A 10-year cohort study of the burden and risk of in-hospital falls and fractures using routinely collected hospital data

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Data sharing statement The full data-extraction algorithm can be obtained on request from VS (vijaya.sundararajan@med.monash.edu.au)

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ABSTRACT

Objectives To document the burden of in-hospital falls and fractures, and to identify factors that may increase the risk of these events.

Design A retrospective cohort analysis

Setting The study was set in the State of Victoria, Australia.

Participants Hospital episode data collected in the Victoria Admitted Episodes Dataset, for all multiday-stay patients 18 years or more admitted to Victorian public hospitals; 1 July 1998 to 30 June 2008. Diagnoses were defined by the International Classification of Disease, 10th Revision, Australian Modification (ICD-10-AM), which includes an in-hospital diagnostic timing code. Outcome measures included rates of in-hospital falls and fractures, length of hospital stay and mortality. Variables included in risk adjustment included financial year, individual demographic and comorbidity data, and hospital characteristics.

Results There were 3 345 415 episodes: 21 250 (0.64%) in-hospital falls and 4559 (0.14%) fractures. In-hospital fall (IHF) episode *rates* increased over the study period, but *fracture* episode rates were stable. Mortality (HR 1.3, CI 1.3 to 1.5) and length of stay (median 19 days vs 5 days, p<0.0001) were increased with IHF. Risk factors for IHF included dementia (rate ratio 1.7, CI 1.6 to 1.8) and delirium (rate ratio 1.8, CI 1.6 to 2.0).

Conclusions Routinely collected data that include a hospital diagnostic timing code offer a standard method of quantifying in-hospital falls and fractures. Unselected in-hospital falls data may be subject to reporting and documentation bias. The utility of using robust selected injuries such as IHF-related fracture as a quality-of-care indicator requires further investigation.

INTRODUCTION

International studies indicate that 3.2–10.6% of hospitalisations are associated with an adverse event, with a substantial impact on patient health outcomes and health costs.[1–3] Falls are serious adverse events associated with increased length of in-hospital stay, functional decline[4–7] and litigation claims.[8]

Accurate measurement of adverse events is important for understanding and reporting *the* performance of healthcare systems. For in hospital falls (IHF), there is a wide variation in the reported burden, reflecting complexity of the problem, heterogeneity in study design, patient population, fall case-definition[9] and contextual factors. Similarly, there is conflicting information about risk factors for IHF and fall-related injuries. Understanding these factors is important, not only to inform interventional strategies, but also for development of robust risk adjustment models for comparative benchmarking of organisational performance.

The main data source for IHF are incident reporting systems. These provide important qualitative information about the nature and causation of falls[10] and safety culture,[11] but do not provide robust epidemiological information for monitoring system performance.[12 13] Medical record review and prospective observational studies provide more detailed clinical information about potential risk factors but are time-consuming and costly to conduct.[1 14 15] Routinely collected data are an alternative source of information about IHF events that capture data for the whole population. To date, the utility of monitoring IHF using routinely collected data has not been widely researched with existing studies limited by the absence of timing codes that accurately identify in-hospital events.[16 17]

The purpose of this study was to perform a retrospective population cohort study to measure rates of public hospital IHF and fall-related fractures (FRFx) and to identify factors which may increase the risk of these two events using routinely collected hospital discharge data over a 10-year period from 1 July 1998 to 30 June 2008.

METHODS

This study was approved by Monash University, Standing Committee on Ethics in Research Involving Humans.

Study setting and population

All residents in Australia have free access to publicly funded hospitals and may also choose to have private insurance for care in private hospitals. More than 5 million people reside in Victoria, the second largest State in Australia.[18] The analysis sample included all public hospital discharge episodes in the State of Victoria included within the Victorian Admitted Episodes Dataset (VAED) for persons aged 18 years or more, admitted for 2 days or more between 1 July 1998 and 30 June 2008.

