



Future hospital service utilisation in older adults living in long-term residential aged care or the community hospitalised with a fall-related injury

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Abstract

Summary This study identified group-based trajectories of hospitalisation for older adults who were living in residential aged care facilities (RACF) or the community for up to 4 years after an index fall injury hospitalisation. Greater than 3 subsequent fall injury hospitalisations and time until move to a RACF were key predictors of RACF and community-living trajectory group memberships, respectively.

Introduction To examine hospital service use trajectories of people aged ≥ 65 years who had a fall injury hospitalisation and were either living in a residential aged care facility (RACF) or the community at the time of the index fall and to identify factors predictive of their trajectory group membership.

Method A group-based trajectory analysis of hospitalisations of people aged ≥ 65 years who had a fall injury hospitalisation during 2008–2009 in New South Wales, Australia, was conducted. Linked hospitalisation and RACF data were examined for a 5-year period. Group-based trajectory models were derived based on number of subsequent hospital admissions following the index fall injury hospitalisation. Multinomial logistic regression examined predictors of trajectory group membership.

Results There were 24,729 fall injury hospitalisations; 78.8% of fallers were living in the community and 21.2% in a RACF. Five distinct trajectory groups were identified for community-living and four trajectory groups for RACF residents. Key predictors of trajectory group membership for both community-living and RACF residents were age group, number of comorbidities and dementia status. For RACF residents, depression, assistance with activities of daily living and number of subsequent fall injury admissions were also predictors of group membership, with time to move to a RACF a predictor of group membership for community living.

Conclusions Identifying trajectories of ongoing hospital use informs targeting of strategies to reduce hospital admissions and design of services to allow community-living individuals to remain as long as possible within their own residence.

Keywords Community · Fall · Hospitalisation · Injury · Residential aged care

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Introduction

Fall injuries are one of the leading causes of hospitalisation for people aged ≥ 65 years worldwide [1, 2], with hip fracture one of the most serious injuries sustained following a fall [3]. For older adults living in the community, experiencing a fall injury is a common event leading to a person moving into long-term institutional care (also known as residential aged care facilities (RACFs) or nursing homes) [4]. Risk factors for falls are multifactorial, are well described and can include intrinsic factors, such as comorbid health conditions, physical activity, medication use or nutritional factors [5] and/or extrinsic factors relating to the environment [5, 6]. Cognitive impairment is a common intrinsic risk factor that is associated with fall risk

in both community-living and RACF residents [7], with fall injury one of the most common reasons why a cognitively impaired older adult is hospitalised in Australia [8].

As age increases, individuals often develop age-associated health conditions requiring medical treatment [9]. This may necessitate assistance to perform activities of daily living (ADLs), whether the person is living in the community or within a RACF [10–12]. Older adults are frequent consumers of hospital services, with around 47% of hospital beds estimated to be required for their treatment [13]. As the proportion of older adults increases worldwide, consumption of hospital services by older adults is predicted to increase [14].

To gain further understanding of the use of hospital services by older adults who have fallen, distinguishing characteristics among those hospitalised need to be identified to ascertain whether there are key characteristics that may inform targeting approaches to the prevention of hospital admissions (e.g. alter the trajectories of hospital use) and/or improved delivery of RACF, hospital or age care services. In particular, estimating the timeframe within which community-living adults transition into a RACF is critical to inform aged care service delivery needs. This study aims to examine the trajectory of hospital service use of people aged ≥ 65 years who had a fall injury hospitalisation between 1 July 2008 and 30 June 2009 in New South Wales (NSW), Australia, who were either living in a RACF or the community at the time of the fall and to identify factors predictive of their trajectory group membership.

Method

A group-based trajectory analysis of hospital use for people aged ≥ 65 years who were hospitalised following a fall injury during 1 July 2008 and 30 June 2009 in NSW was conducted and their trajectories followed for a 4-year period. Group-based trajectory analysis identifies clusters of individuals that follow similar progressions over time within the study population and that are also heterogeneous from other clusters [15].

Data sources

Hospitalisation data include information on all admissions to public and private hospitals in NSW. Hospitalisation data contains information on patient demographics, diagnoses, external cause(s), type of hospital discharge and clinical procedures. Diagnoses and external cause codes were classified using the International Classification of Diseases, 10th Revision, Australian Modification (ICD-10-AM).

The RACF data collection includes information on all permanent residents, and people admitted for respite care or transitional aged care in RACF. Transitional aged care is a short-

term, restorative care aimed at optimising independence after hospitalisation and is available for up to 12 weeks [16]. The RACF data collection contains information on the type of admission, discharge status and the dates of admission and discharge. For each permanent RACF resident, an appraisal of their ability to perform ADLs (e.g. mobility), their behavioural characteristics (e.g. cognition, depression) and their health care needs is conducted within 2 months of admission [17]. Cognition was assessed using the Psychogeriatric Assessment Scales-Cognitive Impairment Scale (PAS-CIS) and depression was assessed using the modified Cornell Scale for Depression (CSD).

Record linkage

Data extracts from the national RACF data collection were linked to NSW hospitalisation data by the Australian Institute of Health and Welfare (AIHW) Data Linkage Unit using name-based probabilistic linkage. The estimated match link rate (i.e. presumed true match linkage cut-off) was 97.6%, link accuracy (i.e. accepted links are presumed to be correct links) was 99.9% and the F-score (i.e. harmonic mean of the two ratios of match link rate and link accuracy) was 98.8%. The RACF appraisal for permanent RACF residents that preceded and occurred closest to the date of the index fall injury hospitalisation was identified to describe the pre-hospitalisation period.

