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ORIGINAL ARTICLE

Effect of hospital-acquired complications on hospital length of stay and cost for older adults after a hip fracture in New South Wales, Australia

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Abstract

Summary For older adults following a hip fracture who had hospital-acquired complications (HACs), hospital length of stay (LOS) and costs were over 40% higher compared to those without HACs. Improving strategies for preventing HACs among older adults after a hip fracture would contribute towards a sustainable healthcare system for an aged society.

Purpose Although HACs can result in a high financial burden for health systems, little is known about the effect of common HACs on hospital LOS and cost among older adults after a hip fracture. This study examined the effect of HACs on hospital LOS and cost among older adults after a hip fracture.

Methods This retrospective cohort study used linked hospitalisation and mortality data in New South Wales, Australia, between 2013 and 2022. Older adults who were admitted after a hip fracture and discharged between July 2014 and June 2022 were identified. A 1:1 matched design was used to determine hospital LOS and care costs between older patients with and without HACs.

Results Among 41,013 older patients hospitalised after a hip fracture, 14,050 (34.3%) experienced a HAC. The most common complication was healthcare-associated infections (43.1%). After matching, patients with HACs had a longer hospital LOS (median 31 days, IQR 17–47 days) compared to patients without HACs (median 22 days, IQR 9–35 days) ($P < 0.001$). Patients with HACs had higher hospital costs (median $84,779, IQR $44,296–$131,426) than patients without HACs (median $60,137, IQR $23,995–$100,300) ($P < 0.001$). For patients with HACs, hospital LOS was 43% longer (95% confidence interval (CI): 1.41–1.46), and hospital costs were 42% higher (95% CI: 0.40–0.44) compared to those without HACs.

Conclusions Implementing strategies for preventing HACs among older adults after a hip fracture would contribute towards a sustainable healthcare system as HACs are potentially preventable.

Keywords Australia · Complication · Hip fracture · Hospital cost · Propensity score matching

Introduction

Hip fracture is a common reason for hospital admission among older adults, and the number of hip fractures worldwide has increased over the past three decades, indicating a large global burden of hip fracture [1, 2]. In older adults, hip fracture is often the results of untreated osteoporosis, a chronic disease that becomes increasingly common with age [3, 4]. Older patients with a hip fracture can be at an increased risk of developing hospital-acquired complication (HACs), such as pneumonia, which may add an additional burden on patients, healthcare providers, and the health system [5, 6]. HACs are an important and commonly used indicator of the quality of hospital care for older adults [7–11]. Therefore, it is crucial to examine the impact of HACs and identify strategies to reduce the incidence of HACs for older adults after a hip fracture.

Prior studies have indicated that HACs increase hospital length of stay (LOS) and associated hospital costs among

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patients with dementia, cardiovascular disease, and chronic kidney diseases [12–14]. Estimating the impact of HACs on hospital costs is essential to inform decisions regarding the allocation of healthcare resources. It is estimated that approximately 15% of the total hospital care costs reportedly resulted from HACs in the Organization of Economic Cooperation and Development's (OECD) countries [15]. HACs were estimated to add 17.3% to hospital care costs in Australian public hospitals [16], while preventing HACs in United States (US) hospitals was estimated to save USD $28 billion between 2010 and 2015 [15]. However, there is a lack of population-based studies examining the effects of HACs on hospital LOS and care costs among older adults after a hip fracture.

The Australian Commission on Safety and Quality in Health Care (ACSQHC) identified 16 common HACs through using hospital administrative data [17]. Therefore, using administrative data can inform the impact of HACs on hospital LOS and costs for improving the health care system for older adults following a hip fracture.

Purpose

The current study examined the effects of HACs on hospital LOS and costs among older adults following a hip fracture, using linked administrative data in New South Wales (NSW), Australia.

Methods

Study design and setting

This retrospective cohort study used linked hospital admission and mortality data in NSW, Australia, between 2013 and 2022. NSW has an estimated 1.4 million residents aged ≥ 65 years (17% of all residents) [18]. Ethical approval and a waiver of consent were obtained from the NSW Population and Health Service Research Ethics Committee (2022/ETH00861).

Data sources

Hospitalisation records included inpatient admissions from all public and private hospitals in NSW, Australia, between 1 July 2013 and 30 June 2022. The data comprised patient-level demographic characteristics, diagnoses, external causes, and clinical procedures. Diagnoses and external causes of injury were classified using the International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Australian Modification (ICD-10-AM) and recorded a principal diagnosis and up to 50 additional diagnosis codes. Mortality data were obtained from the NSW Registry of Births, Deaths and Marriages to identify the date of death. Hospitalisation and mortality records were probabilistically linked by the Centre for Health Record Linkage using personally identifiable information such as names, address, date of birth, and sex.

