Predictors of fracture from falls reported in hospital and residential care facilities: A cross-sectional study

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Complete List of Authors:	Chari, Satyan; Monash University, Physiotherapy; Queensland Health, Royal Brisbane and Women's Hospital McRae, Prue; Royal Brisbane and Women's Hospital, Safety and Quality Varghese, Paul; Queensland Health, Geriatric Medicine, Princess Alexandra Hospital Ferrar, Kaye; Queensland Health, Patient Safety Centre Haines, Terry; Monash University, Physiotherapy

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Predictors of fracture from falls reported in hospital and residential care facilities: A cross-sectional study

Satyan Chari[1,2,3,4], Prue McRae[4,5], Paul Varghese[4,6,7], Kaye Ferrar[8], Terry P Haines[9,10,11*]

1 – Program Coordinator Falls Prevention, Safety and Quality Unit, Royal Brisbane and Women's Hospital, Queensland Health, Australia

2 –Research Fellow, Queensland Health Office of Health and Medical Research (OHMR)

3 – Ph D Candidate, Physiotherapy Department, Monash University, Frankston, Australia

4 – Queensland Falls Injury Prevention Collaborative

5 – Falls Prevention, Safety and Quality Unit, Royal Brisbane and Women's Hospital, Queensland Health, Australia

6 – Director of Geriatric Medicine, Geriatric Assessment and Rehabilitation Unit, Princess Alexandra Hospital, Queensland Health, Australia

7 – School of Medicine, University of Queensland, St Lucia, Australia

8 – Data Analysis Team, Patient Safety Centre, Queensland Health, Australia

9 – Director of Research, Southern Physiotherapy Clinical School, Physiotherapy Department, Monash University, Frankston, Australia.

10 – Director of Allied Health Research Unit, Southern Health, Cheltenham, Australia

11 – School of Health and Rehabilitation Sciences, University of Queensland, St Lucia, Australia

Corresponding Author

Satyan Chari

Email: srcha5@student.monash.edu.au

Telephone: +61 7 3636 5375

Fax: +61 7 3636 1406

Postal: Safety and Quality Unit, Level 7, Block 7, Royal Brisbane and Women's Hospital, Herston 4029, Queensland, Australia

*Senior Author

Contributorship:

SC designed the study, wrote the study plan, acquired data, prepared data, conducted data analysis, interpreted results, drafted and revised the paper. PMc contributed to data analysis, interpretation of results, initial draft and subsequent revisions. PV contributed to the development of study design, data analysis, interpretation of results, development of initial draft and subsequent revisions. KF contributed to writing the study plan, acquiring data, data preparation, conducting data analysis, interpreting results, initial draft and final revisions. TH provided overall supervision to the study, designed the study, co-wrote the study plan, contributed to data preparation, data analysis, interpretation of results, initial draft and subsequent revisions.

Data sharing:

There is no additional data.

ABSTRACT

Background: Fall-related fractures are associated with substantial human and economic costs. An improved understanding of the predictors of fall-related fracture in healthcare settings would be useful in developing future interventions.

Methods: We employed a retrospective cross-sectional design to identify predictors for fracture from adult falls reported over three years across 197 public healthcare facilities in Queensland, Australia. Associations between fall-related factors and fracture outcomes were analysed using logistic regression analysis.

Results: We analysed 24 218 falls (with 229 fractures) among adult hospital patients and 8 980 falls (with 74 fractures) among aged care residents. In the adjusted hospital model, advanced age (eighty years and over), female gender, falls from standing, and falls that were not witnessed, were all associated with increased fracture odds. In the adjusted residential care model, falls during reaching activities in standing, and falls due to tripping were associated with increased odds of fracture. Hospital patients who had been screened for their risk of falling at admission suffered fewer fractures than those who had not.

Conclusion: Our findings suggest that screening of hospital patients for their risk of falling may protect patients from injurious falls. Falls from upright postures appear to be more likely to result in fractures than other falls in healthcare settings.

Key Words: Falls, Fracture, Patient, Hospital, Residential Care, Risk Factors

ARTICLE SUMMARY

Article focus

- To explore and identify predictive relationships between factors related to falls in institutional settings and fractures outcomes through the analysis of routinely reported clinical incident data.

Key Points

- Certain types of falls sustained in hospital and residential care settings are more likely to be associated with fracture than others.
- These include falls from more upright positions, and falls due to tripping.
- Hospital patients who have been screened for their risk of falling are less likely to experience fracture producing falls than those who are not.

Strengths and Limitations

- This research highlights new associations between falls screening and fracture outcomes.
- An important limitation of this study is that voluntary clinical incident reporting systems are likely to be affected by reporting inconsistencies and error, due to which results of our study should only be applied to practice with caution.

INTRODUCTION

Falls among older people in institutional settings are an issue of growing concern. (1) While not all falls are injurious, the ones that cause serious injuries, such as hip fractures, are responsible for the major portion of the economic (2) and human cost (2,3) described in the literature. As a result, preventing such injurious falls is an important public health priority.

Typically, fall prevention trials have implemented interventions targeting modifiable risk factors for falls among older people identified as being at risk of falling, and some have been successful in reducing fall rates. (4-6) Nevertheless, due to the large numbers of older people who would be considered to be at risk of falling in hospital and residential care settings, such broad approaches can be expensive to implement and sustain. A more cost-effective approach would be to focus directly on the prevention of injurious falls among older people at risk of sustaining fall-related injury. However, our understanding of the predictors of fall-related injury in health care settings is currently inadequate to develop such targeted interventions. The aim of this study was to advance an understanding of fall-related fracture predictors in hospital and residential care settings, by examining incident reports completed after falls in these environments.

METHODS

Design

This retrospective cross-sectional study utilised clinical incident reports completed after adult falls in healthcare settings (hospital and residential care) and explored predictive relationships between fall-related factors and fracture outcomes using logistic regression analysis.

Participants

All adult fall-related incidents reported on the Queensland Health (QH) clinical incident reporting system (also known as 'PRIME') between 1 January 2007 and 30 November 2009 were included in our dataset.

Setting

QH operates 167 hospital facilities with 8 859 beds, 27 residential care facilities with 1 798 beds and four specialised psychiatric residential facilities with 458 beds respectively. QH hospital facilities are geographically scattered with fifteen facilities in metropolitan areas, 78 in regional areas and 74 in remote areas across the State. All but one facility (a 538 bed tertiary metropolitan hospital in southeast Queensland) utilise the PRIME reporting system.

The PRIME reporting system is accessible online by QH staff. Once basic information about the individual is entered, the reporter inputs incident details through a series of drop-down fields pertaining to the specific incident type (for example, a fall or pressure ulcer). The system generates additional fields on subsequent pages based on the incident type chosen by the reporter. Some fields are mandatory and required to be completed before progressing to subsequent sections. Reporters are able to save incomplete reports and exit at any point, with the option to return and finalise the report at a later stage. The reporting interface is designed to be usable by reporters without prior experience with the system, however regular training sessions are available for staff in addition to comprehensive online resources and local support from expert users. To ensure report accuracy, ward managers are responsible for reviewing incidents periodically. The QH Patient Safety Centre (PSC) monitors overall system functionality and coordinates system improvements as necessary.

Procedure

The institutional human research ethics review committee of the Royal Brisbane and Women's Hospital (RBWH) approved this study. We included all mandatory and non-mandatory fields collected in relation to individual fall incidents across QH facilities for the observation period. Retrieved fields included date of incident, time of incident, the incident severity level, health district, facility, service area, ward/unit, date of birth, gender, universal reference number (patient ID), place of incident (such as bedroom, bathroom, or toilet), injuries sustained, function when the fall occurred (such as standing, walking, or sitting), activity when fall occurred (such showering, grooming, or resting), fall mechanism (such as slip, trip, or overbalance), whether a fall risk screen or assessment was completed upon admission, and whether the fall was witnessed. The QH clinical incident (CI) data dictionary provides definitions for a selection of fall-related field types. These are listed in Table 1.