The VAED was developed to meet national reporting obligations and support output-based funding of Victorian hospitals.[19] It includes demographic, administrative and clinical information, and is externally linked to the Victorian Death Registrations. Since 1998, clinical information in the VAED has been coded using the International Classification of Diseases, 10 Revision, Australian Modification (ICD-10-AM). There are now 40 diagnostic code fields. For each diagnostic code, the timing of diagnosis is indicated by a corresponding variable which can take on several values: P (principal reason for admission), A (associated condition—comorbidity) or C (a new diagnosis arising during admission).[20 21] Good to excellent coding quality of ICD-10-AM has been demonstrated for principal procedure codes, many diagnostic codes and coding of comorbid diagnoses.[22]

An IHF was defined as a fall event that occurred at any time during a single multiday stay hospital episode and was coded for inclusion in the VAED. A FRFx was defined as any fracture that occurred during a single hospital episode in which there was also documented an IHF and which was coded within the VAED. ICD-10-AM codes were used to define falls (W codes), injuries (S codes) and fractures (T codes) (table 1). Coders follow standard coding criteria for the inclusion of additional diagnoses; therefore, only IHF associated with analgesia administration, radiological investigation, increased clinical monitoring or injuries are coded. Fractures without falls were excluded, as these may represent misclassification of prehospital fractures diagnosed late or pathological fracture.

In the most recent audit of coding quality in Victoria, conducted in 2005–2006 of 10 010 (approximately 1% of all non-chemotherapy/non-dialysis) public hospital discharges, the prevalence of in-hospital falls based on the coding algorithm above was 3.64% in the original hospital coding versus 3.60% for the auditors; furthermore, using the auditor's codes as the reference standard, the sensitivity was 95.3% and the specificity 99.8%. The κ was 0.94 (personal communication).

Further elements of the data for analysis are summarised in table 1. The Charlson condition diagnoses and additional fall and fracture risk conditions (osteoporosis, stroke, Parkinson's disease, ataxia, visual impairment, deafness, delirium) were included in risk adjustment; these comorbidities included only those present on admission. In-hospital comorbid diagnoses, flagged by the C-diagnosis timing code, were excluded.[23 24]

Statistical analysis

The data were extracted and analysed using SAS8.2 (SAS Institute, Cary, North Carolina).[25] Crude rates of IHF were expressed as rate/1000 bed days. A descriptive analysis was undertaken to investigate associations between covariates of interest and fall events.

Multivariable Poisson regression models, corrected for overdispersion (PROC GENMOD), were then fitted to ascertain independent associations for experiencing an IHF or FRFx. The risk of FRFx was considered in two ways; for the whole population on admission (FRX model 1, denominator all episodes) and for those who experienced an IHF (FRFx model 2, denominator IHF episodes).

To assess the impact of fall-related events on survival, an index admission was defined for patients with a first IHF after 1 July 2002 (no IHF or presenting fall between 1 July 1998 and 30 June 2002). Controls were matched to these cases by age and gender from a randomly selected sample population without IHF with a first public hospital admission after 1 July 2000. Survival was defined from the date of the index admission to the date of death

Table 1 Summary of data-extraction variables

	Covariate definition/label
Fall	ICD-10-AM* three-digit codes W01, W03, W04, W05, W06, W07, W08, W10, W13, W17, W18, W19
Injury	Two-digit codes T0, T1, T8, T9 and Three-digit code T79
Fracture	Three-digit codes S12, S22, S32, S42, S52, S62, S72, S82, S92,T02, T08, T10, T12
Event timing	Diagnosis timing code of 'C,' indicating that diagnosis occurred in hospital
Length of stay	Days
Year of fall	Financial year (1 July to 30 June)
Age	5-year groups
Gender	Male, female
Marital status	Yes/no
Australian-born	Yes/no
English-speaking country of birth	Yes/no
Geographic setting	Metropolitan/rural
Socio-economic†	Based on the geographic area of residence, the lowest quartile of Socio-Economic Indexes for Areas score versus top three quartiles is presented for education occupation and education resources
Hospital care type	Acute/newborn, palliative, geriatric, mental/alcohol-related, rehabilitation, interim, nursing home
Admission type	Emergency, elective
Admission source	Home, transfer, other
Stay type	Sameday, multiday
Hospital type	Teaching, other
Diagnostic-related group	Medical, surgical, other
Previous fall history	Documentation in previous separation as presenting or in hospital fall (yes, no)
Presenting with fall	P fall (yes, no)
Comorbidities other than those listed in the Charlson Index	
Ataxia	Four-digit codes G110, G111, G112, G113, G114, G118, G119, R270, R278
Deafness	Three-digit code H90, four-digit codes; H910, H911, H912, H913, H918, H919, Q780
Delirium	Four-digit codes F050, F051, F058, F059, F104, F106, F114, F124, F134, F144, F154, F164, F174, F184, F194, F430
Neuromyalgia	Four-digit code M792
Osteoporosis	Three-digit codes; M80, M81, M82
Parkinson's disease	Three-digit code G20
Vision impairment	Three-digit codes; H53, H54

*All diagnostic codes are defined using ICD-10-AM.
†http://www.abs.gov.au/websitedbs/D3310114.nsf/home/Seifa_entry_page.

or the end of follow-up (30 June 2008). The risk of mortality was investigated using a Cox proportional hazards model, adjusted for covariates of interest and expressed as a HR. The FRF Cox proportional hazards model was conducted among the cases of IHF in this truncated sample. The relationships between IHF, FRFx and median length of stay were assessed using the non-parametric Wilcoxon Rank Sum test.