Case identification

All fall injuries were identified using a principal diagnosis of injury (ICD-10-AM: S00-T75 and T79) and a fall external cause code (ICD-10-AM: W00-W19) in the hospitalisation data. The index admission was the first fall injury hospitalisation during 1 July 2008 to 30 June 2009. Following the index fall admission, all hospitalisations, regardless of cause for each individual, were examined. A person's place of residence was identified as being in a RACF if their fall injury hospitalisation date occurred after their RACF admission date; otherwise the person was indicated to be living in the community. Older adults living in a RACF could be permanent residents ($n = 4970$; 94.7%) or living in a RACF for transitional ($n = 56$; 1.0%) or respite ($n = 225$; 4.3%) care.

Identification of comorbidities, dementia and geographic location

The Charlson comorbidity index was used to identify the number of comorbidities using diagnosis classifications from hospital records [18]. The Charlson comorbidity index was categorised by number of comorbidities into nil, 1–2 and ≥ 3 comorbidities. Dementia was excluded from the count of comorbidities, was considered separately and was identified

using the ICD-10-AM diagnosis classifications of F00–F03, F05.1, G30 and G31 recorded in up to 50 diagnosis fields. Depression was identified using diagnoses in hospitalisation records for community dwelling (ICD-10-AM: F20.4, F31.3, F31.4, F31.5, F32, F33, F34.1, F41.2, F43.2). A 12-month look-back period was used for the identification of all comorbidities (i.e. to 1 July 2007). The Australian Statistical Geographical Standard identified geographical location, with remoteness based on distance to service centres [19]. The five remoteness categories were categorised into urban (i.e. major cities) and rural (i.e. inner regional, outer regional, remote and very remote).

Data management and analysis

All analyses were conducted within the Secure Unified Research Environment (SURE) and performed using SAS version 9.4 [20]. All hospital episodes of care related to the index fall injury hospitalisation were linked to form a period of care. Chi-square tests of independence or Fisher's exact test were used to examine the characteristics of the trajectory groups. Group-based trajectory modelling was conducted using PROC TRAJ [21] to examine the course and frequency of hospital service use up to 4 years post the index fall injury hospitalisation for both RACF residents and community-dwelling residents. RACF and community-dwelling residents were analysed separately as additional data were available for RACF residents. For the trajectory analysis, the number of hospitalisations in each 6-month period, regardless of cause, post the index fall injury hospital admission was the outcome. A zero-inflated Poisson model (i.e. ZIP model) was not able to be used to examine number of hospitalisations due to a floating point exception. Therefore, the number of hospitalisations for any cause post the index fall injury hospitalisation were categorised into 1–2, 3–4, 5–6, 7–8, 9–10 or ≥ 11 hospitalisations and analysed using a censored normal (i.e. CNORM) model for each 6-month period. Deaths were not excluded from the models as these were viewed as part of the trajectory, with some individuals having several hospital admissions prior to death.

Model selection was assessed for between two and five trajectory groups set to a quadratic equation. For RACF residents, a four-group model had the best fit as it had one of the lowest Bayesian information criteria (BIC) and Akaike's information criteria (AIC) (BIC = -23033.32 and AIC = -22980.79) of the models examined (smaller BIC and AIC values indicate better model fit), and had the best average posterior probability (AvePP) of group membership for the four groups ranging from 0.75 to 0.90 (i.e. ideally greater than > 0.7) [15]. For community-dwelling residents, the five-group model had the best fit with BIC and AIC of -149313.6 and -149234.8 , respectively, and AvePP ranging from 0.70 to 0.96.

Multinomial logistic regression was used to examine predictors of hospital user group trajectories. Variables included in the model were those that were available in the data, had previously been identified as associated with repeat hospital service use or admission to RACF for older people [22–24] and were significant in univariate analysis: age group, sex, number of comorbidities (i.e. 0, 1–2, ≥ 3), dementia (yes/no), fall mechanism, hip fracture (yes/no), hospital length of stay (i.e. 1–7, 8–14, 15–21 and ≥ 22 days), geographic region (urban/rural) and number of fall injury hospitalisations (i.e. 1, 2, ≥ 3). For RACF residents, dependency to perform ADL, behaviour, depression and mobility were also included in the model. For individuals living in the community, time until move to RACF was also included in the model. Injury type and nature of injury were excluded as they were correlated with hip fracture and cognition was excluded from the RACF model as it was correlated with dementia status. A backwards stepwise regression was used to sequentially eliminate factors from the model that did not significantly contribute to risk of trajectory group membership at 0.25 [25]. Odds ratios (OR) and 95% confidence intervals (95%CI) were calculated. As RACF appraisal information (i.e. ADL, behaviour, mobility and depression) was missing for 1441 residents, the missing values for these four categorical variables were imputed. This represents 27.4% of the RACF sample—missing data of a proportion of this size within a sample ≥ 5000 has been reported as acceptable [26]. Imputation was conducted using the discriminant function method with 100 imputations using PROC MI with a relative efficiency of 99%. Parameter estimates were log-transformed and were used to generate pooled ORs and 95%CIs with PROC MIANALYSE.

Results

Residential aged care residents

There were 5251 (21.2% of all older adults hospitalised with a fall injury) RACF residents who were hospitalised following a fall injury in 2008–2009. The mean age of RACF residents was 86.4 years (SD 6.7) at the index fall injury hospital admission and 75.0% were female. RACF residents were disaggregated into four groups based on the trajectory analysis (Fig. 1a): low (52.8%) (Group 1), moderate declining (19.2%) (Group 2), moderate chronic (27.1%) (Group 3) and high (0.9%) (Group 4) hospital service users. RACF-low users had the highest proportion of residents aged ≥ 90 years (38.4%) and living with dementia (58.8%), with severe cognitive impairment (33.3%), high dependency for ADL (27.2%), high behavioural issues (43.1%), requiring physical assistance or mechanical lifting for mobility transfers (46.7%) and requiring physical assistance for locomotion (33.0%) compared with the other three RACF trajectory groups. Just