Case identification

Older adults aged ≥ 65 years admitted and discharged from hospital after a hip fracture were identified using a principal diagnosis of hip fracture (ICD-10-AM: S72.0 – S72.2) between 1 July 2014 and 30 June 2022. The first hip fracture hospitalisation in this period for each adult was designated as the index admission. Transfers within and between hospitals were grouped to form one hospitalisation record as the period of care. Patients admitted to private hospitals (n = 2544) were excluded because most hospitalisation data of patients admitted at private hospitals lacked information on Australian Refined-Diagnosis Related Groups (AR-DRGs) to estimate hospital care costs. Older adults who died at the index admission (n = 2820) and had missing information on covariates (n = 1090) were also excluded from the analysis.

HACs

ACSQHC identified 16 common HACs through a comprehensive process that included literature reviews, clinical engagement and testing with public and private hospitals [17]. HACs can be identified using the ICD-10-AM, and condition onset flags (COF), which distinguish between diagnoses 'present on admission' and 'condition onset' during hospitalisation from administrative data [17]. Information on HACs was obtained from the diagnosis classifications and a COF of 1 (i.e., condition with onset during the episode of admitted patient care) for the index hospitalisation [17]. HACs were identified for 13 complications relevant to older adults that could be determined by using diagnosis classifications (i.e., ICD-10-AM 8 th to 12 th editions) and a COF [17]. The HACs included: pressure injury, falls resulting in fracture or other intracranial injury, healthcare-associated infection, surgical complications requiring unplanned return to theatre, respiratory complications, venous thromboembolism, renal failure, gastrointestinal bleeding, medication complications, delirium, incontinence, endocrine complications, and cardiac complications [17]. Three complications (unplanned intensive care unit admission, third and fourth degree perineal laceration during delivery, and neonatal birth trauma) were not included as HACs in the current study.

Identification of comorbidities, frailty risk, place of incident and hip fracture surgery

Charlson comorbidities and frailty risk were identified using a one-year look-back period from an admission of up to 51 diagnosis classifications in the hospital admission data. The number of Charlson comorbidities was categorized as nil, 1, and ≥ 2 comorbidities [19]. Frailty risk was estimated using the Hospital Frailty Risk Score (HFRS) [20]. The HFRS ranges from 0 to 99, and patients were allocated into three categories: HFRS < 5, HFRS 5–15, and HFRS > 15 [20]. The incident place of incidence (i.e., residential institution and home or other places) was identified using the ICD-10-AM place and other location identifying classifications in the hospitalisation data. Additionally, hip fracture-related surgery was identified using procedure codes (47519–00, 47522–00, 47528–01, 47531–00, 49315–00, 49318–00, and 49319–00) based on the prior study [21].

Identification of geographic location

Using the Australian Statistical Geographical Standard [22], which defines five classes of remoteness basis of a measure of relative access to services, was dichotomized as urban (i.e., major cities) or rural (i.e., inner regional, outer regional, remote, and very remote).

Study outcomes: hospital LOS and hospital care cost

Hospital LOS was determined during a period of care for the index hospital admission. LOS was capped at 365 days. AR-DRGs and LOS were used to estimate hospital care costs based on a prior study [23]. Estimates of public hospital care costs were obtained from the National Hospital Costing Data Collection between the Financial Year (FY) 2014–2015 and FY 2021–2022 [24]. The average hospital care costs per AR-DRG included costs for direct care costs and indirect care costs (including overhead costs) such as costs for medical and nursing clinical services, non-clinical salaries, pathology, imaging, allied health, pharmaceuticals, operating rooms, emergency departments, supplies and ward, specialist procedure suites, prosthetics, staff-on cost, hotel, depreciation costs, and patient travel [24]. The average daily cost per AR-DRG was multiplied by LOS up to 120 days of the index injury hospitalisation, and where a LOS exceeded 120 days, a flat rate of $200 per day was applied [23]. All costs from FY 2014–2015 to FY 2020–2021 were adjusted for FY2021–2022 Australian dollars using an inflation calculator [25].