RESULTS

The dataset included 3 345 415 episodes, of which 21 250 (0.64%) were coded with an IHF, and 4559 were coded with an FRFx (17.6% IHF and 0.14% total episodes). Notably, 827 (18%) in hospital fractures) occurred in an episode without a coded IHF; in which there was an associated diagnosis of cancer in 71 (8.6%) or metastatic cancer (3.8%). There were 1656 in hospital hip fractures (44.4% all in hospital fractures). Overall FRFx accounted for 18.5% of all in-hospital injuries.

IHF were more common when the presenting episode diagnosis was a fall (1.5% vs 0.6%, p<0.0001) or an injury (1.0% vs 0.6%, p<0.0001). Similarly FRFx was more prevalent in those admitted with a fall (21.2% vs 17.1%, p<0.0001), any fracture (23.8% vs 16.8%, p<0.0001) or hip fracture (25.8% vs 17%, p<0.0001). Of those admitted with hip fracture, 8.7% experienced a further FRFx.

The general characteristics of all hospital discharges are summarised in table 2. Nearly one-third of all episodes occurred in rural settings. Over 50% of episodes were for individuals over 50 years of age. The proportion over 80 years (19.4% total population) was higher for those with an IHF (50.9%) and FRFx (57.3%). There was a higher proportion of women (63%) in the

Table 2 Summary of demographic and clinical details for hospital episodes associated with falls and fall-related fractures (FRF) in Victorian public hospitals between 1998 and 2008

	All episodes N=3344588		Episodes for IHF N=21250			Episodes for FRFx N=3732		
	N	Percentage	N	Percentage	Row (%)	N	Percentage	Row (IHF) %
Age (years)								
18–39	945222	28.3	679	3.2	0.1	56	1.5	8.2†
40–49	302701	9.1	650	3.1	0.2	63	1.7	9.7†
50–59	343593	10.3	1035	4.9	0.3	140	3.8	13.5
60–69	451678	13.5	2129	10.0	0.5	302	8.1	14.2*, †
70–79	654272	19.6	5942	28.0	0.9	1034	27.7	17.4
80–89	524673	15.7	8179	38.5	1.6	1638	43.9	20.0+
90+	123276	3.7	2636	12.4	2.1	499	13.4	18.9
Gender								
Female	1952479	58.4	11020	51.9	0.6	2350	63.0	21.3*
Male	1392936	41.6	10230	48.1	0.7*	1382	37.0	13.5†
Australian-born	2246610	77.2	13485	63.5	0.6†	2387	64.0	17.7
English-speaking country of birth	2535841	75.8	15724	74.0	0.6†	2768	74.2	17.6
Married	1640294	49.8	8481	39.9	0.5†	1282	34.3	15.1†
Rural	942013	28.9	4894	23.3	0.5†	817	22.1	16.7
Socio-economic								
Education occupation	928424	27.8	5422	25.5	0.6†	918	24.6	16.9
Education resources	473998	14.2	2846	13.3	0.6	465	12.5	16.3
Comorbid conditions								
Cancer	328146	9.8	2876	13.5	0.9*	405	10.9	14.1*
Metastatic cancer	161561	4.8	1557	7.3	1.0*	217	5.8	13.9*
Chronic heart failure	216452	6.5	2589	12.2	1.2*	483	12.9	18.7
Cerebrovascular disease	158876	4.8	2617	12.3	1.7*	431	11.6	16.5
Connective tissue disease	25452	0.8	223	1.1	0.9*	57	1.5	25.6
Chronic pulmonary disease	243823	7.3	1838	8.7	0.8*	359	9.6	19.5
Dementia	151519	4.5	4017	18.9	2.7*	844	22.6	21.0*
Diabetes	246011	7.4	1896	8.9	0.8*	363	9.7	19.2
Severe diabetes	102253	3.1	1301	6.1	1.3*	177	4.7	13.6
HIV	6753	0.2	57	0.3	0.8	9	0.2	15.8
Liver disease	16910	0.5	212	1	1.3*	34	0.9	15.7
Severe liver disease	12810	0.4	151	0.7	1.2*	20	0.5	13.3*
Myocardial infarction	113555	3.4	742	3.5	0.7	122	3.3	16.4
Paraplegia	88510	2.7	1635	7.7	1.9*	247	6.6	15.1
Peptic ulcer disease	23912	0.7	179	0.8	0.8	33	0.9	15.6
Peripheral vascular disease	36571	1.1	343	1.6	0.9*	62	1.7	18.1
Renal disease	164412	4.9	2203	10.4	1.3*	347	9.3	15.8
Ataxia	9382	0.3	205	1.0	2.2*	26	0.7	12.7
Delirium	45092	1.4	1272	6.0	2.8*	240	6.4	18.9
Hearing deficit	16459	0.5	417	2.0	2.5*	69	1.9	16.6
Osteoporosis	34521	1.0	663	3.1	1.9*	228	6.1	34.4*
Parkinson's disease	30819	0.9	933	4.4	3.0*	170	4.6	18.2
Visual deficit	27934	0.8	540	2.5	1.9*	97	2.6	18.0