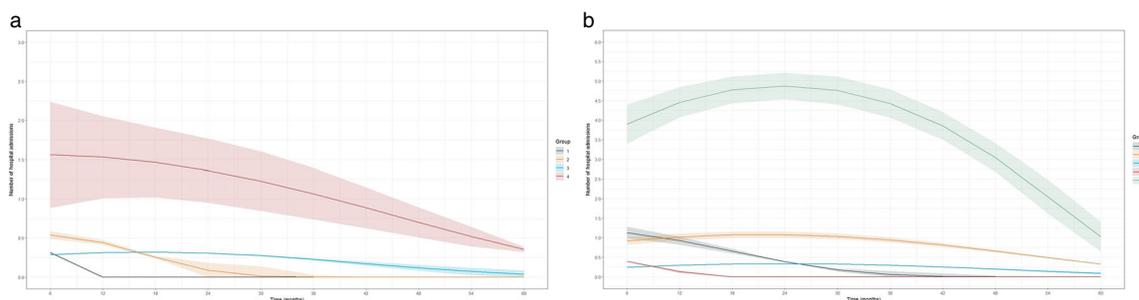


Fig. 1 Six monthly trajectories of hospitalisations up to 5 years post an index fall injury hospitalisation of individuals aged ≥ 65 years living in residential care (a) or the community (b), linked hospitalisation and

RACF records in NSW, 1 July 2008 to 30 June 2013^{1,2}. ¹Shaded area represents 95% CIs. ²Y-axis scale 1 = 1–2, 2 = 3–4, 3 = 5–6, 4 = 7–8, 5 = 9–10 or 6 = ≥ 11 hospitalisations

less than one-third (32.1%) of RACF-low users were living in a rural location, 38.8% sustained a hip fracture following their fall and 8.3% died in-hospital.

Both RACF-moderate declining and RACF-moderate chronic users had similar characteristics by age group, sex and dementia status (45.2% and 43.4%, respectively). However, RACF-moderate declining users had a higher proportion of comorbidities (40.8% vs 33.6%), moderate dependency for ADL (35.1% vs 28.8%), required physical assistance for locomotion (24.8% vs 19.3%) and had almost double the proportion of fall injury admissions during the 4-year period than RACF-moderate chronic users (18.4% vs 9.6%). RACF-high users had the highest proportion of residents aged ≤ 70 years, with ≥ 1 Charlson comorbidity (61.2%), with major depression (26.7%) and who fell during a trip, slip or stumble (28.6%), but the lowest proportion living with dementia (16.3%) compared with the other three RACF trajectory groups. RACF-high users had the highest proportion of residents with nil ADL dependency or behavioural issues, residents who were independent for mobility transfers and independent for locomotion compared with the other three RACF trajectory groups (Tables 1 and 2).

Compared with RACF-low users, RACF-moderate declining and RACF-high users were more likely to have a higher number of fall injury hospitalisations during the study period and to experience major depression. RACF-high users were also twice as likely to have between 1 and 2 chronic health conditions (OR 2.21; 95%CI 1.14–4.29) compared with RACF-low users. RACF-moderate chronic users were more likely to be female and to have a longer hospital LOS compared with RACF-low users (OR 1.40; 95%CI 1.15–1.69). Individuals within all three RACF trajectory groups had a lower likelihood of living with dementia and of requiring assistance with ADLs compared with RACF-low users.

Community living

There were 19,478 (78.8% of all older adults hospitalised with a fall injury) people living in the community who were hospitalised following a fall injury in 2008–2009. The mean

age of community-living people was 80.6 years (SD 7.8) at the index fall injury hospital admission and 68.0% were female. There were 8,340 (42.8%) community-living individuals that after their index fall injury hospitalisation were later admitted to an RACF within the period examined. The community-living older adults were disaggregated into five groups based on the trajectory analysis: moderate declining (9.2%) (Group 1), chronic (9.3%) (Group 2), low constant (50.4%) (Group 3), low declining (30.7%) (Group 4), and high (0.4%) (Group 5) hospital service users (Fig. 1b).

Just over half (51.1%) of the community-moderate declining users were aged 80–89 years and 11.7% living with dementia. Community-moderate declining users had the highest proportion of individuals with a hospital LOS ≥ 22 days (35.0%), ≥ 3 fall injury hospital admissions (3.3%) and those that moved within 6 months into a RACF (23.1%) compared with the four other community-living trajectory groups. Both community-chronic and community-low constant users had lower proportions of people living with dementia (5.2% and 8.2%, respectively) compared with community trajectory groups 1, 4 and 5. Community-chronic users had the highest proportion of people who moved into a RACF at ≥ 31 –60 months (17.6%), while community-low constant users had the highest proportion of females (71.2%), those without comorbidities (74.1%) and fractures (61.3%) compared with community trajectory groups 1, 4 and 5.

Community-low declining users had the highest proportion of people aged ≥ 90 , had 16.6% of people living with dementia and had 7.4% in-hospital deaths compared with the other community-living groups. Community-high users had just over half their group aged ≤ 70 years (55.6%), 19.8% with ≥ 3 comorbidities, 1.2% living with dementia and 80.3% living in an urban location. Community-high users commonly fell on the same level due to a slip, trip or stumble (43.2%), and almost all (97.5%) had one other fall injury hospitalisation and less than one-third (32.1%) moved into a RACF during the study time period (Tables 3 and 4).

All community trajectory groups, bar community-high users, were more likely to have a higher number of females compared with community-moderate declining users.

