was associated with a 48% longer LOS compared to being admitted under trauma (IRR = 1.48, p = < 0.001). Requiring surgical management resulted in significantly longer admission (IRR 1.52, p = < 0.001). Inpatient complications were significantly and strongly associated with LOS; those with delirium having a 41% increased LOS (IRR = 1.41, p = < 0.001), inpatient fall a 46% increased LOS (IRR = 1.46, $p = 0.002$), pneumonia a 28% increased LOS (IRR = 1.28, $p = 0.005$), VTE a 43% increased LOS (IRR = 1.43, $p = 0.023$), blood transfusion a 34% increased LOS (1.34, p = < 0.001) or unplanned ICU admission a 52% increased LOS (IRR = 1.52, $p = 0.017$). Full results of the multivariable analysis are summarised in Table 3.

For the secondary outcome of mortality, results of the univariable analysis are displayed in Supplementary Table 1. In multivariable analysis few variables were statistically associated, see Table 4. Those that were, included being admitted to a unit other than trauma, orthopaedics, or

Table 2 Results of univariable analysis for the primary outcome of LOS

Variable	IRR	95% CI	*p* value
Age	1.01	(1.00–1.01)	0.002
Sex - Females	0.90	(0.81–0.99)	0.038
NESB - Yes	1.09	(0.96–1.25)	0.195
Initial Unit			
Trauma	REF	(REF - REF)	REF
General Medicine	1.09	(0.95–1.25)	0.220
Orthopaedic	1.14	(1.01–1.30)	0.041
Other	1.58	(1.31–1.93)	< 0.001
Mobility			
Independent nil aid	REF	(REF - REF)	REF
Independent with aid	1.03	(0.92–1.15)	0.663
Supervision	0.89	(0.68–1.18)	0.403
Assistance	0.77	(0.58–1.02)	0.059
Non Ambulant	0.67	(0.38–1.26)	0.181
Bathing	0.96	(0.84–1.10)	0.575
Dressing	0.89	(0.77–1.05)	0.154
Toileting	0.75	(0.61–0.92)	0.005
Transferring	0.71	(0.57–0.90)	0.003
Continence	1.13	(0.98–1.32)	0.101
Feeding	0.64	(0.48–0.89)	0.006
Katz Score	1.03	(0.99–1.07)	0.123
Usual Residence			
Home Alone	REF	(REF - REF)	REF
Home with Others	0.94	(0.84–1.05)	0.294
RACF	0.59	(0.48–0.73)	< 0.001
SRS	1.70	(1.12–2.72)	0.017
Low Fall	1.25	(1.12–1.39)	< 0.001
Complications			
Delirium	1.66	(1.48–1.87)	< 0.001
Inpatient Fall	1.74	(1.36–2.24)	< 0.001
UTI	1.58	(1.29–1.96)	< 0.001
Pneumonia	1.77	(1.49–2.12)	< 0.001
VTE	2.03	(1.48–2.86)	< 0.001
MI	1.52	(0.97–2.56)	0.089
Transfusion	1.69	(1.49–1.92)	< 0.001
Pressure Injury	1.51	(1.12–2.08)	0.009
Unplanned ICU	2.40	(1.71–3.50)	< 0.001
Anticoagulants	0.93	(0.82–1.06)	0.275
Polypharmacy	1.24	(1.11–1.38)	< 0.001
CCI	1.06	(1.03–1.10)	< 0.001
Dementia	1.20	(1.03–1.42)	0.025
Surgery	1.54	(1.39–1.70)	< 0.001

general medicine with a near four times odds of dying during their acute admission (Odds Ratio (OR) = 3.84, $p = 0.003$), noting that this would include patients being admitted directly to palliative care. Otherwise, complications including delirium (OR = 2.80, $p = 0.001$), pneumonia (4.55, p = < 0.001) and blood transfusions (OR = 3.38, p = < 0.001) were all significant risk factors for inpatient mortality.