(Table 1 here)

We examined raw data and eliminated duplicate records, along with records that pertained to community clients and falls that occurred while hospital patients or aged care residents were outside the healthcare facility. We also excluded falls that related to hospital patients under the age of eighteen. In total, we removed 3 812 records through this process, resulting in a final dataset of 33 198 incidents. The dataset was interrogated for inconsistencies through the creation of frequency tables, data ranges and histograms at various stages of the data preparation process.

For fields with multiple response options, we coded for the presence or absence of each response variable separately to enable logistic regression analysis. Similarly, for 'Age at time of fall', a continuous variable, we created age-ranges and then coded within these categories dichotomously. Prior to analysis, we separated records into hospital and residential care datasets. This decision was based on a review of the literature, which suggested that hospital and residential care populations were sufficiently different in terms of demographic characteristics, health status, risk factor profile, level of frailty, and systems of care delivery to require separate analysis. (7-12)

Microsoft® Excel 2002 and Access 2002 were used for data preparation and coding. We used Microsoft® Excel 2007 to create tables and StatCorp® Stata SE version 10 to perform all statistical analysis.

Data Analysis

We examined relationships between individual predictor variables and fractures using univariate and multiple logistic regression analysis. We clustered fall incidents by universal identification number employing robust variance estimates to account for the dependency between multiple fall records contributed by the same individual. We additionally subjected predictor variables to factor analysis (principal components) to explore between-variable colinearity prior to building a multiple logistic regression model as described by Hosmer and Lemeshow. (13) We started by including all univariate predictor variables with p-values equal to or less than 0.25 in the initial model. We then adopted a stepwise backward elimination approach to progressively remove variables with the highest p-values until all remaining variables in the model had p-values of equal to or less than 0.05. Excluded variables were subsequently re-entered into the model in order of statistical significance, and retained if they achieved p-values of 0.05 or less in the final model.

RESULTS

The final dataset consisted of 24 218 hospital fall incidents and 8 980 residential care fall incidents. Table 2 presents a comparison of demographic, fall and fall-related fracture characteristics for hospital and residential care subsets.

(Table 2 here)

Table 3 provides unadjusted odds-ratios for the likelihood of fracture when individual fall-related variables are present. Table 4 and 5 present the models developed for hospital and residential care datasets respectively, adjusted for the effects of other variables entered into the model. Results showed that male hospital patients were considerably less likely to fracture upon falling than female patients [OR: 0.42, p<0.001]. Further, patients of advanced age (80 years and over) were the age group most likely to fracture upon falling in hospital [OR: 1.44, p<0.001]. We found a number of fall-related characteristics to be predictive of fracture. 'Falls while walking' were associated with higher odds of fracture in both hospital [OR: 1.96, p<0.001] and residential care settings [OR: 2.04, p<0.001] than falls during other functions. 'Falls due to trips' were strongly predictive of fracture outcomes across both settings as an unadjusted variable but only in residential care [OR: 2.89, p=0.006] once adjusted for the effects of other variables. Falls in certain physical locations were associated with an increased probability of fracture outcomes. Considered individually, falls in corridors or hallways [OR: 2.10, p=0.006] were strongly associated with fractures in hospital, while falls in resident rooms (but not the immediate bedside environment) were similarly associated with an elevated risk of fractures [OR: 1.88, p=0.011] in the adjusted residential care model.

In the adjusted hospital model, we found that falls reported as having been 'witnessed' were half as likely to be associated with fracture outcomes [OR: 0.51, p=0.003] than falls reported as being unwitnessed. Among hospital patients who had been reported as having been screened for their fall risk at admission, falls were less likely to be associated with fractures [OR: 0.60, p=0.012] than among patients for whom a risk screen was not completed. Temporal factors were also associated with the likelihood of fall-related fracture outcomes across both hospital and residential care models.

(Table 3 here)

(Table 4 here)

(Table 5 here)

DISCUSSION

Cost-effectiveness is increasingly being seen as important in the evaluation of programs aimed at preventing falls in hospitals. (14) Previous cost-of-falls studies have recognised that the economic burden of falls is heavily skewed towards falls that result in fracture. (12, 15) The present study identified specific characteristics of falls (and fallers) which increased the likelihood of fractures. Such data is necessary for the development of future interventions to prevent these high cost falls.

Our results revealed that female hospital patients were almost twice as likely to sustain fractures upon falling as male patients. These results are directionally consistent with previous findings on gender-specific fall injury rates (5, 12). The lack of a comparable trend in the residential care dataset could be attributed to the smaller size of our residential care sample. However, previous studies have documented a reduction in the female gender bias for fracture in people of advanced age or the 'oldest' old group, (16) hypothesising an acceleration of physiological bone changes in men of advanced age. As our residential care group was considerably older than the hospital group with a mean age difference of ten years, such an explanation could be plausible.

In line with current biomechanical models for fall-related fractures (17-19), our results support the premise that the likelihood of fracture is elevated for falls from more upright postures compared to falls from lower heights. In our hospital dataset for example, falls while walking, falls while standing and falls in corridor areas were predictive of fractures. Conversely, falls reported to have happened when patients were resting had a lower association with fractures in hospital. A similar trend was observable in the residential care model in terms of both activity and spatial factors.

On adjusting for other variables in the hospital multiple regression model, falls that were reported as having been witnessed by staff were found to be half as likely to be associated with fractures than unwitnessed falls. It would be reasonable to assume that a number of these witnessed falls happened when patients were under the supervision of a staff member. Therefore, intervention by staff may have contributed to the reduced odds of fracture. At the same time, supervised patients might be less likely to engage in 'risky' activities than unsupervised patients would due to input from the staff member. For example, patients would be less likely to mobilise without their prescribed mobility aid if a staff member were present to encourage its use. While we recognise that a fall being 'witnessed' does not equate to the fall being supervised in all instances, our results do highlight appropriate supervision as an important part of a holistic approach to keeping older patients safe.

Falls that were reported as having occurred between the periods from two and three in the afternoon and nine and ten at night were associated with increased fracture odds in hospital after adjusting for other variables in the multiple logistic regression model. These periods potentially intersect nursing shift changeover times. As previously posited in this paper, the reduced availability of supervision could be a factor influencing the risk of fall-related fracture outcomes during such periods. We also identified relationships between falls in certain time periods and fractures in the residential care settings. These were falls between seven and eight in the morning, four and five in the afternoon and between seven and eight at night. Although convergence was not readily identifiable between all of these periods and any single daily activity routine or known physiological phenomena, a composite influence of underlying factors may be an explanation. Due to the relatively high odds of fracture from falls during these periods in residential care settings, further investigation is warranted.

Our results suggest that patients who suffered serious falls were less likely to have been screened for their risk of falling upon admission. While such an association has not been previously discussed in the literature, there are possible mechanisms through which falls risk screening could preferentially prevent injurious falls. Theoretically, patients identified to be at risk of falling may receive interventions more frequently that those patients whose risk has not yet been established. If some of these interventions have a greater effect in preventing falls associated with fracture, it would explain our results. An example of this would be the completion of mobility assessments for patients identified to be at risk of falling. Patients who receive mobility assessments would be safer while mobilising thereby reducing the risk of falls while walking, which is a type of fall associated with fractures in our data. It should be noted that there is considerable heterogeneity in falls risk screening processes across Queensland Health facilities with a mixture of validated falls risk screening tools, formal and informal clinical judgment based approaches being employed.

A parsimonious adjusted model proved elusive for both hospital and residential care data sets, with a number of variables retaining p-values equal to or less than 0.05. Despite this, the final model explained only a modest proportion of the overall variance in the outcome variable. While this could be indicative of Type I error or a high degree of random chance governing fracture phenomena, it is at least partly due to the recognised multifactorial nature of fall-related fractures. A comprehensive explanatory model would require the inclusion of other independently predictive intrinsic variables such as diagnosis, frailty, cognitive and mobility status in addition to the variables we considered here.

Falls due to tripping were strongly predictive of fractures in both hospital and residential care settings when considered individually. Although falls due to tripping did not retain statistical significance after being adjusted for other factors in the hospital model, these results signify the need for greater emphasis on managing low-level trip hazards for older people and improving their ability to safely negotiate hospital environments.