Table 1 Demographic and RACF appraisal characteristics of individuals aged ≥ 65 years living in residential aged care who had an index fall injury hospitalisation by trajectory groups based on number of hospital admissions, linked hospitalisation and RACF records in NSW, 1 July 2008 to 30 June 2013

	RACF-low group 1 (n = 2771; 52.8%)		RACF-moderate declining group 2 (n = 1006; 19.2%)		RACF-moderate chronic (group 3) (n = 1425; 27.1%)		RACF-high (group 4) (n = 49; 0.9%) ¹		χ^2 (df)
	n	%	n	%	n	%	n	%	
Age group									
65–69	33	1.2	18	1.8	34	2.4	<5	–	102.8 (9)*
70–79	311	11.2	141	14.0	224	15.7	16	32.7	
80–89	1364	49.2	530	52.7	789	55.4	20	40.8	
90+	1063	38.4	317	31.5	378	26.5	#	–	
Gender									
Male	729	26.3	263	26.1	307	21.5	14	28.6	12.6 (3)***
Female	2042	73.7	743	73.9	1118	78.5	35	71.4	
Number of Charlson comorbidities (excl dementia)									
Nil recorded	1716	61.9	596	59.2	947	66.5	19	38.8	28.1 (6)*
1–2	847	30.6	323	32.1	386	27.1	22	44.9	
≥ 3	208	7.5	87	8.7	92	6.5	8	16.3	
Dementia									
Yes	1629	58.8	455	45.2	618	43.4	8	16.3	136.7 (3)*
Geographical location of residence²									
Urban	1871	67.5	736	73.2	1053	73.9	37	75.5	23.8 (3)*
Rural	888	32.1	267	26.5	365	25.6	12	24.5	
Activities of daily living (dependency)³									
Nil	92	4.5	80	11.1	140	13.9	8	26.7	219 (9)*
Low	630	30.6	272	37.8	434	43.2	17	46.7	
Moderate	777	37.8	252	35.1	289	28.8	<5	–	
High	559	27.2	115	16.0	141	14.0	<5	–	
Behaviour³									
Nil	264	12.8	121	16.8	221	22.0	9	30.0	98.9 (9)*
Low	422	20.5	181	25.2	260	25.9	#	–	
Moderate	486	23.6	179	24.9	237	23.6	10	33.3	
High	886	43.1	238	33.1	286	28.5	<5	–	
Complex health care³									
Nil	439	21.3	164	22.8	273	27.2	8	26.7	36.1 (9)*
Low	826	40.1	295	41.0	426	42.4	#	–	

Table 1 (continued)

	RACF-low group 1 (<i>n</i> = 2771; 52.8%)		RACF-moderate declining group 2 (<i>n</i> = 1006; 19.2%)		RACF-moderate chronic (group 3) (<i>n</i> = 1425; 27.1%)		RACF-high (group 4) (<i>n</i> = 49; 0.9%) ¹		χ^2 (df)
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	
Moderate	584	28.4	192	26.7	251	25.0	12	40.0	
High	209	10.2	68	9.5	54	5.4	<5	–	
Mobility transfers ³									
Independent	434	21.1	213	29.6	340	33.9	12	40.0	107.3 (9)*
Requires supervision	664	32.3	236	32.8	360	35.9	11	36.7	
Requires physical assistance	804	39.1	238	33.1	272	27.1	#	–	
Requires mechanical lifting	156	7.6	32	4.5	32	3.2	<5	–	
Mobility, locomotion ³									
Independent	289	14.0	157	21.8	228	22.7	10	33.3	93.7 (6)*
Requires supervision	1089	52.9	384	53.4	582	58.0	15	50.0	
Requires physical assistance	680	33.0	178	24.8	194	19.3	5	16.7	
Cognition (PAS-CIS) ³									
No/minimal (0–3)	267	13.0	156	21.7	219	21.8	10	33.3	170.9 (9)*
Mild (4–9)	512	24.9	221	30.7	360	35.9	13	43.3	
Moderate (10–15)	593	28.8	201	28.0	255	25.4	<5	–	
Severe (16–21)	686	33.3	141	19.6	170	16.9	<5	–	
Depression (CSD) ⁴									
No/minimal (≤ 8)	1,084	52.7	386	53.7	567	56.5	13	43.3	23.1 (9)***
Mild (9–13)	388	18.9	133	18.5	206	20.5	#	–	
Moderate (14–18)	335	16.3	97	13.5	130	13.0	<5	–	
Major (19–38)	250	12.2	103	14.3	101	10.1	8	26.7	

PAS-CIS, Psychogeriatric Assessment Scales-Cognitive Impairment Scale; CSD, Cornell Scale for Depression

¹ Cell sizes <5 or disguised as # to prevent identification of cell sizes <5

² There were 22 missing for geographic location of residence

³ There were 1440 missing for activities of daily living, behaviour, complex health care, mobility transfers and locomotion and cognition

⁴ There were 1441 missing for depression

**p* < 0.0001

***p* < 0.0006

****p* < 0.006

Table 2 Fall injury characteristics and health outcomes of individuals aged ≥ 65 years living in residential aged care who had an index fall injury hospitalisation by trajectory groups based on number of hospital admissions, linked hospitalisation and RACF records in NSW, 1 July 2008 to 30 June 2013