Table 3 Results of multivariable analysis for the primary outcome of LOS

Variable	IRR	95% CI	*p* value
Age	1.01	(1.00–1.01)	< 0.001
Sex - Females	0.90	(0.81–0.99)	0.036
Initial Unit			
Trauma	REF	(REF - REF)	REF
General Medicine	1.10	(0.96–1.27)	0.177
Orthopaedic	0.87	(0.75–1.01)	0.073
Other	1.48	(1.22–1.80)	< 0.001
Mobility			
Independent nil aid	REF	(REF - REF)	REF
Independent with aid	0.95	(0.84–1.07)	0.382
Supervision	0.87	(0.66–1.14)	0.316
Assistance	0.81	(0.60–1.10)	0.171
Non Ambulant	0.94	(0.51–1.73)	0.845
Toileting	0.79	(0.58–1.09)	0.150
Transferring	1.21	(0.83–1.75)	0.322
Feeding	0.85	(0.57–1.25)	0.403
Usual Residence			
Home Alone	REF	(REF - REF)	REF
Home with Others	0.89	(0.80–0.99)	0.033
RACF	0.41	(0.31–0.53)	< 0.001
SRS	1.34	(0.91–1.99)	0.143
Low Fall	1.26	(1.11–1.43)	< 0.001
Complications			
Delirium	1.41	(1.25–1.59)	< 0.001
Inpatient Fall	1.46	(1.15–1.86)	0.002
UTI	1.20	(0.99–1.46)	0.066
Pneumonia	1.28	(1.08–1.53)	0.005
VTE	1.43	(1.05–1.96)	0.023
MI	1.22	(0.80–1.87)	0.359
Transfusion	1.34	(1.17–1.53)	< 0.001
Pressure Injury	1.21	(0.91–1.61)	0.187
Unplanned ICU	1.52	(1.08–2.14)	0.017
Polypharmacy	1.23	(1.10–1.37)	< 0.001
CCI	1.03	(1.00–1.07)	0.051
Dementia	1.48	(1.24–1.76)	< 0.001
Surgery	1.52	(1.34–1.73)	< 0.001

Most variables were associated with functional decline on univariable regression analysis (Supplementary Table 2). Those that weren't included ADLs dressing and continence, as well as anticoagulation. After adjustment (Table 5), age was no longer associated ($p = 0.340$). Females trended to be more likely to have experienced functional decline (OR = 1.33, $p = 0.070$) and those of NESB were twice as likely to experience this outcome (OR = 1.82, $p = 0.006$). Compared with being independent without gait aid, those with a gait aid were associated with a 52% increased risk of functional decline (OR = 1.52, $p = 0.034$). Low fall mechanism was a strong predictor of functional decline in this population (OR = 1.66, $p = 0.006$). Being from RACF was associated with a marked decreased risk based on this measure

Table 4 Results of multivariable analysis for the secondary outcome of mortality

Variable	OR	95% CI	*p* - value
Age	1.02	(0.99–1.05)	0.227
Sex - Females	0.57	(0.31–1.04)	0.067
Initial Unit			
Trauma	REF	(REF - REF)	REF
General Medicine	0.85	(0.38–1.86)	0.689
Orthopaedic	1.38	(0.54–3.52)	0.501
Other	3.84	(1.58–9.15)	0.003
Mobility			
Independent nil aid	REF	(REF - REF)	REF
Independent with aid	0.74	(0.38–1.44)	0.374
Supervision	0.43	(0.09–1.64)	0.253
Assistance	0.35	(0.08–1.32)	0.138
Non Ambulant	0.19	(0.01–1.91)	0.204
Katz Score	0.79	(0.62–1.01)	0.246
Usual Residence			
Home Alone	REF	(REF - REF)	REF
Home with Others	0.69	(0.36–1.31)	0.246
RACF	1.49	(0.50–4.32)	0.469
SRS	0.78	(0.04–5.07)	0.829
Low Fall	1.67	(0.77–3.77)	0.205
Complications			
Delirium	2.80	(1.56–5.08)	0.001
Pneumonia	4.55	(2.44–8.42)	< 0.001
MI	2.41	(0.47–9.53)	0.242
Transfusion	3.38	(1.74–6.60)	< 0.001
Anticoagulants	1.49	(0.81–2.66)	0.189
Polypharmacy	1.67	(0.79–3.83)	0.202
CCI	1.02	(0.86–1.19)	0.810
Dementia	0.78	(0.33–1.71)	0.545
Surgery	0.24	(0.11–0.53)	0.001