Limitations

There are a number of important limitations to our study, several of which are known shortcomings of cross-sectional research with routinely collected incident data (20, 21). As our sample was extracted from a voluntary incident reporting system, it is recognised that many unreported incidents would be missing from analysis. Admittedly, a reporting bias towards injurious falls might also introduce an unknown degree of skew. Variations in incident reporting culture are unavoidable in large heterogeneous organisations such as Queensland Health, which consists of numerous facilities spread across large geographical areas and servicing diverse populations. These variations in reporting can be a substantial confounder for cross-sectional studies such as this where data is aggregated across multiple sites.

We recognise that by using 'fracture' as the outcome variable, we are aggregating fracture types with potentially dissimilar fracture mechanisms and therefore risk factors. Clearly, there is some suggestive evidence that activities preceding fracture producing falls vary depending on the resultant fracture type (22).

Another potential confounder is that most falls in health facilities are unwitnessed by staff. In our sample, fewer than twenty-five per cent of hospital falls and sixteen per cent of residential care falls were reported as having been witnessed. It is likely that details relating to these unwitnessed incidents are based on information collected from patients or residents themselves, other observers, and the reporter's investigation of the circumstances surrounding the fall. It is possible that any extrapolation on the part of reporters could introduce error and negatively influence veracity of the data.

Within the limitations listed here, our results would be useful in the development of future intervention strategies to address the problem of injurious falls in hospital and residential care settings.

FUNDING DISCLOSURE

This investigator-initiated study was seed-funded by an $8,000 internal research grant from the Queensland Health Patient Safety Centre, which contributed towards off-line research time for the principal investigator. The principal investigator commenced a five-year Queensland Health research fellowship during the latter stages of this study, which supported part of the time spent in manuscript preparation and finalisation.

CONFLICTS OF INTEREST

None declared.

Table 1 Fall-related field definitions[λ]

Type of fall	
Slip	Fall or loss of balance occurring from loss of traction on surface
Trip	Loss of balance usually while walking resulting from portion of foot or lower limb contacting an obstacle.
Legs gave way	Involuntary loss of mechanical support in the leg or legs
Dizziness	Loss of equilibrium, for example, a spinning sensation, or light-headedness, or a feeling you are about to fall
Faint	Loss of consciousness
Overbalance	Movement of the body beyond its base of support
Activity at time of fall	
Walking	*(No definition provided)*
Standing	Standing without other overt activity
Sitting to Standing	Moving from a sitting position to a standing position, eg rising from bed or chair or toilet
Standing to sitting	Moving from a standing to sitting position, eg lowering to a bed, chair or toilet
Standing from lying position	Moving from a lying to standing position, eg getting out of bed
Standing to lying position	Moving from lying to standing, eg getting in to bed
Rolling out of bed	Rolling out of bed on to the floor
Sitting	Sitting without other activity
Seating to seating	Transferring from one seated position to another, eg chair or toilet to wheelchair
Reaching for object while seated	*(No definition provided)*
Reaching for object while standing	*(No definition provided)*
Function attempted by patient at time of fall	
Toileting	All activities involved in getting to and using the toilet
Bathing or showering	All activities involved in bathing or showering, including getting to the shower
Resting	Includes movement to the location of rest
Exercising	Activity undertaken for therapeutic or recreational purposes, eg. going for a walk, or a part of treatment program
Grooming or dressing	Includes activities such as brushing hair or teeth, dressing, etc
Use entertainment	Includes activities such as picking up a book or turning on the TV

λ Source: Queensland Health PRIME Clinical Incident Data Dictionary v 4.1 2008

Table 2 Characteristics of study sample: Falls and fall-related fracture		
	Hospital	Residential Care Facilities
Reported falls	24,218	8,980
Mean age (SD)	70.14 (17.28)	80.48 (10.65)
Median age	74.35	82.37
Gender (Male %)	57	54
Reported fractures (% reported falls)	229 (0.94)	74 (0.82)
Mean age (SD)	75.83 (15.21)	82.63 (9.99)
Median Age	78.98	85.33
Gender (Male %)	33	44

Table 3 Univariate analysis of fall-related predictors of fracture outcomes in hospital and residential care settings

	Hospital		Residential care	
Variable	O/R[a] (95% CI)	*p*-value[b]	O/R[a] (95% CI)	*p*-value[b]
Activity Factors				
Reaching in standing	0.67 (0.34-1.31)	0.251	2.64 (1.13-6.16)	0.024*
Rolling out of bed	0.29 (0.10-0.78)	0.015*	0.86 (0.26-2.76)	0.802
Sitting	0.23 (0.08-0.62)	0.004*	0.40 (0.09-1.67)	0.214
Walking	1.96 (1.50-2.56)	<0.001*	2.04 (1.27-3.27)	0.003*
Type of Fall				
Trip	2.06 (1.32-3.22)	0.001*	3.88 (1.90-7.94)	<0.001*
Slip	0.70 (0.49-0.98)	0.043*	0.57 (0.27-1.20)	0.143
Function Factors				
Resting	0.40 (0.22-0.73)	0.003*	0.33 (0.10-1.05)	0.062
Person Factors				
Age between 40 and 60	0.46 (0.27-0.78)	0.004*	0.29 (0.04-2.21)	0.238
Age over 80	1.51 (1.16-1.96)	0.002*	1.27 (0.74-2.16)	0.377
Male Gender	0.37 (0.28-0.50)	0.000*	0.67 (0.40-1.12)	0.132
Spatial/Environmental Factors				
Bedside	0.63 (0.46-0.84)	0.002*	0.45 (0.14-1.44)	0.179
Bedroom areas other than bedside	1.36 (1.00-1.85)	0.048*	1.50 (0.93-2.42)	0.091
Corridor/Hallway	2.39 (1.58-3.62)	0.000*	0.88 (0.38-2.02)	0.770
Other areas – Not classified	1.24 (0.45-3.35)	0.671	3.08 (1.11-8.55)	0.031*
Temporal Factors				
1600-1700	0.92 (0.43-1.97)	0.844	2.12 (1.03-4.35)	0.040*
1900-2000	0.92 (0.41-2.07)	0.848	2.86 (1.35-6.05)	0.006*
Other factors				
Risk screened/assessed at admission	0.66 (0.48-0.92)	0.015*	0.41 (0.16-1.04)	0.061

[a] Odds ratio (95% Confidence interval)
[b] Significance level
*Significant variable (p equal to or less than 0.05)

Table 4 Adjusted Odds Ratios– Hospital fractures

Logistic regression	Number of obs =	17016
	Wald $chi^2(10)$ =	101.60
	Prob > chi^2 =	0.0000
Log pseudo-likelihood = -911.42064	Pseudo R^2 =	0.0554

Variable	O/R (95% CI)	*p*-value
Witnessed by staff	0.51 (0.33-0.79)	0.003
Risk screened/assessed at admission	0.60 (0.41-0.89)	0.012
Standing	2.08 (1.22-3.55)	0.007
Walking	1.86 (1.32-2.62)	<0.001
Resting	0.52 (0.27-0.97)	0.043
Male gender	0.42 (0.30-0.58)	<0.001
Corridor/hallway	2.10 (1.23-3.58)	0.006
Age between 40 and 60	0.52 (0.27-0.98)	0.046
Age 80 and over	1.44 (1.05-1.99)	<0.001
1400-1500 hours	1.97 (1.09-3.54)	0.023
2100-2200 hours	1.73 (1.01-2.97)	0.044

Table 5 Adjusted Odds Ratios - Residential care fractures

Logistic regression	Number of obs =	8973
	Wald $chi^2(10)$ =	62.61
	Prob > chi^2 =	0.0000
Log pseudo-likelihood = -406.85361	Pseudo R^2 =	0.0510