	RACF-Low (group 1) (<i>n</i> = 2771; 52.8%)		RACF-moderate declining (group 2) (<i>n</i> = 1006; 19.2%)		RACF-moderate chronic (group 3) (<i>n</i> = 1425; 27.1%)		RACF-high (group 4) (<i>n</i> = 49; 0.9%) ¹		χ^2 (df) or Fisher's exact test
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	
Type of fall									
Fall on same level slip, trip or stumble	508	18.3	231	23.0	362	25.4	14	28.6	53.0 (12)*
Fall involving chair or wheelchair	169	6.1	53	5.3	63	4.4	<5	–	
Fall involving bed or other furniture (excluding chairs)	239	8.6	89	8.9	101	7.1	<5	–	
Other fall on same level	616	22.2	252	25.1	348	24.4	12	24.5	
Other and unspecified fall	1239	44.7	381	37.9	551	38.7	21	42.9	
Principal nature of injury									
Fracture	1688	60.9	512	50.9	734	51.5	25	51.0	77.4 (15)*
Open wound	344	12.4	175	17.4	214	15.0	8	16.3	
Dislocations, sprains and strains	34	1.2	12	1.2	27	1.9	<5	–	
Superficial injuries	239	8.6	126	12.5	181	12.7	6	12.2	
Injury to internal organs	134	4.8	36	3.6	46	3.2	<5	–	
Other and unspecified injuries	332	12.0	145	14.4	223	15.7	8	16.3	
Principal bodily location of injury									
Head or neck	626	22.6	296	29.4	385	27.0	11	22.5	111.3 (12)*
Thorax or abdominal region	382	13.8	172	17.1	251	17.6	10	20.4	
Upper extremities	290	10.5	144	14.3	223	15.7	8	16.3	
Lower extremities	1452	52.4	382	38.0	549	38.5	20	40.8	
Other injuries	21	0.8	12	1.2	17	1.2	0	–	
Hip fracture									
Yes	1074	38.8	239	23.8	330	23.2	8	16.3	146.9 (3)*
Hospital length of stay (days)									
1–7	1561	56.3	606	60.2	776	54.5	26	53.1	54.7 (9)*
8–14	505	18.2	121	12.0	192	13.5	12	24.5	
15–21	241	8.7	75	7.5	126	8.8	5	10.2	
≥ 22	464	16.7	204	20.2	331	23.2	6	12.2	
In-hospital death²									
Yes	231	8.3	0	–	0	–	0	–	$p < 0.0001$
Number of fall injury admissions for 5-year period post index fall admission									
1	2545	91.8	821	81.6	1288	90.4	41	83.7	98.1 (6)*
2	205	7.4	153	15.2	123	8.6	#	–	
≥ 3	21	0.8	32	3.2	14	1.0	<5	–	

¹ Cell sizes < 5 or disguised as # to prevent identification of cell sizes < 5

² Fisher's exact test

* $p < 0.0001$

** $p < 0.006$

Community-low declining users had a higher likelihood of living with dementia (OR 1.83; 95%CI 1.55–2.17), being hospitalised for a fall-related hip fracture (OR 1.22; 95%CI 1.06–1.41) and of living in rural NSW (OR 1.26; 95%CI 1.11–1.42) compared with community-moderate declining users. Community-high users were at least twice as likely to

have 1–2 (OR 2.06; 95%CI 1.24–3.40) or ≥ 3 chronic health conditions (OR 2.87; 95%CI 1.52–5.42) compared with community-moderate declining users. All community trajectory groups were less likely to move into a RACF within 12 months of their index fall injury hospitalisation compared with community-moderate declining users, with community-

Table 3 Demographic and fall characteristics post an index fall injury hospitalisation for trajectory groups based on number of hospital admissions of individuals aged ≥ 65 years living in the community, linked hospitalisation, RACF and ACAP records in NSW, 1 July 2008 to 30 June 2013

	Community-moderate declining (group 1) (<i>n</i> = 1798; 9.2%)		Community-chronic (group 2) (<i>n</i> = 1806; 9.3%)		Community-low constant (group 3) (<i>n</i> = 9810; 50.4%)		Community-low declining (group 4) (<i>n</i> = 5983; 30.7%)		Community-high (group 5) (<i>n</i> = 81; 0.4%) ¹		χ^2 (df)
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	
Age group											
65–69	115	6.4	204	11.3	1095	11.2	643	10.8	#	–	330.7 (12)*
70–79	500	27.8	662	36.7	3243	33.1	1683	28.1	32	39.5	
80–89	918	51.1	831	46.0	4445	45.3	2608	43.6	32	39.5	
90+	265	14.7	109	6.0	1027	10.5	1049	17.5	<5	–	
Gender											
Male	706	39.3	640	35.4	2828	28.8	2019	33.8	37	45.7	114.2 (4)*
Female	1092	60.7	1,166	64.6	6982	71.2	3964	66.3	44	54.3	
Number of Charlson comorbidities (excl dementia)											
Nil recorded	996	55.4	1085	60.1	7270	74.1	3773	63.1	31	38.3	562.9 (8)*
1–2	605	33.7	598	33.1	2211	22.5	1696	28.4	34	42.0	
≥ 3	197	11.0	123	6.8	329	3.4	514	8.6	16	19.8	
Dementia											
Yes	210	11.7	94	5.2	807	8.2	995	16.6	1	1.2	345.9 (4)*
Depression²											
Yes	6	0.3	9	0.5	46	0.5	20	0.3	<5	–	<i>p</i> < 0.09
Geographical location of residence³											
Urban	1307	72.7	1325	73.4	6906	70.4	4055	67.8	65	80.3	32.1 (4)*
Rural	477	26.5	456	25.3	2818	28.7	1838	30.7	15	18.5	
Type of fall											
Fall on same level slip, trip or stumble	656	36.5	736	40.8	4012	40.9	2176	36.4	35	43.2	80.5 (16)*
Fall involving chair or wheelchair	62	3.4	59	3.3	308	3.1	232	3.9	<5	–	
Fall involving bed or other furniture (excluding chairs)	75	4.2	63	3.5	254	2.6	242	4.0	<5	–	
Other fall on same level	379	21.1	330	18.3	1787	18.2	1256	21.0	16	19.8	
Other and unspecified fall	626	34.8	618	34.2	3449	35.2	2077	34.7	26	32.1	

¹ Cell sizes < 5 or disguised as # to prevent identification of cell sizes < 5

² Fisher's exact test

³ There were 216 missing for geographic location of residence

**p* < 0.0001

low declining users less likely to move into a RACF up until 2.5 years following their index fall injury hospitalisation (Table 5).