Table 5 Results of multivariable analysis for the secondary outcome of functional decline

Variable	OR	95% CI	*p* value
Age	1.01	(0.99–1.02)	0.340
Sex - Females	1.33	(0.98–1.81)	0.070
NESB - Yes	1.82	(1.20–2.80)	0.006
Initial Unit			
Trauma	REF	(REF - REF)	REF
General Medicine	1.31	(0.85–2.02)	0.224
Orthopaedic	1.05	(0.65–1.70)	0.831
Other	0.63	(0.35–1.16)	0.132
Mobility			
Independent nil aid	REF	(REF - REF)	REF
Independent with aid	1.52	(1.04–2.24)	0.034
Supervision	1.04	(0.42–2.74)	0.934
Assistance	1.62	(0.60–4.65)	0.352
Non Ambulant	0.88	(0.15–5.08)	0.887
Bathing	1.97	(1.02–4.06)	0.053
Toileting	0.39	(0.13–1.19)	0.090
Transferring	0.67	(0.20–2.23)	0.509
Feeding	0.22	(0.07–0.69)	0.009
Usual Residence			
Home Alone	REF	(REF - REF)	REF
Home with Others	0.87	(0.63–1.20)	0.393
RACF	0.21	(0.09–0.51)	< 0.001
SRS	3.74	(0.63–72.15)	0.229
Low Fall	1.66	(1.15–2.39)	0.006
Complications			
Delirium	4.25	(2.63–7.12)	< 0.001
Inpatient Fall	1.66	(0.70–4.45)	0.274
UTI	1.88	(0.81–5.03)	0.172
Pneumonia	1.52	(0.77–3.15)	0.241
VTE	2.66	(0.67–17.90)	0.220
MI	1.95	(0.32–38.49)	0.547
Transfusion	3.17	(1.91–5.46)	< 0.001
Pressure Injury	1.31	(0.44–4.55)	0.645
Unplanned ICU	3.94	(0.64–77.31)	0.218
Polypharmacy	1.05	(0.75–1.45)	0.784
CCI	1.11	(1.00–1.24)	0.055
Dementia	1.74	(0.91–3.49)	0.106
Surgery	2.16	(1.49–3.17)	< 0.001

(OR = 0.21, p = < 0.001) as was dependence with feeding (OR = 0.22, $p = 0.009$). Requiring surgery was associated with a two times increased risk of functional decline (OR = 2.16, $p < 0.001$). Complications including delirium (OR = 4.25, $p < 0.001$) and blood transfusion (OR = 3.17, $p < 0.001$) were major risk factors, whereas other complications were not.

Discussion

This study found several factors for identifying older patients admitted following trauma who are at increased risk of longer LOS as well as functional decline and mortality. Firstly, those admitted with trauma from a low fall are both common (64% of admissions) and experience 26% longer LOS compared to those with higher impact trauma. This group are also 66% more likely to experience functional decline and have increased risk of mortality although this did not reach statistical significance (OR = 1.67, $p = 0.205$). Secondly, there were high rates of complications in this population, and these were associated with poorer outcomes. Delirium, inpatient fall, pneumonia, VTE, blood transfusions and unplanned ICU admissions were all associated with increased LOS (of between 28% and 52%), with delirium having more than four times increased odds and blood transfusion more than three times odds of functional decline. Delirium and blood transfusions were also associated with a 2.8- and 3.38-times risk of mortality respectively and pneumonia was associated with 4.55 times risk. This risk is beyond that of unmodifiable factors after controlling for confounders including age, admitting unit, premorbid living arrangement, polypharmacy, comorbidities, dementia diagnosis and surgery.