Variable	O/R (95% CI)	*p*-value
Reaching in standing	3.51 (1.44-8.56)	0.006
Walking	2.11 (1.24-3.58)	0.006
Trip	2.89 (1.35-6.17)	0.006
Bedroom areas other than bedside	1.88 (1.15-3.07)	0.011
Other areas – Not classified	3.19 (1.15-8.85)	0.025
0700-0800	2.56 (1.08-6.07)	0.033
1600-1700	2.59 (1.24-5.39)	0.011
1900-2000	3.33 (1.55-7.14)	0.002

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STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract ✓
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found ✓
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported ✓
Objectives	3	State specific objectives, including any prespecified hypotheses ✓
Methods		
Study design	4	Present key elements of study design early in the paper ✓
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection ✓
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants ✓
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable ✓
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group ✓
Bias	9	Describe any efforts to address potential sources of bias ✓
Study size	10	Explain how the study size was arrived at ✓
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why ✓
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding ✓
		(*b*) Describe any methods used to examine subgroups and interactions ✓
		(*c*) Explain how missing data were addressed ✓
		(*d*) If applicable, describe analytical methods taking account of sampling strategy ✓
		(*e*) Describe any sensitivity analyses ✓
Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed ✓
		(b) Give reasons for non-participation at each stage N/A
		(c) Consider use of a flow diagram N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders ✓ (where available)
		(b) Indicate number of participants with missing data for each variable of interest Not possible for size of dataset
Outcome data	15*	Report numbers of outcome events or summary measures ✓
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included ✓
		(*b*) Report category boundaries when continuous variables were categorized ✓
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses ✓

1

Discussion		
Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Predictors of fracture from falls reported in hospital and residential care facilities: A cross-sectional study

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Predictors of fracture from falls reported in hospital and residential care facilities: A cross-sectional study

Satyan Chari[1,2,3,4], Prue McRae[4,5], Paul Varghese[4,6,7], Kaye Ferrar[8], Terry P Haines[9,10,11*]

1 – Program Coordinator Falls Prevention, Safety and Quality Unit, Royal Brisbane and Women's Hospital, Queensland Health, Australia

2 –Research Fellow, Queensland Health Office of Health and Medical Research (OHMR)

3 – Ph D Candidate, Physiotherapy Department, Monash University, Frankston, Australia

4 – Queensland Falls Injury Prevention Collaborative

5 – Falls Prevention, Safety and Quality Unit, Royal Brisbane and Women's Hospital, Queensland Health, Australia

6 – Director of Geriatric Medicine, Geriatric Assessment and Rehabilitation Unit, Princess Alexandra Hospital, Queensland Health, Australia

7 – School of Medicine, University of Queensland, St Lucia, Australia

8 – Data Analysis Team, Patient Safety Centre, Queensland Health, Australia

9 – Director of Research, Southern Physiotherapy Clinical School, Physiotherapy Department, Monash University, Frankston, Australia.

10 – Director of Allied Health Research Unit, Southern Health, Cheltenham, Australia

11 – School of Health and Rehabilitation Sciences, University of Queensland, St Lucia, Australia

Corresponding Author

Satyan Chari

Email: srcha5@student.monash.edu.au

Telephone: +61 7 3636 5375

Fax: +61 7 3636 1406

Postal: Safety and Quality Unit, Level 7, Block 7, Royal Brisbane and Women's Hospital,

Herston 4029, Queensland, Australia

*Senior Author

ABSTRACT

Background: Fall-related fractures are associated with substantial human and economic costs. An improved understanding of the predictors of fall-related fracture in healthcare settings would be useful in developing future interventions.

Methods: We employed a retrospective cross-sectional design to identify predictors for fracture from adult falls reported over three years across 197 public healthcare facilities in Queensland, Australia. Associations between fall-related factors and fracture outcomes were analysed using logistic regression analysis.

Results: We analysed 24 218 falls (with 229 fractures) among adult hospital patients and 8 980 falls (with 74 fractures) among aged care residents. In the adjusted hospital model, advanced age (eighty years and over), female gender, falls from standing, and falls that were not witnessed, were all associated with increased fracture odds. In the adjusted residential care model, falls during reaching activities in standing, and falls due to tripping were associated with increased odds of fracture. Hospital patients who had been screened for their risk of falling at admission suffered fewer fractures than those who had not.

Conclusion: Our findings suggest that screening of hospital patients for their risk of falling may protect patients from injurious falls. Falls from upright postures appear to be more likely to result in fractures than other falls in healthcare settings.

Key Words: Falls, Fracture, Patient, Hospital, Residential Care, Risk Factors

ARTICLE SUMMARY

Article focus

- To explore and identify predictive relationships between factors related to falls in institutional settings and fractures outcomes through the analysis of routinely reported clinical incident data.

Key Points

- Certain types of falls sustained in hospital and residential care settings are more likely to be associated with fracture than other types.
- These include falls from more upright positions, and falls due to tripping.
- Hospital patients who have been screened for their risk of falling may be less likely to experience fracture producing falls than those who are not.

Strengths and Limitations

- This research highlights new associations between falls screening and fracture outcomes.
- An important limitation of this study is that voluntary clinical incident reporting systems are likely to be affected by reporting inconsistencies and error, due to which results of our study should only be applied to practice with caution.

INTRODUCTION

Falls among older people in institutional settings are an issue of growing concern. (1) While not all falls are injurious, the ones that cause serious injuries, such as hip fractures, are responsible for the major portion of the economic (2) and human cost (2,3) described in the literature. As a result, preventing fall-related fracture is an important public health priority (4).

Typically, fall prevention trials have implemented interventions targeting modifiable risk factors for falls among older people identified as being at risk of falling, and some have been successful in reducing fall rates. (5-7) Nevertheless, due to the large numbers of older people who would be considered to be at risk of falling in hospital and residential care settings, such broad approaches can be expensive to implement and sustain. A more cost-effective approach would be to focus directly on the prevention of injurious falls among older people at risk of sustaining fall-related injury. However, our understanding of the predictors of fall-related injury in health care settings is currently inadequate to develop such targeted interventions. The aim of this study was to advance an understanding of fall-related fracture predictors in hospital and residential care settings, by examining incident reports completed after falls in these environments.

METHODS

Design

This retrospective cross-sectional study utilised clinical incident reports completed after adult falls in healthcare settings (hospital and residential care) and explored predictive relationships between fall-related factors and fracture outcomes using logistic regression analysis.

Participants

All adult fall-related incidents reported on the Queensland Health (QH) clinical incident reporting system (also known as 'PRIME') between 1 January 2007 and 30 November 2009 were included in our dataset**.**

Setting

QH operates 167 hospital facilities with 8 859 beds, 27 residential care facilities with 1 798 beds and four specialised psychiatric residential facilities with 458 beds respectively. QH hospital facilities are geographically scattered with fifteen facilities in metropolitan areas, 78 in regional areas and 74 in remote areas across the State. All but one facility (a 538 bed tertiary metropolitan hospital in southeast Queensland) utilise the PRIME reporting system.

The PRIME reporting system is accessible online by QH staff. Once basic information about the individual is entered, the reporter inputs incident details through a series of drop-down fields pertaining to the specific incident type (for example, a fall or pressure ulcer). The system generates additional fields on subsequent pages based on the incident type chosen by the reporter. Some fields are mandatory and required to be completed before progressing to subsequent sections. Reporters are able to save incomplete reports and exit at any point, with the option to return and finalise the report at a later stage. The reporting interface is designed to be usable by reporters without prior experience with the system, however regular training sessions are available for staff in addition to comprehensive online resources and local support from expert users. To ensure report accuracy, ward managers are responsible for reviewing incidents periodically. The QH Patient Safety Centre (PSC) monitors overall system functionality and coordinates system improvements as necessary.

Procedure

The institutional human research ethics review committee of the Royal Brisbane and Women's Hospital (RBWH) approved this study. We included all mandatory and non-mandatory fields collected in relation to individual fall incidents across QH facilities for the observation period. Retrieved fields included date of incident, time of incident, the incident severity level, health district, facility, service area, ward/unit, date of birth, gender, universal reference number (patient ID), place of incident (such as bedroom, bathroom, or toilet), injuries sustained, function when the fall occurred (such as standing, walking, or sitting), activity when fall occurred (such showering, grooming, or resting), fall mechanism (such as slip, trip, or overbalance), whether a fall risk screen or assessment was completed upon admission, and whether the fall was witnessed. The QH clinical incident (CI) data dictionary provides definitions for a selection of fall-related field types. These are listed in Table 1.