Discussion

With one in three community-living and around one in two RACF residents estimated to fall each year [9, 27], examining the trajectories of fallers is critical to characterise the different patterns of ongoing hospital service use. For the individuals who fell and were hospitalised while residing in a RACF, four

distinct trajectory groups of subsequent hospital use were identified. Community-living older adults who were hospitalised following a fall injury had five key hospital use trajectory groups.

While their patterns of hospital service use differed, there were key features that defined trajectory group membership for both community-living and RACF residents. Key features included age group, number of comorbidities and dementia status. For RACF residents, additional characteristics defining trajectory group membership were depression, number of subsequent fall injury hospital admissions and dependency for ADLs. For community-living individuals,

Table 4 Fall injury characteristics and health outcomes post an index fall injury hospitalisation for trajectory groups based on number of hospital admissions of individuals aged ≥ 65 years living in the community, linked hospitalisation, RACF and ACAP records in NSW, 1 July 2008 to 30 June 2013

	Community-moderate declining (group 1) ($n = 1798$; 9.2%)		Community-chronic (group 2) ($n = 1806$; 9.3%)		Community-low constant (group 3) ($n = 9810$; 50.4%)		Community-low declining (group 4) ($n = 5983$; 30.7%)		Community-high (group 5) ($n = 81$; 0.4%) ¹		χ^2 (df) or Fisher's exact test
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	
Principal nature of injury											
Fracture	984	54.7	1019	56.4	6011	61.3	3524	58.9	41	50.6	116.3 (20)*
Open wound	216	12.0	189	10.5	968	9.9	653	10.9	7	8.6	
Dislocations, sprains and strains	46	2.6	60	3.3	330	3.4	149	2.5	#	–	
Superficial injuries	210	11.7	196	10.9	848	8.6	500	8.4	7	8.6	
Injury to internal organs	78	4.3	67	3.7	425	4.3	372	6.2	<5	–	
Other and unspecified injuries	264	14.7	275	15.2	1226	12.5	785	13.1	18	22.2	
Principal bodily location of injury											
Head or neck	387	21.5	358	19.8	1932	19.7	1258	21.0	14	17.3	38.9 (16)**
Thorax or abdominal region	374	20.8	346	19.2	1796	18.3	1067	17.8	18	22.2	
Upper extremities	372	20.7	432	23.9	2378	24.2	1315	22.0	#	–	
Lower extremities	637	35.4	648	35.9	3553	36.2	2235	36.2	35	43.2	
Other injuries	28	1.6	22	1.2	151	1.5	108	1.8	<5	–	
Hip fracture											
Yes	309	17.2	258	14.3	1,693	17.3	1,229	20.5	14	17.3	47.6 (4)*
Hospital length of stay (days)											
1–7	755	42.0	892	49.4	4874	49.7	2683	44.8	39	48.2	64.5 (12)*
8–14	241	13.4	241	13.3	1247	12.7	817	13.7	9	11.1	
15–21	173	9.6	145	8.0	817	8.3	555	9.3	6	7.4	
≥ 22	629	35.0	528	29.3	2872	29.3	1928	32.2	27	33.3	
In-hospital death ²											
Yes	0	–	0	–	0	–	440	7.4	0	–	$p < 0.0001$
Number of fall injury admissions for 5-year period											
1	1499	83.4	1586	87.8	9273	94.5	5607	93.7	79	97.5	403.4 (8)*
2	240	13.4	182	10.1	488	5.0	345	5.8	<5	–	
≥ 3	59	3.3	36	2.0	49	0.5	31	0.5	#	–	
Time until move to RACF after index fall injury admission											
Not with 5 years	877	48.8	985	54.5	6120	62.4	4557	76.2	55	67.9	2045.3 (24)*
≤ 6 months	415	23.1	178	9.9	1249	12.7	1061	17.3	5	6.2	
7–12 months	180	10.0	90	5.0	332	3.4	190	3.2	<5	–	
13–18 months	156	8.7	72	4.0	369	3.8	45	0.8	<5	–	
19–24 months	107	6.0	75	4.2	340	3.5	38	0.6	<5	–	
25–30 months	41	2.3	88	4.9	384	3.9	22	0.4	<5	–	
≥ 31 to 60 months	22	1.2	318	17.6	1016	10.4	70	1.2	10	12.4	

¹ Cell sizes < 5 or disguised as # to prevent identification of cell sizes < 5² Fisher's exact test* $p < 0.0001$ ** $p < 0.001$

time to move into a RACF following the index fall injury hospitalisation was also a key feature defining trajectory group membership.

For RACF-low users, over one-third of residents were aged ≥ 90 years and both RACF-moderate declining and RACF-moderate chronic users had a lower likelihood of older

Table 5 Predictors of trajectory group membership for for RACF residents and community-living individuals aged ≥ 65 years post an index fall injury hospitalisation, multinomial logistic results for linked hospitalisation, RACF and ACAP records in NSW, 1 July 2008 to 30 June 2013