The median acute LOS for this cohort was seven days, in line with published Australian data [2, 16] and in studies of geriatric trauma admissions with geriatric consultation models which have reported LOS of 3–19 days, with most reporting LOS of around seven days [8]. Length of stay is influenced by many factors, however may be improved with system and process changes [17].

It is already established that falls are the major cause of trauma related admissions, and this study is in keeping with previous published data [18]. This likely represents underlying frailty of this group, with increased risk of serious injury including fractures with minimal trauma and decreased physical and functional reserve in the face of trauma resulting in admission to hospital.

Current trauma guidelines do not identify low fall as a triage criterion triggering trauma team response and review. Trauma triage criteria are designed to identify patients presenting with trauma with high risk of significant injury for urgent, coordinated response, starting in the pre-hospital setting, through emergency departments and onto relevant trauma team care. Trauma team care has been shown to improve outcomes in patients presenting with trauma, including in the older population [19, 20]. However, it has been well recognised, that adult triage criteria under triage older patients who are at risk of significant injury despite their apparent low impact mechanism and initial clinical presentation, including "normal" vital signs [21–24]. Some researchers have argued for the inclusion of low falls as part of geriatric trauma triage tools [25–27], however it is recognised that this reduces specificity of these triage tools and risks overwhelming trauma teams and centres due to the prevalence of low falls in the community. There is ongoing debate on how best to triage older persons with trauma and this study highlights those at high risk including those with low falls.

Although our institution is a major trauma centre with an established trauma unit, not all older persons admitted with trauma are admitted under the trauma team. In this study, 21% of older patients presenting with trauma were admitted to general medicine teams, potentially without trauma team review, however this data was not recorded. There was a suggestion of a trend to longer LOS and functional decline in this group compared with those admitted under trauma. The lack of trauma team coordinated care including input from geriatric trauma specialists which only see patients admitted under trauma may contribute to this and be an area of improvement.

There is significant variation in the reporting of complications in the geriatric trauma population given the variability of the patient population as well variation in the types and definitions of complications reported. In this cohort, the rate of any complication was 44%. This is higher than previously reported [28], however rates are not directly comparable. Rates of complications were less than that seen in hip fracture populations using a similar definition of complications [13] which is unsurprising given the hip fracture population is an older, frailer group [29]. Recent studies have demonstrated that complications contribute to increased risk of mortality, and that the relative risk attributable to complications increases with increasing age and injury severity [30]. In this study, delirium was a common complication seen in a quarter of all patients. This is slightly higher than in other studies of trauma patients not requiring surgery [31]. Park et al., were able to demonstrate that rates of delirium were reduced following the introduction of a trauma pathway for older patients (RR 0.54, 95% CI 0.37 to 0.80), suggesting that complications such as delirium are in part modifiable and can be targeted by interventions.

There is a paucity of evidence of trauma care for older adults within the existing trauma model, including on the benefit of trauma specialist centres and whether they provide value to the increasingly older demographic. Tonkins et al. identified only two studies in older persons with low impact trauma assessing the benefit of major trauma centres over lower-level centres [7]. They report that the results were discordant and highlighted the need for research to ensure that a trauma response system, including hospital care, is fit for purpose for the increasingly predominant demographic of trauma presentations (low impact trauma in an older person).