*Higher prevalence of in-hospital falls (IHF) or FRFx.
†Lower prevalence of IHF or FRFx associated with variable, assessed using univariate statistical analysis, p≤0.001.

FRFx group. The most prevalent comorbidities among the total population were: cancer, diabetes, pulmonary disease and chronic heart failure. However, dementia was the major comorbid condition associated with IHF (18.9%) and FRFx (22.6%). There was also a higher proportion of episodes with a comorbid diagnosis of delirium among IHF (6.0%) and FRFx (6.4%) compared with the total population (1.4%).

Hospital characteristics are summarised in table 3. Emergency admissions accounted for fewer FRFx episodes (44.5% vs 52.4% total). Acute and newborn care type accounted for the highest volume of episodes for all groups, but geriatric type was prominent in IHF (14.4%) and FRFx (20.3%) compared with total (2.8%), as was rehabilitation type (IHF 10.3%, FRFx 14.2%, total 3.8%).

Unadjusted rates of IHF increased over the 10-year period (from 0.41 to 0.88 IHF/1000 bed days) (table 4). The fracture rates were discordant between models. Rates for FRFx (0.11 to 0.13/1000 bed days) remained stable in Model 1 but were markedly reduced in FRFx Model 2 (0.09 to 0.03/1000 bed days). These trends were also noted in the adjusted data (figure 1).

In the Poisson regression model (table 5), the strongest associations with IHF were: increasing age and comorbidities; HIV (RR 2.2, CI 1.4 to 3.5), liver disease (RR 1.8, CI 1.4 to 2.4), Parkinson's disease (RR 1.7, CI 1.5 to 1.9), ataxia (RR 1.6, CI 1.2 to 2.0), dementia (RR 1.7, CI 1.6 to 1.8) and delirium (RR 1.8, CI 1.6 to 2.0). In FRFx Model 2 there was similarly a strong association with increasing age, and comorbidities but an inverse relationship with male gender (RR 0.8, CI 0.7 to 0.9). Of interest, a history of previous fall was associated with a somewhat lower IHF rate (RR 0.8, CI 0.8 to 0.9) and FRFx (model 1) rate (RR 0.8, CI 0.7 to 0.9), but this was not the case for FRFx-model 2. There were no additional factors in this second fracture model for which an independent association with fracture could be identified.

The median length of stay (LOS) was longer for episodes associated with an IHF (19 days vs 5 days, p<0.0001), and this difference was greater for episodes associated with FRFx (23 days vs 5 days, p<0.0001).

The HR for mortality for an IHF was increased at 1.3 (CI 1.3 to 1.5, p<0.0001). An FRFx conferred no additional mortality risk (HR 1.1, CI 1.0 to 1.3).

DISCUSSION

We have quantified the burden of IHF and FRFx across a broad range of public hospitals in Victoria, Australia. While the definition of falls in this study was limited by the Australian coding standard to more serious falls and fall-related events, the data-extraction algorithm provides a reproducible process for data analysis. It may be suitable for benchmarking comparisons where ICD-10 coding forms the basis of data definition, and comparable quality of the coding can be established. With the specific in-hospital diagnosis timing codes, we have been able to provide population level figures about falls in all hospital episode types. In contrast, the Agency for Healthcare Research and Quality (AHRQ) in the USA has included within their Patient Safety Indicator set a falls indicator in which the population of interest is restricted to post surgical falls in an attempt to avoid including false-positive adverse events. The introduction of the 'present on admission' flag throughout the US and the 'condition-onset flag' Australia-wide in late 2008 may widen the utility of standardised algorithms such as those presented here.