(Table 1 here)

We examined raw data and eliminated duplicate records, along with records that pertained to community clients and falls that occurred while hospital patients or aged care residents were outside the healthcare facility. We also excluded falls that related to hospital patients under the age of eighteen. In total, we removed 3 812 records through this process, resulting in a final dataset of 33 198 incidents. The dataset was interrogated for inconsistencies through the creation of frequency tables, data ranges and histograms at various stages of the data preparation process.

For fields with multiple response options, we coded for the presence or absence of each response variable separately to enable logistic regression analysis. Similarly, for 'Age at time of fall', a continuous variable, we created age-ranges and then coded within these categories dichotomously. Prior to analysis, we separated records into hospital and residential care datasets. This decision was based on a review of the literature, which suggested that hospital and residential care populations were sufficiently different in terms of demographic characteristics, health status, risk factors, level of frailty, levels of activity and systems of care delivery to require separate analysis. (8-13)

Microsoft® Excel 2002 and Access 2002 were used for data preparation and coding. We used Microsoft® Excel 2007 to create tables and StatCorp® Stata SE version 10 to perform all statistical analysis.

Data Analysis

We examined relationships between individual predictor variables and fractures using univariate and multiple logistic regression analysis. We clustered fall incidents by universal identification number employing robust variance estimates to account for the dependency between multiple fall records contributed by the same individual. We additionally subjected predictor variables to factor analysis (principal components) to explore between-variable colinearity prior to building a multiple logistic regression model as described by Hosmer and Lemeshow. (14) We started by including all univariate predictor variables with p-values equal to or less than 0.25 in the initial model. We then adopted a stepwise backward elimination approach to progressively remove variables with the highest p-values until all remaining variables in the model had p-values of equal to or less than 0.05. Excluded variables were subsequently re-entered into the model in order of statistical significance, and retained if they achieved p-values of 0.05 or less in the final model.

RESULTS

The final dataset consisted of 24 218 hospital fall incidents and 8 980 residential care fall incidents. Table 2 presents a comparison of demographic, fall and fall-related fracture characteristics for hospital and residential care subsets.

(Table 2 here)

Table 3 provides unadjusted odds-ratios for the likelihood of fracture when individual fall-related variables are present. Table 4 and 5 present the models developed for hospital and residential care datasets respectively, adjusted for the effects of other variables entered into the model. Results showed that male hospital patients were considerably less likely to fracture upon falling than female patients [OR: 0.42, $p<0.001$]. Further, patients of advanced age (80 years and over) were the age group most likely to fracture upon falling in hospital [OR: 1.44, $p<0.001$].

We found a number of fall-related characteristics to be predictive of fracture. ‘Falls while walking’ were associated with higher odds of fracture in both hospital [OR: 1.96, $p<0.001$] and residential care settings [OR: 2.04, p<0.001] than falls during other functions. 'Falls due to trips' were strongly predictive of fracture outcomes across both settings as an unadjusted variable but only in residential care [OR: 2.89, p=0.006] once adjusted for the effects of other variables. Falls in certain physical locations were associated with an increased probability of fracture outcomes. Considered individually, falls in corridors or hallways [OR: 2.10, p=0.006] were strongly associated with fractures in hospital, while falls in resident rooms (but not the immediate bedside environment) were similarly associated with an elevated risk of fractures [OR: 1.88, p=0.011] in the adjusted residential care model.

In the adjusted hospital model, we found that falls reported as having been 'witnessed' were half as likely to be associated with fracture outcomes [OR: 0.51, p=0.003] than falls reported as being unwitnessed. Among hospital patients who had been reported as having been screened for their fall risk at admission, falls were less likely to be associated with fractures [OR: 0.60, p=0.012] than among patients for whom a risk screen was not completed. Temporal factors were also associated with the likelihood of fall-related fracture outcomes across both hospital and residential care models.

(Table 3 here)

(Table 4 here)

(Table 5 here)

DISCUSSION

Cost-effectiveness is increasingly being seen as important in the evaluation of programs aimed at preventing falls in hospitals. (15) Previous cost-of-falls studies have recognised that the economic burden of falls is heavily skewed towards falls that result in fracture. (13, 16) The present study identified specific characteristics of falls (and fallers) which increased the likelihood of fractures. Such data is necessary for the development of future interventions to prevent these high cost falls.

Our results revealed that female hospital patients were almost twice as likely to sustain fractures upon falling as male patients. These results are directionally consistent with previous findings on gender-specific fall injury rates (6, 13). The lack of a comparable trend in the residential care dataset could be attributed to the smaller size of our residential care sample. However, previous studies have documented a reduction in the female gender bias for fracture in people of advanced age or the 'oldest' old group, (17) hypothesising an acceleration of physiological bone changes in men of advanced age. As our residential care group was considerably older than the hospital group with a mean age difference of ten years, such an explanation could be plausible.

In line with current biomechanical models for fall-related fractures (18-20), our results support the premise that the likelihood of fracture is elevated for falls from more upright postures compared to falls from lower heights. In our hospital dataset for example, falls while walking, falls while standing and falls in corridor areas were predictive of fractures. Conversely, falls reported to have happened when patients were resting had a lower association with fractures in hospital. A similar trend was observable in the residential care model in terms of both activity and spatial factors. Falls while walking were strongly predictive of fracture in both adjusted models. Compared with falls from static positions, this could relate to higher impact forces from an additive effect of an individual's existing motion and the fall-related acceleration.

On adjusting for other variables in the hospital multiple regression model, falls that were reported as having been witnessed by staff were found to be half as likely to be associated with fractures than unwitnessed falls. It would be reasonable to assume that a number of these witnessed falls happened when patients were under the supervision of a staff member. Therefore, intervention by staff may have contributed to the reduced odds of fracture. At the same time, supervised patients might be less likely to engage in 'risky' activities than unsupervised patients would due to input from the staff member. For example, patients would be less likely to mobilise without their prescribed mobility aid if a staff member were present to encourage its use. While we recognise that a fall being 'witnessed' does not equate to the fall being supervised in all instances, our results do highlight appropriate supervision as an important part of a holistic approach to keeping older patients safe.

Falls that were reported as having occurred between the periods from two and three in the afternoon and nine and ten at night were associated with increased fracture odds in hospital after adjusting for other variables in the multiple logistic regression model. These periods potentially intersect nursing shift changeover times. As previously posited in this paper, the reduced availability of supervision could be a factor influencing the risk of fall-related fracture outcomes during such periods. We also identified relationships between falls in certain time periods and fractures in the residential care settings. These were falls between seven and eight in the morning, four and five in the afternoon and between seven and eight at night. Although convergence was not readily identifiable between all of these periods and any single daily activity routine or known physiological phenomena, a composite influence of underlying factors may be an explanation. Due to the relatively high odds of fracture from falls during these periods in residential care settings, further investigation is warranted.

Our results suggest that patients who suffered serious falls were less likely to have been screened for their risk of falling upon admission. While such an association has not been previously discussed in the literature, there are possible mechanisms through which falls risk screening could preferentially prevent injurious falls. Theoretically, patients identified to be at risk of falling may receive interventions more frequently that those patients whose risk has not yet been established. If some of these interventions have a greater effect in preventing falls associated with fracture, it would explain our results. An example of this would be the completion of mobility assessments for patients identified to be at risk of falling. Patients who receive mobility assessments would be safer while mobilising thereby reducing the risk of falls while walking, which is a type of fall associated with fractures in our data. It should be noted that there is considerable heterogeneity in falls risk screening processes across Queensland Health facilities with a mixture of validated falls risk screening tools, formal and informal clinical judgment based approaches being employed.