Novel models of care involving geriatricians working in partnership with trauma teams have arisen at the hospital level in recognition of the specific needs of older persons presenting with trauma. A recent meta-analysis on implementing geriatric trauma consultation by a geriatrician to patients admitted with trauma showed a reduced LOS of 1.11 days but no reduction in mortality [8]. Contrastingly however, a geriatric co-management model has recently reported lower mortality but with increased LOS [32]. This was in adults aged over 80 years of age and it was noted by the authors that the trade-off of lower mortality was an increased LOS and decreased discharge to previous residence (i.e. functional decline). In our study, patients admitted to "other" units without dedicated physician or geriatric input experienced longer LOS compared to being admitted under trauma with geriatric co-management. The impact of geriatric co-management on LOS requires further investigation.

The strengths of this study are that the cohort was defined using a large representative, dedicated geriatric specific trauma registry at a major trauma centre and includes patients of all causes of trauma (excluding isolated hip fractures) and across all units. Importantly, data on geriatric specific variables including function and complications were available for analysis. This makes

this study relevant to patients admitted with trauma as a whole, rather than subgroups.

However, limitations are acknowledged relating to the use of the observational study design that cannot determine causality. Data was obtained via chart review which may introduce further bias due to missingness or inaccuracies, including unreliable baseline on which to base hospital acquired complications such as delirium. This data set did not routinely collect frailty data across the cohort and is acknowledged as a limitation, however the inclusion of multiple other co-variates would have expected to have significant co-linearity with frailty including comorbidities, functional status and residential status. The observational study design leaves open the possibility of other unmeasured confounders, for example the impact of COVID-19, and limitations on the ability to assess longer term outcomes post discharge such as 30-day mortality and longer term functional recovery as further limitations. The results of this study relate to a single centre in an Australian capital city and may not be generalisable to other settings which could be explored in further studies.

Conclusions

This study highlights factors for older persons admitted following trauma at risk of longer LOS as potential areas to focus quality improvement and service innovations that may improve outcomes and improve service delivery for an aging population. In this cohort, patients admitted following low falls were both common and high risk. Inpatient complications are also significantly associated with longer LOS and poorer outcomes. Further studies are required to determine the best strategies to best provide geriatric care to older persons experiencing trauma and their impact on reducing LOS as well as other outcomes.

Abbreviations

LOS	Length of stay
TOPS	Trauma in older person's service
IRR	Incidence rate ratio
CI	Confidence ratio
RMH	Royal Melbourne Hospital
CCI	Charlson comorbidity index
NSEB	Non-English speaking background
UTI	Urinary tract infection
VTE	Venous thromboembolism
MI	Myocardial infarction
ICU	Intensive Care Unit
VIF	Variable inflation factor
IQR	Inter quartile range
RACF	Residential Aged Care Facility
ADL	Activities of daily living
OR	Odds ratio

Supplementary Information

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Supplementary Material 1

Supplementary Material 2

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Not Applicable.

Author contributions

CE: Conceptualisation, Methodology, Formal Analysis, Investigation, Data Curation, Writing– Original Draft, Visualisation. WKL: Writing– Review and Editing, Methodology. AG: Investigation, Data Curation. RA: Writing– Review and Editing. DR: Writing– Review and Editing. KG: Conceptualisation, Methodology Data Curation, Writing - Review and Editing, Supervision, Funding acquisition.

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Data availability

The datasets generated and/or analysed during the current study are not publicly available, as this was a condition of Human Research Ethical Approval from Melbourne Health. Further clarification of any of the findings are available from the corresponding author on reasonable request provided it does not violate the conditions of this ethics approval.

Declarations

Ethics approval and consent to participate

This project was undertaken as part of the Evaluation of Outcomes of a New Model of Care: Trauma Older Persons Service Project. Ethics and clinical governance were approved by the Royal Melbourne Human Research Ethics committee: HREC/72410/MH-2021 which adheres to national guidelines by the National Health and Medical Research Council based on the Declaration of Helsinki principles. Individual consent to participate was waived as part of this ethics approval for this observational study of routinely collected data.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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