There is limited ability to compare our results to previous studies due to differences in methodology. Our baseline IHF rate is significantly lower than that reported in other Australian studies based on incident reporting data (5.4–7.9 falls/1000 bed days).[26 27] Although rates of IHF within different (often small) patient populations and settings have been reported to vary between 0.3 and 19.0/1000 bed days based on incident reporting data,[28] our low rate almost certainly reflects the definition of the denominator IHF for this study and the failure therefore to capture all IHF, especially falls of lower severity. It is also difficult to compare fall-related injury rates.[9] Overall, previous studies based on a variety of settings and patient populations report the proportion of fall injuries to be between 26.7% and 70% of all fall incidents, and the proportion of fracture injuries to vary between 2.1 and 6%.[7 27–30] Our higher proportion of fracture injuries is

Table 3 Summary of hospital characteristics for in-hospital falls (IHF) and fall-related fractures (FRFx) between 1 July 1998 and 30 June 2008

	Total episodes N=3344588		IHF episodes N=21250			FRFx episodes N=3732		
Characteristic	**N**	**Percentage**	**N**	**Percentage**	**Row percentage**	**N**	**Percentage**	**Row percentage (of IHF)**
Emergency admission	1751778	52.4	11397	53.6	0.7	1659	44.5	14.6†
Care type								
Acute and newborn‡	2913988	87.1	13787	64.9	0.50	1953	52.3	14.2†
Palliative	39931	1.2	647	3.0	1.6	123	3.3	19.0
Geriatric	93542	2.8	3061	14.4	3.3	759	20.3	24.8*
Mental and ETOH	145752	4.4	791	3.7	0.5	218	5.8	27.6*
Rehab	127538	3.8	2181	10.3	1.7	528	14.2	24.2*
Interim care§	9865	0.3	169	0.8	1.7	24	0.6	14.2
Interim care—nursing§ home type	14799	0.4	614	2.9	4.2	127	3.4	20.7
Admission source								
Home	1451945	43.4	7741	36.4	0.5	996	26.7	12.9†
Transfer	346474	10.4	5216	24.1	1.5*	1101	29.5	21.5*
Other	1546996	46.2	8383	39.5	0.5	1635	43.8	19.5*
Teaching hospital	1941541	58.5	11349	53.7	0.6†	1769	47.5	15.6†
Previous separation with fall¶	599692	17.9	6518	30.7	1.1*	1250	33.5	19.3

*Higher prevalence of IHF or FRFx.
†Lower prevalence of IHF or FRFx associated with variable, assessed using uni-variate statistical analysis, p≤0.001.
‡Acute and Newborn care type includes all acute hospital admissions other than those specified. For this analysis, only persons 18 years or more are included in the analysis.
§There are two types of interim care; those where persons have already been designed nursing home type (35 days of continuous care, assessed by aged care assessment service) and those without such a designation.
¶Either a previous presenting fall or an in-hospital fall hospital episode.
EOH, alcohol related conditions.

Table 4 Unadjusted rates of in-hospital fall (IHF) and fall-related fracture (FRF) separations between 1 July 1998 and 30 June 2008

	IHF (all separations as denominator)				FRFx (all separations as denominator)*				FRFx (IHF separations as denominator)*			
Financial year	N	Percentage year separations	Total year LOS days	Rate IHF per 1000 bed days	N	Percentage separations	Total LOS Days	Rate per 1000 bed days	N	Percentage IHF separations	Total LOS Days	Rate per 1000 bed days
1998/1999	1179	0.36	2826882	0.41	324	0.03	2825179	0.11	324	27.48	35720	9.07
1999/2000	1599	0.49	2905376	0.55	381	0.04	2903397	0.13	381	23.83	48934	7.79
2000/2001	1888	0.59	2946043	0.64	426	0.04	2942569	0.14.	426	22.56.	63130	6.75
2001/2002	1956	0.61	3076914	0.64	405	0.04	3074980	0.13.	405	20.71	67294	6.02
2002/2003	2065	0.62	3150331	0.66	384	0.03	3147893	0.12.	384	18.60	64040	6.00
2003/2004	2173	0.65	3159931	0.69	368	0.03	3157745	0.12.	368	16.94	65198	5.64
2004/2005	2250	0.66	3160069	0.71	330	0.03	3158080	0.10.	330	14.67	65382	5.05
2005/2006	2559	0.74	3165787	0.81	338	0.03	3164179	0.11.	338	13.21	69464	4.87
2006/2007	2786	0.80	3169544	0.88.	378	0.03	3166395	0.12	378	13.57	74789	5.05
2007/2008	2795	0.79	3173031	0.88	398	0.03	3170188	0.13	398	14.24	73974	5.38