A parsimonious adjusted model proved elusive for both hospital and residential care data sets, with a number of variables retaining p-values equal to or less than 0.05. Despite this, the final model explained only a modest proportion of the overall variance in the outcome variable. While this could be indicative of Type I error or a high degree of random chance governing fracture phenomena, it is at least partly due to the recognised multifactorial nature of fall-related fractures. A comprehensive explanatory model would require the inclusion of other independently predictive intrinsic variables such as diagnosis, frailty, cognitive and mobility status in addition to the variables we considered here.

A recent landmark study examining causative mechanisms for falls in older people highlighted tripping as a frequent cause of falls in institutional settings (21). In our study falls due to tripping were also independently predictive of fractures in both hospital and residential care settings. Consequently, there is a need for greater emphasis on managing low-level trip hazards for older people and improving their ability to safely negotiate institutional environments.

Limitations

There are a number of important limitations to our study, several of which are known shortcomings of cross-sectional research with routinely collected incident data (22, 23). As our sample was extracted from a voluntary incident reporting system, it is recognised that many unreported incidents would be missing from analysis. Admittedly, a reporting bias towards injurious falls might also introduce an unknown degree of skew. Variations in incident reporting culture are unavoidable in large heterogeneous organisations such as Queensland Health, which consists of numerous facilities spread across large geographical areas and servicing diverse populations. These variations in reporting can be a substantial confounder for cross-sectional studies such as this where data is aggregated across multiple sites.

We recognise that by using ‘fracture’ as the outcome variable, we are aggregating fracture types with known differences in injury mechanisms (24). This approach could therefore conceal underlying divergences in risk factors. Additionally, there is some suggestive evidence that activities preceding fracture producing falls vary depending on the resultant fracture type (25).

Another potential confounder is that most falls in health facilities are unwitnessed by staff. In our sample, fewer than twenty-five per cent of hospital falls and sixteen per cent of residential care falls were reported as having been witnessed. It is likely that details relating to these unwitnessed incidents are based on information collected from patients or residents themselves, other observers, and the reporter's investigation of the circumstances surrounding the fall. It is possible that any extrapolation on the part of reporters could introduce error and negatively influence veracity of the data.

An important weakness of our study is the inability to account for the effect of exposure rates with this approach. In this study, we identified fall-related predictors of fracture outcomes by comparing falls resulting in fracture with falls that did not. While this approach is useful in identifying fall types that are associated with high injury risk, it is not possible to estimate the overall risk of fall-related fracture associated with particular activities or situational factors. For example, while our data allows us to compare the odds of a fracture outcome from falls during mobilization with the odds of fracture from other fall types, we cannot comment on the overall risk of fall-related fracture during mobilisation without the addition of information on exposure rates and activity-related fall rates. Nevertheless, such cumulative estimates of risk were outside the scope of the present study and could be the focus of future work.

Within the limitations listed here, our results would be useful in the development of future intervention strategies to address the problem of injurious falls in hospital and residential care settings.

FUNDING DISCLOSURE

This investigator-initiated study was seed-funded by an $8,000 internal research grant from the Queensland Health Patient Safety Centre, which contributed towards off-line research time for the principal investigator. The principal investigator commenced a five-year Queensland Health research fellowship during the latter stages of this study, which supported part of the time spent in manuscript preparation and finalisation.

CONFLICTS OF INTEREST

None declared.

Contributorship:

SC co-designed the study, wrote the study plan, acquired data, prepared data, conducted data analysis, interpreted results, drafted and revised the paper. PMc contributed to data analysis, interpretation of results, initial draft and subsequent revisions. PV contributed to the development of study design, data analysis, interpretation of results, development of initial draft and subsequent revisions. KF contributed to writing the study plan, acquiring data, data preparation, conducting data analysis, interpreting results, initial draft and final revisions. TH provided overall supervision to the study, co-designed the study, co-wrote the study plan, contributed to data preparation, data analysis, interpretation of results, development of initial draft and subsequent revisions.

Data sharing:

No additional data.

Table 1 Fall-related field definitions[λ]

Type of fall	
Slip	Fall or loss of balance occurring from loss of traction on surface
Trip	Loss of balance usually while walking resulting from portion of foot or lower limb contacting an obstacle.
Legs gave way	Involuntary loss of mechanical support in the leg or legs
Dizziness	Loss of equilibrium, for example, a spinning sensation, or light-headedness, or a feeling you are about to fall
Faint	Loss of consciousness
Overbalance	Movement of the body beyond its base of support
Activity at time of fall	
Walking	*(No definition provided)*
Standing	Standing without other overt activity
Sitting to Standing	Moving from a sitting position to a standing position, eg rising from bed or chair or toilet
Standing to sitting	Moving from a standing to sitting position, eg lowering to a bed, chair or toilet
Standing from lying position	Moving from a lying to standing position, eg getting out of bed
Standing to lying position	Moving from lying to standing, eg getting in to bed
Rolling out of bed	Rolling out of bed on to the floor
Sitting	Sitting without other activity
Seating to seating	Transferring from one seated position to another, eg chair or toilet to wheelchair
Reaching for object while seated	*(No definition provided)*
Reaching for object while standing	*(No definition provided)*
Function attempted by patient at time of fall	
Toileting	All activities involved in getting to and using the toilet
Bathing or showering	All activities involved in bathing or showering, including getting to the shower
Resting	Includes movement to the location of rest
Exercising	Activity undertaken for therapeutic or recreational purposes, eg. going for a walk, or a part of treatment program
Grooming or dressing	Includes activities such as brushing hair or teeth, dressing, etc
Use entertainment	Includes activities such as picking up a book or turning on the TV

λ Source: Queensland Health PRIME Clinical Incident Data Dictionary v 4.1 2008

Table 2 Characteristics of study sample: Falls and fall-related fracture

	Hospital	Residential Care Facilities
Reported falls	24,218	8,980
Mean age (SD)	70.14 (17.28)	80.48 (10.65)
Median age	74.35	82.37
Gender (Male %)	57	54
Reported fractures (% reported falls)	229 (0.94)	74 (0.82)
Mean age (SD)	75.83 (15.21)	82.63 (9.99)
Median Age	78.98	85.33
Gender (Male %)	33	44

Table 3 Univariate analysis of fall-related predictors of fracture outcomes in hospital and residential care settings

	Hospital		Residential care	
Variable	O/R[a,c] (95% CI)	*p*-value[b]	O/R[a] (95% CI)	*p*-value[b]
Activity Factors				
Reaching in standing	0.67 (0.34-1.31)	0.251	2.64 (1.13-6.16)	0.024*
Rolling out of bed	0.29 (0.10-0.78)	0.015*	0.86 (0.26-2.76)	0.802
Sitting	0.23 (0.08-0.62)	0.004*	0.40 (0.09-1.67)	0.214
Walking	1.96 (1.50-2.56)	<0.001*	2.04 (1.27-3.27)	0.003*
Type of Fall				
Trip	2.06 (1.32-3.22)	0.001*	3.88 (1.90-7.94)	<0.001*
Slip	0.70 (0.49-0.98)	0.043*	0.57 (0.27-1.20)	0.143
Function Factors				
Resting	0.40 (0.22-0.73)	0.003*	0.33 (0.10-1.05)	0.062
Person Factors				
Age between 40 and 60	0.46 (0.27-0.78)	0.004*	0.29 (0.04-2.21)	0.238
Age over 80	1.51 (1.16-1.96)	0.002*	1.27 (0.74-2.16)	0.377
Male Gender	0.37 (0.28-0.50)	0.000*	0.67 (0.40-1.12)	0.132
Spatial/Environmental Factors				
Bedside	0.63 (0.46-0.84)	0.002*	0.45 (0.14-1.44)	0.179
Bedroom areas other than bedside	1.36 (1.00-1.85)	0.048*	1.50 (0.93-2.42)	0.091
Corridor/Hallway	2.39 (1.58-3.62)	0.000*	0.88 (0.38-2.02)	0.770
Other areas – Not classified	1.24 (0.45-3.35)	0.671	3.08 (1.11-8.55)	0.031*
Temporal Factors				
1600-1700	0.92 (0.43-1.97)	0.844	2.12 (1.03-4.35)	0.040*
1900-2000	0.92 (0.41-2.07)	0.848	2.86 (1.35-6.05)	0.006*
Other factors				
Risk screened/assessed at admission	0.66 (0.48-0.92)	0.015*	0.41 (0.16-1.04)	0.061