Data management and analysis

All analyses were performed using SAS version 9.4 (SAS Institute Inc). Patients with and without HACs were randomly matched 1:1 using a greedy algorithm 5–1 digit match based on propensity score to adjust for covariates (i.e., sex, age group, location of residence, number of Charlson comorbidities, frailty risk, place of incident, hip fracture-related surgery, and FY of hospitalization after a hip fracture) [26]. From the hospitalization data, information on patient sex (male and female), age (65–74, 75–84, and ≥ 85), and FY of hospitalization after a hip fracture (FY 2014–2015 to FY 2021–2022). Covariates recognised in the literature [12, 27, 28] and available in the hospitalisation data were included in the regression model to examine the association of HACs with hospital LOS and care costs. The C-statistic was calculated to evaluate the model's goodness of fit. After matching, patient characteristics were compared between the two cohorts using absolute standardized differences (ASD). An ASD > 0.1 indicated a significant imbalance in a covariate [29]. The Wilcoxon rank sum test was used to compare outcomes between patients with and without HACs. The effect of HACs on hospital LOS was estimated using the rate ratio based on the negative-binomial regression. The effect of HACs on hospital costs was estimated using the coefficient of HACs based on a linear regression model (log-transformed). Sensitivity analyses were conducted to examine the effect of HACs on LOS and costs through negative binomial and linear regression models, respectively, adjusted for all covariates. In addition, multivariable binominal logistic regression models adjusted for all covariates were conducted to compare mortality within six months after hospital discharge between older adults with and without HACs.

Results

There were 41,013 older adults admitted after a hip fracture and discharged between July 2014 and June 2022 (Fig. 1). The mean age was 83.3 years (SD: 8.1 years) at the time of admission, and 69.2% of patients were female. Of these, 14,050 older adults (34.3%) who experienced at least one HAC.

Compared to patients without HACs, a higher proportion of patients with HACs were aged 85 years or older (54.5%), had ≥ 2 Charlson comorbidities (26.0%) and had an intermediate or high frailty risk (76.3%). Additionally, a higher proportion of patients with HACs had fractured their hip at home or other places (75.3%) and underwent hip fracture surgery (94.5%) than patients without HACs. The most common complications experienced by hip fracture patients were healthcare-associated infections (*n* = 6058, 43.1%), and delirium (*n* = 4390, 31.2%) (Table 1).