Characteristic	Community (<i>n</i> = 19,478)													
	Residential aged care (<i>n</i> = 5,251)		Group 3 vs 1		Group 4 vs 1		Group 2 vs 1		Group 3 vs 1		Group 4 vs 1		Group 5 vs 1	
	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI
Age group¹														
70–79	0.99	0.53–1.87	0.78	0.45–1.35	0.79	0.21–2.93	0.79	0.61–1.02	0.77***	0.62–0.96	0.69**	0.55–0.86	0.60	0.30–1.18
80–89	0.79	0.43–1.45	0.55***	0.32–0.93	0.20***	0.05–0.72	0.56*	0.44–0.73	0.63*	0.51–0.78	0.68***	0.55–0.85	0.38**	0.19–0.76
90+	0.57	0.31–1.07	0.29*	0.17–0.50	0.10**	0.03–0.43	0.27*	0.19–0.38	0.53*	0.41–0.67	1.06	0.83–1.37	0.19**	0.06–0.62
Gender²														
Female	1.07	0.89–1.27	1.36**	1.15–1.61	1.43	0.71–2.90	1.23**	1.07–1.41	1.53*	1.37–1.70	1.26*	1.13–1.42	0.92	0.59–1.45
Number of Charlson comorbidities (excl dementia)³														
1–2	1.08	0.91–1.28	0.77**	0.66–0.90	2.21***	1.14–4.29	0.99	0.86–1.15	0.55*	0.49–0.62	0.79*	0.70–0.89	2.06**	1.24–3.40
≥ 3	1.09	0.82–1.45	0.65***	0.49–0.87	2.29	0.91–5.72	0.62**	0.49–0.81	0.26*	0.22–0.32	0.78***	0.65–0.95	2.87**	1.52–5.42
Dementia³														
Yes	0.68*	0.58–0.80	0.67*	0.58–0.78	0.21*	0.09–0.47	0.56*	0.43–0.73	0.90	0.76–1.07	1.83*	1.55–2.17	0.13***	0.02–0.95
Hip fracture³														
Yes	0.60*	0.50–0.71	0.54*	0.46–0.63	0.58	0.25–1.34	0.91	0.75–1.09	1.12	0.97–1.28	1.22**	1.06–1.41	1.13	0.62–2.05
Hospital length of stay (days)⁴														
8–14	0.71***	0.56–0.89	0.88	0.72–1.08	1.48	0.69–3.16	–	–	–	–	–	–	–	–
15–21	0.86	0.64–1.14	1.09	0.84–1.40	1.27	0.45–3.56	–	–	–	–	–	–	–	–
≥ 22	1.15	0.93–1.42	1.40*	1.15–1.69	0.55	0.21–1.48	–	–	–	–	–	–	–	–
Number of fall injury admissions for 5-year period⁵														
2	2.12*	1.68–2.68	1.06	0.83–1.36	1.74	0.69–4.40	–	–	–	–	–	–	–	–
≥ 3	4.40*	2.46–7.86	1.22	0.60–2.50	8.09***	1.58–41.33	–	–	–	–	–	–	–	–
Geographical location of residence⁶														
Rural	0.73*	0.62–0.86	0.69*	0.59–0.81	0.61	0.30–1.22	0.89	0.76–1.04	1.07	0.96–1.21	1.26**	1.11–1.42	0.59	0.33–1.05
Activities of daily living (dependency)⁷														
Low	0.52*	0.36–0.74	0.47*	0.35–0.64	0.22***	0.07–0.63	–	–	–	–	–	–	–	–
Moderate	0.43*	0.28–0.66	0.31*	0.21–0.44	0.04*	0.01–0.21	–	–	–	–	–	–	–	–
High	0.28*	0.17–0.47	0.25*	0.16–0.38	0.01*	0.00–0.16	–	–	–	–	–	–	–	–
Behaviour⁷														
Low	1.13	0.84–1.53	0.89	0.69–1.14	0.63	0.22–1.84	–	–	–	–	–	–	–	–
Moderate	1.08	0.79–1.48	0.84	0.64–1.10	0.91	0.29–2.87	–	–	–	–	–	–	–	–
High	0.90	0.65–1.25	0.68**	0.51–0.89	0.33	0.08–1.42	–	–	–	–	–	–	–	–

Table 5 (continued)

Characteristic	Residential aged care (n = 5,251)				Community (n = 19,478)									
	Group 2 vs 1		Group 3 vs 1		Group 4 vs 1		Group 2 vs 1		Group 3 vs 1		Group 4 vs 1		Group 5 vs 1	
	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI	OR	95%CI
Depression ⁷ (CSD)														
Mild	0.98	0.77–1.26	1.07	0.86–1.32	1.75	0.68–4.51	–	–	–	–	–	–	–	–
Moderate	0.84	0.64–1.11	0.82	0.64–1.06	0.69	0.15–3.10	–	–	–	–	–	–	–	–
Major	1.33***	1.00–1.78	0.95	0.72–1.24	5.27***	1.75–15.86	–	–	–	–	–	–	–	–
Time until move to RACF after index fall injury admission														
≤ 6 months	–	–	–	–	–	–	0.49*	0.40–0.60	0.49*	0.43–0.56	0.44*	0.38–0.51	0.25**	0.10–0.64
7–12 months	–	–	–	–	–	–	0.54*	0.41–0.71	0.31*	0.26–0.37	0.20*	0.16–0.24	0.11***	0.01–0.77
13–18 months	–	–	–	–	–	–	0.50*	0.37–0.67	0.40*	0.33–0.49	0.05*	0.04–0.08	0.35	0.11–1.15
19–24 months	–	–	–	–	–	–	0.74	0.54–1.01	0.51*	0.40–0.64	0.07*	0.05–0.10	0.73	0.26–2.07
25–30 months	–	–	–	–	–	–	2.29*	1.56–3.36	1.49***	1.07–2.08	0.10*	0.06–0.17	1.42	0.43–0.56
≥ 31 to 60 months	–	–	–	–	–	–	14.28*	9.17–22.24	7.08*	4.61–10.89	0.62	0.38–1.01	8.28*	3.71–18.48

¹ Reference group was 65–69 years

² Reference group was male

³ Reference group was nil

⁴ Reference group was 1–7 days

⁵ Reference group was one

⁶ Reference group was urban and not known geographical location of residence not shown

⁷ Reference group was nil

**p* < 0.0001

***p* < 0.001

****p* < 0.05

residents hospitalised (i.e. ≥ 80 years) compared with RACF-low users. For community-moderate declining users, over two-thirds of older adults were aged ≥ 80 years. Older age has long been associated with increasing number of comorbid health conditions and the need for health service use [9, 28].