*The denominator does not include episodes in which there was an in hospital fracture but no associated fall.
LOS, length of stay.

again probably due to application of the Australian coding standard and therefore differences in injury definition which reduce the IHF denominator to include only more serious falls.

The results highlight the need for caution in interpreting trends and in choosing useful indicators of quality of care. Ideally, a useful indicator can identify systemic variation after adequate adjustment for patient case mix. Increasing adjusted IHF rates may reflect changes in coding practice associated with increasing awareness, better reporting of fall events in hospital and consequently reporting of less serious events as well as real changes in IHF rates. The differences in trends noted for adjusted IHF rates and fracture rates support the premise that the IHF rates reported in the later years of our analysis may be of lower severity: the stable fracture rates in model 1 and decreasing FRFx rates in Model 2 support a dilution effect due to more reporting of less serious falls. Therefore, FRFx rates are likely to be a more useful indicator of system performance, although, in view of relatively low event rates, further investigation is needed to determine the utility of such an indicator for interorganisational comparisons.

In addition to monitoring high-level indicators of system performance, there is increasing interest in measuring individual organisational performance, benchmarking and reporting performance to internal and external stakeholders, including the public. Such comparative data require robust risk adjustment models to ensure credible figures to drive quality improvement at a local level and to avoid time-consuming investigation of false-positive events. The purpose of our study was not to develop and validate a fall or fracture risk prediction tool but to investigate the utility of routinely collected data for contributing to understanding individual and population risk, in particular for identifying factors for inclusion in future risk-adjustment models. In so doing, we have confirmed a number of previously reported important IHF factors.[31] The relationship between structural care type other than acute and newborn for FRFx rates is expected.[32] Of particular importance is the strong association with cognitive impairment (dementia and delirium) which will become an increasing challenge to organisations treating an ageing population. The association of HIV with IHF and FRFx is in keeping with known increased prevalence of

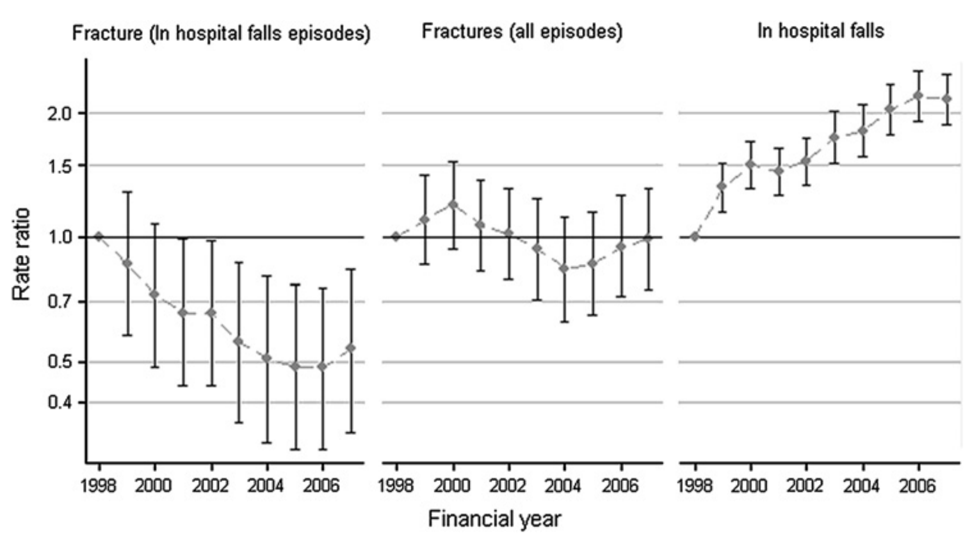

Figure 1 Burden of IHF and FRFx between 1st July 1998 and 30th June 2008. Rate ratios adjusted for variables of interest.