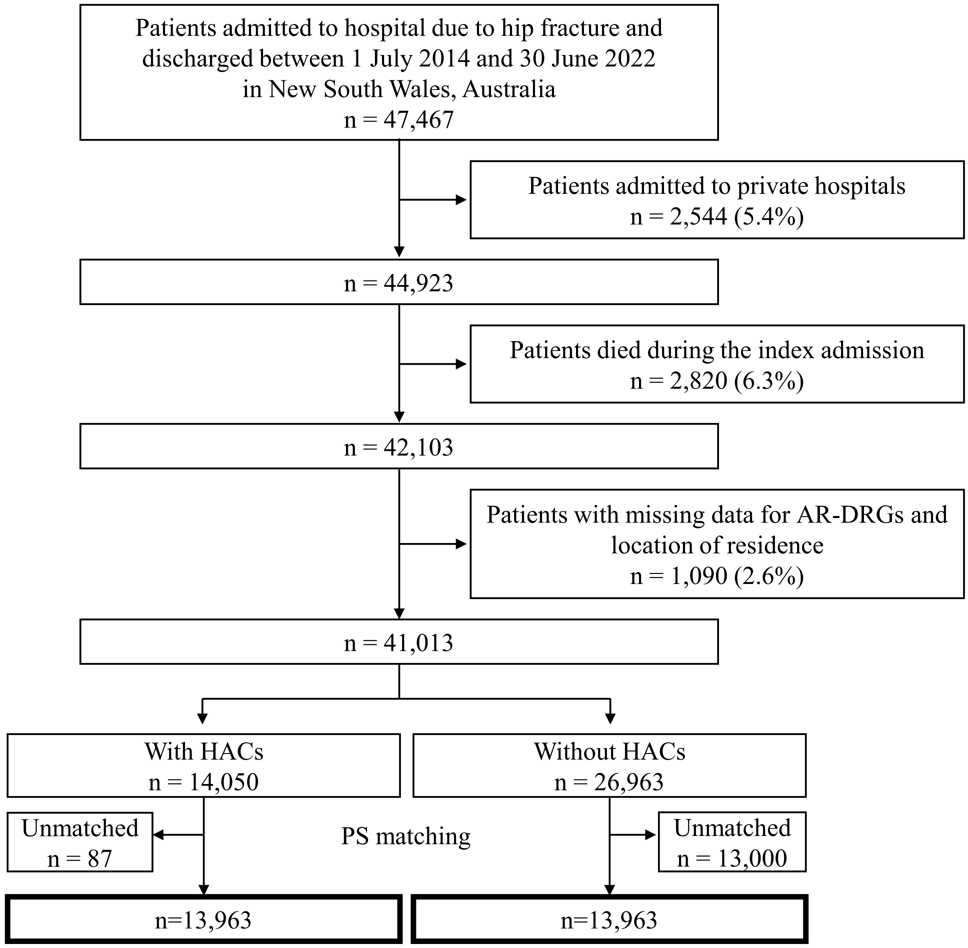

Fig. 1 Flow chart of patient selection

After 1:1 propensity score matching, the two patient cohorts (with and without HACs) consisted of 13,963 matched pairs. The C-statistic of the propensity score model was 0.63 (95% CIs: 0.63–0.64). The ASD between the groups was within the acceptable margin of 0.1 for all characteristics (Table 2).

In the matched pairs, patients with HACs had a longer hospital LOS (median 31 days, IQR 17–47 days) compared to patients without HACs (median 22 days, IQR 9–35 days) ($P < 0.001$) (Table 3). Patients with HACs also had higher hospital costs (median $84,779, IQR $44,296–$131,426) than patients without HACs (median $60,317, IQR $23,995–$100,300) ($P < 0.001$). For patients with HACs, hospital LOS was 43% longer (95% confidence interval (CI): 1.41–1.46), and hospital costs were 42% higher (95% CI: 0.40–0.44) compared to patients without HACs. The results were similar when the effect estimates were analysed through negative binomial and linear regression models adjusted for all covariates (Supplementary Table S1). Older adults with HACs also had a higher risk of mortality within six months after hospital discharge (Supplementary Table S2).

Discussion

This study examined the effects of HACs on hospital LOS and costs among older adults who sustained a hip fracture using large population-based data. The current study found that over one in three older patients hospitalised after a hip fracture experienced a HAC. Among older patients with HACs, the excess LOS was a median of 9 days, and the excess hospital care cost was AUD$24,642 compared to older patients without HACs. Older patients with HACs had over a 40% longer hospital LOS and higher hospital costs than patients without HACs. In addition to strategies to prevent hip fracture, including bone protective medications and fall prevention, improving approaches to prevent HACs in older adults after a hip fracture would contribute towards a sustainable healthcare system.

The current study finding that HACs led to longer hospital LOS and higher hospital costs was consistent with the previous studies [12–14, 30]. This current study also included a sensitivity analysis adjusted for all covariates after matching showed that older patients with HACs had

Table 1 Characteristics of older adults after a hip fracture with and without HACs before matching

Characteristics	HACs, n = 14,050		No HACs, n = 26,963		ASD[a]
	n	%	n	%	
Sex					
Male	4536	32.3	8085	30.0	0.040
Female	9514	67.7	18,878	70.0	
Age group					
65–74	1675	11.9	5191	19.3	0.171*
75–84	4713	33.5	9472	35.1	0.027
≥85	7662	54.5	12,300	45.6	0.146*
Location of residence					
Urban	10,079	71.7	18,281	67.8	0.070
Rural	3971	28.3	8682	32.2	
Number of Charlson comorbidities					
Nil	6028	42.9	13,680	50.7	0.129*
1	4374	31.1	8112	30.1	0.019
≥2	3648	26.0	5171	19.2	0.131*
Frailty risk, HFRS					
Low (<5)	3334	23.7	8376	31.1	0.137*
Intermediate (5-–15)	6643	47.3	11,739	43.5	0.061
High (>15)	4073	29.0	6848	25.4	0.066
Place of incident					
Residential institution	3474	24.7	7909	29.3	0.086
Home or other places	10,576	75.3	19,054	70.7	
Hip fracture surgery					
No	772	5.5	3850	14.3	0.261*
Yes	13,278	94.5	23,113	85.7	
FY of hospitalization after a hip fracture					
July 2014 to June 2015	1782	12.7	3763	14.0	0.031
July 2015 to June 2016	1946	13.9	3583	13.3	0.013
July 2016 to June 2017	2053	14.6	3451	12.8	0.043
July 2017 to June 2018	2004	14.3	3365	12.5	0.042
July 2018 to June 2019	1738	12.4	3330	12.4	<0.001
July 2019 to June 2020	1632	11.6	3225	12.0	0.009
July 2020 to June 2021	1534	10.9	3215	11.9	0.026
July 2021 to June 2022	1361	9.7	3031	11.2	0.042
HACs					
1. Pressure injury	424	3.0	-	-	
2. Falls resulting in fracture or other intracranial injury	271	1.9	-	-	
3. Healthcare-associated infection	6058	43.1	-	-	
4. Surgical complications requiring unplanned return to theatre	2194	15.6	-	-	
6. Respiratory complications	1039	7.4	-	-	
7. Venous thromboembolism	575	4.1	-	-	
8. Renal failure	1508	10.7	-	-	
9. Gastrointestinal bleeding	372	2.6	-	-	
10. Medication complications	2579	18.4	-	-	
11. Delirium	4390	31.2	-	-	
12. Incontinence	252	1.8	-	-	
13. Endocrine complications	572	4.1	-	-	
14. Cardiac complications	1794	12.8	-	-	