[a] Odds ratio (95% Confidence interval)
[b] Significance level
[c]– Reference value for all comparisons using odds ratios are 1.00; Each variable is compared against all other remaining variables within category. For example, within 'Activity Factors', odds for facture during falls while 'reaching in standing'

are expressed as a ratio against odds for fracture after falls related to all other activity variables. Hospital and residential care results are presented in parallel but have been analyzed separately.
*Significant variable (p equal to or less than 0.05)

Table 4 Adjusted Odds Ratios– Hospital fractures

Logistic regression	Number of obs	=	17016
	Wald $chi^2(10)$	=	101.60
	Prob > chi^2	=	0.0000
Log pseudo-likelihood = -911.42064	Pseudo R^2	=	0.0554

Variable	O/R (95% CI)	*p*-value
Witnessed by staff	0.51 (0.33-0.79)	0.003
Risk screened/assessed at admission	0.60 (0.41-0.89)	0.012
Standing	2.08 (1.22-3.55)	0.007
Walking	1.86 (1.32-2.62)	<0.001
Resting	0.52 (0.27-0.97)	0.043
Male gender	0.42 (0.30-0.58)	<0.001
Corridor/hallway	2.10 (1.23-3.58)	0.006
Age between 40 and 60	0.52 (0.27-0.98)	0.046
Age 80 and over	1.44 (1.05-1.99)	<0.001
1400-1500 hours	1.97 (1.09-3.54)	0.023
2100-2200 hours	1.73 (1.01-2.97)	0.044

Table 5 Adjusted Odds Ratios - Residential care fractures

Logistic regression	Number of obs	=	8973
	Wald $chi^2(10)$	=	62.61
	Prob > chi^2	=	0.0000
Log pseudo-likelihood = -406.85361	Pseudo R^2	=	0.0510

Variable	O/R (95% CI)	*p*-value
Reaching in standing	3.51 (1.44-8.56)	0.006
Walking	2.11 (1.24-3.58)	0.006
Trip	2.89 (1.35-6.17)	0.006
Bedroom areas other than bedside	1.88 (1.15-3.07)	0.011
Other areas – Not classified	3.19 (1.15-8.85)	0.025
0700-0800	2.56 (1.08-6.07)	0.033
1600-1700	2.59 (1.24-5.39)	0.011
1900-2000	3.33 (1.55-7.14)	0.002

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Predictors of fracture from falls reported in hospital and residential care facilities: A cross-sectional study

Satyan Chari[1,2,3,4], Prue McRae[4,5], Paul Varghese[4,6,7], Kaye Ferrar[8], Terry P Haines[9,10,11*]

1 – Program Coordinator Falls Prevention, Safety and Quality Unit, Royal Brisbane and Women's Hospital, Queensland Health, Australia

2 –Research Fellow, Queensland Health Office of Health and Medical Research (OHMR)

3 – Ph D Candidate, Physiotherapy Department, Monash University, Frankston, Australia

4 – Queensland Falls Injury Prevention Collaborative

5 – Falls Prevention, Safety and Quality Unit, Royal Brisbane and Women's Hospital, Queensland Health, Australia

6 – Director of Geriatric Medicine, Geriatric Assessment and Rehabilitation Unit, Princess Alexandra Hospital, Queensland Health, Australia

7 – School of Medicine, University of Queensland, St Lucia, Australia

8 – Data Analysis Team, Patient Safety Centre, Queensland Health, Australia

9 – Director of Research, Southern Physiotherapy Clinical School, Physiotherapy Department, Monash University, Frankston, Australia.

10 – Director of Allied Health Research Unit, Southern Health, Cheltenham, Australia

11 – School of Health and Rehabilitation Sciences, University of Queensland, St Lucia, Australia

Corresponding Author

Satyan Chari

Email: srcha5@student.monash.edu.au

Telephone: +61 7 3636 5375

Fax: +61 7 3636 1406

Postal: Safety and Quality Unit, Level 7, Block 7, Royal Brisbane and Women's Hospital, Herston 4029, Queensland, Australia

*Senior Author

Contributorship:

SC co-designed the study, wrote the study plan, acquired data, prepared data, conducted data analysis, interpreted results, drafted and revised the paper. PMc contributed to data analysis, interpretation of results, initial draft and subsequent revisions. PV contributed to the development of study design, data analysis, interpretation of results, development of initial draft and subsequent revisions. KF contributed to writing the study plan, acquiring data, data preparation, conducting data analysis, interpreting results, initial draft and final revisions. TH provided overall supervision to the study, co-designed the study, co-wrote the study plan, contributed to data preparation, data analysis, interpretation of results, development of initial draft and subsequent revisions.

Data sharing:

There is no additional data.

ABSTRACT

Background: Fall-related fractures are associated with substantial human and economic costs. An improved understanding of the predictors of fall-related fracture in healthcare settings would be useful in developing future interventions.

Methods: We employed a retrospective cross-sectional design to identify predictors for fracture from adult falls reported over three years across 197 public healthcare facilities in Queensland, Australia. Associations between fall-related factors and fracture outcomes were analysed using logistic regression analysis.

Results: We analysed 24 218 falls (with 229 fractures) among adult hospital patients and 8 980 falls (with 74 fractures) among aged care residents. In the adjusted hospital model, advanced age (eighty years and over), female gender, falls from standing, and falls that were not witnessed, were all associated with increased fracture odds. In the adjusted residential care model, falls during reaching activities in standing, and falls due to tripping were associated with increased odds of fracture. Hospital patients who had been screened for their risk of falling at admission suffered fewer fractures than those who had not.

Conclusion: Our findings suggest that screening of hospital patients for their risk of falling may protect patients from injurious falls. Falls from upright postures appear to be more likely to result in fractures than other falls in healthcare settings.

Key Words: Falls, Fracture, Patient, Hospital, Residential Care, Risk Factors

ARTICLE SUMMARY

Article focus

- To explore and identify predictive relationships between factors related to falls in institutional settings and fractures outcomes through the analysis of routinely reported clinical incident data.

Key Points

- Certain types of falls sustained in hospital and residential care settings are more likely to be associated with fracture than other types.
- These include falls from more upright positions, and falls due to tripping.
- Hospital patients who have been screened for their risk of falling ~~are~~ may be less likely to experience fracture producing falls than those who are not.

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Strengths and Limitations

- This research highlights new associations between falls screening and fracture outcomes.
- An important limitation of this study is that voluntary clinical incident reporting systems are likely to be affected by reporting inconsistencies and error, due to which results of our study should only be applied to practice with caution.

INTRODUCTION

Falls among older people in institutional settings are an issue of growing concern. (1) While not all falls are injurious, the ones that cause serious injuries, such as hip fractures, are responsible for the major portion of the economic (2) and human cost (2,3) described in the literature. As a result, preventing fall-related ~~such injurious falls is~~fracture is an important public health priority (4).

Typically, fall prevention trials have implemented interventions targeting modifiable risk factors for falls among older people identified as being at risk of falling, and some have been successful in reducing fall rates. (5~~4~~-7~~6~~) Nevertheless, due to the large numbers of older people who would be considered to be at risk of falling in hospital and residential care settings, such broad approaches can be expensive to implement and sustain. A more cost-effective approach would be to focus directly on the prevention of injurious falls among older people at risk of sustaining fall-related injury. However, our understanding of the predictors of fall-related injury in health care settings is currently inadequate to develop such targeted interventions. The aim of this study was to advance an understanding of fall-related fracture predictors in hospital and residential care settings, by examining incident reports completed after falls in these environments.

METHODS

Design

This retrospective cross-sectional study utilised clinical incident reports completed after adult falls in healthcare settings (hospital and residential care) and explored predictive relationships between fall-related factors and fracture outcomes using logistic regression analysis.

Participants

All adult fall-related incidents reported on the Queensland Health (QH) clinical incident reporting system (also known as 'PRIME') between 1 January 2007 and 30 November 2009 were included in our dataset.