Table 5 Poisson regression model: summary of the rate ratios for covariates associated with in-hospital falls and fractures for Victorian public hospital episodes between 1 July 1998 and 30 June 2008, adjusted for variables of interest

Factor	Falls Rate ratio (99% CI)	FRFx Model 1 (denominator—all episodes)	FRFx Model 2 (denominator—in-hospital fall episodes)
Age (years)			
<18–39	1	1	1
40–49	2.0 (1.7 to 2.4)	2.6 (1.4 to 4.7)	1.1 (0.4 to 2.9)
50–59	2.5 (2.1 to 3.0)	4.8 (2.9 to 8.1)	1.2 (0.5 to 2.8)
60–69	3.5 (3.0 to 4.1)	7.1 (4.4 to 11.5)	1.5 (0.7 to 3.2)
70–79	5.5 (4.7 to 6.4)	13.0 (8.2 to 20.6)	1.6 (0.8 to 3.2)
80–89	7.6 (6.5 to 8.8)	19.5 (12.3 to 30.8)	1.8 (0.9 to 3.7)
90+	9.4 (8.0 to 11.1)	22.5 (14.0 to 36.2)	2.1 (1.0 to 4.7)
Male	1.2 (1.1 to 1.2)	0.8 (0.7 to 0.9)	0.7 (0.6 to 0.8)
Australian-born	1.0 (0.9 to 1.1)	1.0 (08 to 1.2)	1.0 (0.8 to 1.4)
English-speaking country of birth	1.1 (1.0 to 1.2)	1.0 (0.8 to 1.3)	1.0 (0.7 to 1.4)
Married	1.0 (0.9 to 1.0)	1.0 (0.9 to 1.1)	1.1 (0.9 to 1.3)
Rural residence	0.9 (0.8 to 1.0)	0.9 (0.7 to 1.0)	1.0 (0.8 to 1.3)
Socio-economic disadvantage			
Education and occupation	1.1 (1.0 to 1.1)	1.1 (1.0 to 1.3)	1.0 (0.8 to 1.3)
Economic resources	1.1 (1.0 to 1.1)	1.0 (0.8 to 1.2)	1.0 (0.7 to 1.3)
Emergency admission	1.3 (1.2 to 1.4)	1.2 (1.0 to 1.4)	1.1 (0.8 to 1.4)
Care type in hospital			
Acute and newborn	1	1	1
Palliative	1.1 (1.0 to 1.3)	1.7 (1.2 to 2.4)	0.9 (0.5 to 1.6)
Geriatric	1.1 (1.0 to 1.3)	1.8 (1.5 to 2.2)	0.9 (0.6 to 1.2)
Mental and ETOH	0.7 (0.6 to 0.8)	1.6(1.3 to 2.1)	0.9 (0.6 to 1.3)
Rehabilitation	1.0 (0.9 1.1)	1.6(1.3 to 2.0)	1.0 (0.7 to 1.4)
Interim	0.7 (0.5 to 0.9)	0.7 (0.4 to 1.4)	0.6 (0.2 to 1.8)
Nursing home	0.8 (0.7 to 1.0)	1.1 (0.8 to 1.5)	0.3 (0.2 to 0.5)
Admission source			
Home	1	1	1
Transfer	1.1 (1.0 to 1.2)	1.0 (0.8 to 1.2)	0.8 (0.6 to 1.1)
Other	1.2 (1.1 to 1.3)	1.0 (0.8 to 1.2)	0.9 (0.6 to 1.2)
Teaching hospital	1.1 (1.0 to 1.2)	1.1 (0.9 to 1.3)	0.9 (0.7 to 1.1)
Previous fall history	0.9 (0.8 to 0.9)	0.8 (0.7 to 0.9)	1.1 (0.9 to 1.3)
Presenting fall for this hospital episode	1.0 (0.9 to 1.1)	1.2 (1.0 to 1.4)	1.1 (0.8 to 1.4)
Comorbidities			
Cancer	1.1 (1.0 to 1.2)	1.0 (0.8 to 1.2)	0.9 (0.6 to 1.2)
Metastatic cancer	1.2 (1.0 to 1.3)	1.1 (0.8 to 1.5)	1.0 (0.7 to 1.6)
Chronic heart failure	1.0 (1.0 to 1.1)	1.0 (0.9 to 1.2)	0.9 (0.7 to 1.2)
Cerebrovascular disease	1.2 (1.1 to 1.3)	1.1 (0.9 to 1.4)	1.0 (0.7 to 1.4)
Connective tissue disease	1.0 (0.8 to 1.3)	1.2 (0.8 to 1.8)	1.1 (0.5 to 2.1)
Chronic pulmonary disease	1.0 (0.9 to 1.1)	1.1 (0.9 to 1.4)	1.2 (0.9 to 1.6)
Dementia	1.7 (1.6 to 1.8)	1.8 (1.5 to 2.0)	0.9 (0.7 to 1.1)
Diabetes	1.0 (0.9 to 1.1)	1.0 (0.9 to 1.2)	1.1 (0.8 to 1.5)
Severe diabetes	1.1 (1.0 to 1.2)	1.0 (0.7 to 1.3)	0.8 (0.5 to 1.2)
HIV	2.2 (1.4 to 3.5)	4.2 (1.4 to 12.6)	0.8 (0.1 to 4.5)
Liver disease	1.8 (1.4 to 2.4)	2.1 (1.1 to 4.2)	1.3 (0.5 to 3.6)
Severe liver disease	1.2 (0.9 to 1.7)	1.2 (0.5 to 2.6)	0.8 (0.2 to 2.8)
Myocardial infarction	0.8 (0.7 to 0.9)	0.9 (0.6 to 1.2)	1.2 (0.8 to 2.0)
Paraplegia	1.1 (1.0 to 1.2)	0.9 (0.7 to 1.2)	0.7 (0.4 to 1.1)
Peptic ulcer disease	0.8 (0.6 to 1.1)	0.9 (0.5 to 1.5)	1.0 (0.4 to 2.5)
Peripheral vascular disease	0.8 (0.7 to 1.0)	0.9 (0.5 to 1.2)	0.8 (0.4 to 1.6)
Renal disease	1.2 (1.1 to 1.3)	1.2 (1.0 to 1.4)	1.0 (0.7 to 1.4)
Ataxia	1.6 (1.2 to 2.0)	1.2 (0.6 to 2.3)	0.7 (0.2 to 1.9)
Delirium	1.8 (1.6 to 2.0)	1.9 (1.6 to 2.4)	1.0 (0.7 to 1.4)
Hearing deficit	1.2 (1.0 to 1.5)	1.0 (0.6 to 1.4)	0.7 (0.4 to 1.3)
Osteoporosis	1.3 (1.1 to 1,5)	1.9 (1.5 to 2.4)	1.3 (0.9 to 1.8)
Parkinson's disease	1.7 (1.5 to 1.9)	1.5 (1.2 to 2.0)	0.9 (0.6 to 1.3)
Visual deficit	1.2 (1.0 to 1.4)	1.2 (0.8 to 1.6)	1.1 (0.6 to 1.9)