Both RACF-high and community-high users had at least twice the likelihood of having comorbid health conditions compared with RACF-low and community-moderate declining users, respectively. Older adults with comorbidities have previously been identified as experiencing a higher number of hospital admissions [29–31], with one study finding that with each additional comorbidity there was a 5% increase on the number of hospital admissions [29]. Both RACF-moderate declining and RACF-high users had a higher likelihood of experiencing major depression than RACF-low users. Major depression has been previously been associated with increased health service use compared with non-depressed individuals [32]. Treatment of depression in RACF residents, including counselling, physical and social activities, could have benefit with optimization of antidepressant medication, which is associated with an increased fall risk [33].

Compared with RACF-low and community-moderate declining users, generally the remaining RACF and community trajectory groups, respectively, had a lower likelihood of living with dementia. Almost three in five RACF residents in the RACF-low user and one in ten community-low declining users were living with dementia. This result seems counterintuitive, as it could generally be expected that older adults living with dementia would have higher use of health services than older adults without dementia [34]. Yet, other authors have also found that people living with dementia used a lower number of health services compared with people without dementia [35]. One possible reason for the lower frequency of hospitalisation for the RACF-low users is that this group had the highest proportion of older residents (i.e. ≥ 90 years), two-thirds had moderate to severe cognitive impairment, and this group had the highest proportions dependent for ADLs, behavioural and mobility issues and also contained all the RACF resident deaths, suggesting that advanced care directives may also have played some part in decision-making regarding frequency of hospital attendance [36].

Within the RACF resident population, both the RACF-moderate declining and RACF-high users experienced a higher likelihood of being hospitalised for subsequent fall injuries within the study period compared with RACF-low users. Similarly, repetitive fall injuries have previously been associated with declining health status and repeat hospitalisation for older adults [24, 37], with falls often being considered an indicator of frailty [37, 38].

Just over one-quarter of the RACF-low users were identified as having high dependency for ADLs, with this group containing over one-third of residents aged ≥ 90 years. As age increases, a person's need for assistance to perform

ADLs generally increases [39, 40]. Chronic health conditions can also adversely impact an individual's ability to perform ADL [41], along with repeated falls, with fallers often reporting difficulties performing ADLs [38] and/or showing a decline in health and physical functioning [37].

The current study identified that around two in five community-living individuals who were hospitalised following a fall injury were admitted to an RACF within the 5-year study timeframe. There were differences in the timeframe of admission by trajectory group, with one-third of the community-moderate declining users admitted to a RACF within 12 months of their fall. Reasons for moving into an RACF are usually multifactorial and commonly involve increasing age and declining physical health [32, 39, 42], all characteristics of the community-moderate declining users where almost two-thirds of adults were aged ≥ 80 years, one in ten were living with dementia, and two in five had ≥ 1 comorbid health condition. Severe cognitive impairment [41, 42] and repeated falls [24] are also commonly associated with a move to a RACF. Previous research has identified similar health service patterns post-fall among community-living individuals to the current study, indicating that older people are likely to be on a spectrum of declining health, with older adults at one end of the spectrum immediately declining (or spiralling) post-fall with, at the other end of the spectrum, older adults having periods of stabilization, before later experiencing declining health over time [24].

While this study is population-based and one of the first to consider health service use trajectories following a fall injury hospitalisation, there are several study limitations. While hospital auditing has identified good-to-excellent classification of principal and comorbid diagnoses classifications in Australian hospital data [43], data validity was not able to be assessed and it is possible there is some misclassification within the data collections. Only in-hospital mortality was able to be considered. This has limited examination of survival post-hospitalisation, which may have altered group trajectories. Survival post-fall injury hospitalisation can vary by injury type and comorbid health status, with 30-day mortality for older adults with a hip fracture and dementia almost double the proportion (12.6%) living without dementia (6.4%), while for older adults with a non-fracture injury and dementia 30-day mortality is around half (5.9%) the proportion of adults who sustained a hip fracture and lower still for older adults without dementia (3.3%) [44]. No indication of the severity of any cognitive impairment was available for older adults living in the community. Just over one-quarter of RACF assessment information was missing and was imputed. However, imputation was conducted using standard PROC MI methods, with 100 imputations that gave a relative efficiency of 99%. Trajectories for older adults living in RACFs were not able to be disaggregated into people who were receiving permanent, respite or transitional

care at the time of their fall due to the low number of people receiving transitional and respite care.

Interest in hospital avoidance programmes for RACF residents is growing, due to increasing life expectancy and greater numbers of older adults living in aged care facilities. While differences exist between models of hospital avoidance programmes, a review of existing programmes identified promising programme elements, including care coordination, access to skilled health professionals, partnerships, capacity building and good communication, that have been associated with reduction in hospital admissions for RACF residents [45]. For community-living individuals, access to hospital in the home and home-based age care services are likely to increase in demand [46], as older adults seek to remain within the familiar surrounds of their own residence. Both RACF hospital avoidance programmes and community-based home aged care services should consider the needs of different RACF and community-living trajectory groups, respectively, in the design of services.

Conclusions

Identifying trajectories of hospital service use of older adults both living in RACFs and the community following a fall injury hospitalisation can inform service requirements in RACFs and timelines for future use of long-term institution care and aged care services. Identification of predictors of trajectory group membership facilitates targeting of strategies to reduce hospital admissions and design of services to allow community-living individuals to remain as long as possible within their own residence.

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Compliance with ethical standards

Ethical approval was obtained from the NSW Population and Health Services Research Ethics Committee (2008/10/108) and the Australian Institute of Health and Welfare (AIHW) Human Research Ethics Committee (2015/1/159).

Conflicts of interest None.

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