HACs, hospital-acquired complications; *HFRS*, Hospital Frailty Risk Score; *ASD*, absolute standardized difference; *FY*, financial year.[a]ASD > 0.1 was marked with *

Table 2 Characteristics of older adults after a hip fracture with and without HACs after matching

Characteristics	HACsn = 13,963		No HACs n = 13,963		ASD[a]
	n	%	n	%	
Sex					
Male	4479	32.1	4418	31.6	0.008
Female	9484	67.9	9545	68.4	
Age group					
65–74	1675	12.0	1650	11.8	0.005
75–84	4713	33.8	4744	34.0	0.004
≥85	7575	54.3	7569	54.2	0.001
Location of residence					
Urban	10,001	71.6	10,051	72.0	0.006
Rural	3962	28.4	3912	28.0	
Number of Charlson comorbidities					
Nil	6028	43.2	6065	43.4	0.004
1	4374	31.3	4387	31.4	0.002
≥2	3561	25.5	3511	25.1	0.007
Frailty risk, HFRS					
Low (<5)	3330	23.8	3241	23.2	0.012
Intermediate (5–15)	6606	47.3	6679	47.8	0.009
High (>15)	4027	28.8	4043	29.0	0.002
Place of incident					
Residential institution	3474	24.9	3509	25.1	0.005
Home or other places	10,489	75.1	10,454	74.9	
Hip fracture surgery					
No	772	5.5	760	5.4	0.003
Yes	13,191	94.5	13,203	94.6	
FY of hospitalization after a hip fracture					
July 2014 to June 2015	1782	12.8	1769	12.7	0.002
July 2015 to June 2016	1942	13.9	1993	14.3	0.009
July 2016 to June 2017	2016	14.4	1973	14.1	0.007
July 2017 to June 2018	1972	14.1	1947	13.9	0.004
July 2018 to June 2019	1732	12.4	1685	12.1	0.008
July 2019 to June 2020	1624	11.6	1589	11.4	0.006
July 2020 to June 2021	1534	11.0	1557	11.2	0.004
July 2021 to June 2022	1361	9.7	1450	10.4	0.017

HACs, hospital-acquired complications; HFRS, Hospital Frailty Risk Score; ASD, absolute standardized difference; FY, financial year.[a]ASD > 0.1 was marked with *

Table 3 Comparison of LOS and hospital costs of older adults with and without HACs after a hip fracture after matching (n = 27,986)

	HACs, n = 13,993		No HACs, n = 13,993		P-value[a]	Effect estimate(95% CI)
	Median	IQR	Median	IQR		
Hospital LOS (days)[b]	31	17–47	22	9–35	<.0001	1.43 (1.41 - 1.46)
Hospital costs	84,779	44,296 –13,1426	60,137	23,995–100,300	<.0001	0.42 (0.40 –

HACs, hospital-acquired complications; IQR, Interquartile Range; CI, Confidence Interval

[a] Wilcoxon rank sum test

[b] Effect estimate was the rate ratio estimated by negative-binomial regression

[c]Effect estimate was the coefficient of HACs estimated by linear (log-transformed) regression