EOH, alcohol related conditions; FRFx, fall-related fracture.

osteopenia and osteoporosis and recent evidence for higher fracture prevalence compared with control populations.[33]

We acknowledge the well-reported limitations of using routinely collected hospital data whose primary purpose is for case mix funding rather than clinical outcomes monitoring.[34] In addition to coding errors, ascertainment of adverse events has been shown to be related to the completeness of record documentation.[1] Our study reinforces the limitation of using such data for understanding associations without additional contextual information, particularly where there is statistical significance but relatively weak increased risk, for instance for male gender on falls risk. Overall, these data are hypothesis-generating and must be supported by more focused observational data to be useful at an organisational level for quality-improvement purposes.

Of interest, presentation with or previous history of a fall-related hospital episode was associated with lower rate ratios of IHF, suggesting there may have been greater awareness and implementation of preventive strategies. Alternatively, patients may have been immobilised by the injury that led to admission, although this association was not found in the fracture models. Similarly, there was no association between clinical comorbidity data and fractures in fracture model 2. We may have failed to show significant associations with fracture risk and mortality outcomes due to small overall fracture numbers; however, additional factors, not currently measured, may be influencing fracture risk in those who fall.[35] We have not differentiated risk for single versus multiple falls.[36] These will not be captured within the discharge dataset unless there were different injurious conditions—for example, a laceration on one occasion and a fracture on another. Finally, our regression models included both individual and aggregate risk factors, and we may not have accounted for all cluster effects.

In Australia, it is estimated that the total estimated health cost attributable to fall injuries will increase threefold between 2001 and 2051, rising to A$1375 million per year.[37] Our analysis illustrates the strengths and weakness of alternate methods to quantifying this burden and contributes to efforts to develop a monitoring system to follow the impact of interventions to reduce hospital associated fall-related injuries in high-risk populations.

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