over a 40% longer hospital LOS and higher hospital costs than patients without HACs. Although prolonged hospital LOS due to HACs in the current study (around ten days) was similar to that observed in a previous Australian study on patients with cardiovascular disease, the previous study showed a stronger effect of HACs on hospital LOS and costs than that of the current study [14]. Among older patients with cardiovascular disease, patients with HACs experienced three times longer hospital LOS and higher hospital costs than older patients without HACs [14]. In addition, another Australian study on older patients with dementia showed that patient with HACs had approximately a 60% longer hospital LOS and higher hospital costs than patients without HACs [13]. This difference may be due to the typically shorter hospital LOS among patients without HACs who had a cardiovascular disease compared to patients with a hip fracture. While the additional LOS due to HACs among older adults with a hip fracture may resemble that seen in patients hospitalised with cardiovascular disease and dementia [13, 14], the relative effect of HACs on hospital burden among older adults after a hip fracture may be less than for patients with different conditions generally required shorter hospital stays. However, the incidence of HACs (34.3%) estimated using ICD-10-AM from hospitalisation data among older patients with a hip fracture was higher than the incidence of HACs (9.3%) among patients with a cardiovascular disease and the incidence of HACs (9.7%) of major hospital episode [14, 31].

The impact of HACs on hospital costs among older adults following a hip fracture was substantially higher than those observed in general hospitalised patients from a prior study [32]. General patients with HACs had 8.3% higher hospital costs than patients without HACs [32]. The difference may be due to the higher prevalence of frailty and physical and cognitive functional decline in older patients after a hip fracture than general hospitalised patients, which likely contributed to a greater risk of HACs and the need for longer hospital LOS [7, 28, 33]. That older adults with HACs had a higher risk of mortality within six months after hospital discharge was consistent with findings from previous studies on HACs [7, 14]. Therefore, preventing HACs among older adults after a hip fracture would contribute towards a sustainable healthcare system in an ageing society.

The current findings that healthcare-associated infection and delirium were common HACs is consistent with previous studies [8, 30, 34]. These two complications should be a high priority for prevention strategies. First, infections in older patients are more frequent than in younger patients due to immunosenescence, and healthcare workers' hands are the most common vehicle for transmitting healthcare-associated infection between patients and other healthcare workers [35, 36]. A recent systematic review also reported that the use of mobile phones by healthcare workers without proper disinfection could increase the risk of healthcare-associated infection [37]. Educational interventions for healthcare workers on hand hygiene and safe handling of mobile phones would be effective ways to prevent healthcare-associated infection [37, 38].

Older adults after a hip fracture appear to be a key target for intervention to prevent delirium because uncontrolled pain is a common predictor for delirium [39]. Several recent systematic reviews showed that pharmacological intervention, such as melatonin and a multifactorial intervention program, including avoidance of antipsychotics, family support, and treating medical factors, can reduce the incidence of delirium [39, 40]. In particular, multifactorial intervention programs would likely be effective for preventing HACs among older adults after a hip fracture because a multifactorial intervention may also reduce other complications (e.g., delirium prevention programs can also reduce inpatient falls) [41].

The strength of this study is that it is population-based, using all hospitalisations of older adults after a hip fracture hospitalised in NSW, Australia. Nevertheless, there are several limitations. First, the current study could not account for several confounders, such as physical and cognitive functional status [7, 42, 43], as this information is not available in hospitalisation data. However, this study included frailty risk estimated by using a one-year look-back period as a covariate in this study [20]. Second, although the current study identified HACs using the definitions developed by the Australian government [17], no assessment of the data validity was able to be conducted. The identification of HACs in this study are likely to be under-enumerated due to under-documentation and classification in the hospitalisation data [44]. Third, although these results are generalisable among citizens hospitalised in NSW, these findings might not be generalisable to other jurisdictions or other countries. However, as HACs are a common issue across low- to high-income countries, the current study highlights the importance of improving strategy strategies to prevent HACs as port of building a sustainable healthcare system [45]. Finally, the cost calculation in this study included only hospital costs, which did not include other treatment-related costs, such as treatment provided by general practitioners and allied health professionals. However, these treatment costs may be relatively minor compared to hospital treatment costs. Despite these limitations, the findings of the current study may inform decisions regarding strategies to reduce HACs among older people, thereby improving healthcare for older adults.

Conclusions

Over one in three older patients who were hospitalised after a hip fracture experienced a HAC. Older patients with HACs had approximately 40% longer hospital LOS and higher hospital costs than patients without HACs. Implementing strategies for preventing HACs among older adults after a hip fracture would contribute towards a sustainable healthcare system as HACs are potentially preventable.

Supplementary information The online version contains supplementary material available at https://doi.org/10.1007/s00198-025-07536-8.

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Data availability The authors do not have permission to share data.

Declarations

Conflicts of interest Seigo Mitsutake, Reidar P Lystad, Tolesa Okuba, Janet C. Long, Jeffrey Braithwaite, Takumi Hirata, Rebecca Mitchell declare that they have no conflict of interest.

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