Setting

QH operates 167 hospital facilities with 8 859 beds, 27 residential care facilities with 1 798 beds and four specialised psychiatric residential facilities with 458 beds respectively. QH hospital facilities are geographically scattered with fifteen facilities in metropolitan areas, 78 in regional areas and 74 in remote areas across the State. All but one facility (a 538 bed tertiary metropolitan hospital in southeast Queensland) utilise the PRIME reporting system.

The PRIME reporting system is accessible online by QH staff. Once basic information about the individual is entered, the reporter inputs incident details through a series of drop-down fields pertaining to the specific incident type (for example, a fall or pressure ulcer). The system generates additional fields on subsequent pages based on the incident type chosen by the reporter. Some fields are mandatory and required to be completed before progressing to subsequent sections. Reporters are able to save incomplete reports and exit at any point, with the option to return and finalise the report at a later stage. The reporting interface is designed to be usable by reporters without prior experience with the system, however regular training sessions are available for staff in addition to comprehensive online resources and local support from expert users. To ensure report accuracy, ward managers are responsible for reviewing incidents periodically. The QH Patient Safety Centre (PSC) monitors overall system functionality and coordinates system improvements as necessary.

Procedure

The institutional human research ethics review committee of the Royal Brisbane and Women's Hospital (RBWH) approved this study. We included all mandatory and non-mandatory fields collected in relation to individual fall incidents across QH facilities for the observation period. Retrieved fields included date of incident, time of incident, the incident severity level, health district, facility, service area, ward/unit, date of birth, gender, universal reference number (patient ID), place of incident (such as bedroom, bathroom, or toilet), injuries sustained, function when the fall occurred (such as standing, walking, or sitting), activity when fall occurred (such showering, grooming, or resting), fall mechanism (such as slip, trip, or overbalance), whether a fall risk screen or assessment was completed upon admission, and whether the fall was witnessed. The QH clinical incident (CI) data dictionary provides definitions for a selection of fall-related field types. These are listed in Table 1.

(Table 1 here)

We examined raw data and eliminated duplicate records, along with records that pertained to community clients and falls that occurred while hospital patients or aged care residents were outside the healthcare facility. We also excluded falls that related to hospital patients under the age of eighteen. In total, we removed 3 812 records through this process, resulting in a final dataset of 33 198 incidents. The dataset was interrogated for inconsistencies through the creation of frequency tables, data ranges and histograms at various stages of the data preparation process.

For fields with multiple response options, we coded for the presence or absence of each response variable separately to enable logistic regression analysis. Similarly, for 'Age at time of fall', a continuous variable, we created age-ranges and then coded within these categories dichotomously. Prior to analysis, we separated records into hospital and residential care datasets. This decision was based on a review of the literature, which suggested that hospital and residential care populations were sufficiently different in terms of demographic characteristics, health status, risk factors profile, level of frailty, levels of activity and systems of care delivery to require separate analysis. (87-132)

Microsoft® Excel 2002 and Access 2002 were used for data preparation and coding. We used Microsoft® Excel 2007 to create tables and StatCorp® Stata SE version 10 to perform all statistical analysis.

Data Analysis

We examined relationships between individual predictor variables and fractures using univariate and multiple logistic regression analysis. We clustered fall incidents by universal identification number employing robust variance estimates to account for the dependency between multiple fall records contributed by the same individual. We additionally subjected predictor variables to factor analysis (principal components) to explore between-variable colinearity prior to building a multiple logistic regression model as described by Hosmer and Lemeshow. (143) We started by including all univariate predictor variables with p-values equal to or less than 0.25 in the initial model. We then adopted a stepwise backward elimination approach to progressively remove variables with the highest p-values until all remaining variables in the model had p-values of equal to or less than 0.05. Excluded variables were subsequently re-entered into the model in order of statistical significance, and retained if they achieved p-values of 0.05 or less in the final model.

RESULTS

The final dataset consisted of 24 218 hospital fall incidents and 8 980 residential care fall incidents. Table 2 presents a comparison of demographic, fall and fall-related fracture characteristics for hospital and residential care subsets.

(Table 2 here)

Table 3 provides unadjusted odds-ratios for the likelihood of fracture when individual fall-related variables are present. Table 4 and 5 present the models developed for hospital and residential care datasets respectively, adjusted for the effects of other variables entered into the model. Results showed that male hospital patients were considerably less likely to fracture upon falling than female patients [OR: 0.42, p<0.001]. Further, patients of advanced age (80 years and over) were the age group most likely to fracture upon falling in hospital [OR: 1.44, p<0.001].

We found a number of fall-related characteristics to be predictive of fracture. ‘Falls while walking’ were associated with higher odds of fracture in both hospital [OR: 1.96, p<0.001] and residential care settings [OR: 2.04, p<0.001] than falls during other functions. 'Falls due to trips' were strongly predictive of fracture outcomes across both settings as an unadjusted variable but only in residential care [OR: 2.89, p=0.006] once adjusted for the effects of other variables. Falls in certain physical locations were associated with an increased probability of fracture outcomes. Considered individually, falls in corridors or hallways [OR: 2.10, p=0.006] were strongly associated with fractures in hospital, while falls in resident rooms (but not the immediate bedside environment) were similarly associated with an elevated risk of fractures [OR: 1.88, p=0.011] in the adjusted residential care model.

In the adjusted hospital model, we found that falls reported as having been 'witnessed' were half as likely to be associated with fracture outcomes [OR: 0.51, p=0.003] than falls reported as being unwitnessed. Among hospital patients who had been reported as having been screened for their fall risk at admission, falls were less likely to be associated with fractures [OR: 0.60, p=0.012] than among patients for whom a risk screen was not completed. Temporal factors were also associated with the likelihood of fall-related fracture outcomes across both hospital and residential care models.

(Table 3 here)

(Table 4 here)

(Table 5 here)

DISCUSSION

Cost-effectiveness is increasingly being seen as important in the evaluation of programs aimed at preventing falls in hospitals. (154) Previous cost-of-falls studies have recognised that the economic burden of falls is heavily skewed towards falls that result in fracture. (132, 165) The present study identified specific characteristics of falls (and fallers) which increased the likelihood of fractures. Such data is necessary for the development of future interventions to prevent these high cost falls.

Our results revealed that female hospital patients were almost twice as likely to sustain fractures upon falling as male patients. These results are directionally consistent with previous findings on gender-specific fall injury rates (6~~5~~, 13~~2~~). The lack of a comparable trend in the residential care dataset could be attributed to the smaller size of our residential care sample. However, previous studies have documented a reduction in the female gender bias for fracture in people of advanced age or the 'oldest' old group, (17~~6~~) hypothesising an acceleration of physiological bone changes in men of advanced age. As our residential care group was considerably older than the hospital group with a mean age difference of ten years, such an explanation could be plausible.

In line with current biomechanical models for fall-related fractures (18~~7~~-20~~19~~), our results support the premise that the likelihood of fracture is elevated for falls from more upright postures compared to falls from lower heights. In our hospital dataset for example, falls while walking, falls while standing and falls in corridor areas were predictive of fractures. Conversely, falls reported to have happened when patients were resting had a lower association with fractures in hospital. A similar trend was observable in the residential care model in terms of both activity and spatial factors. - Falls while walking were strongly predictive of fracture in both adjusted models. Compared with falls from static positions, this could relate to higher impact forces from an additive effect of an individual's existing motion and the fall-related acceleration.

On adjusting for other variables in the hospital multiple regression model, falls that were reported as having been witnessed by staff were found to be half as likely to be associated with fractures than unwitnessed falls. It would be reasonable to assume that a number of these witnessed falls happened when patients were under the supervision of a staff member. Therefore, intervention by staff may have contributed to the reduced odds of fracture. At the same time, supervised patients might be less likely to engage in 'risky' activities than unsupervised patients would due to input from the staff member. For example, patients would be less likely to mobilise without their prescribed mobility aid if a staff member were present to encourage its use. While we recognise that a fall being 'witnessed' does not equate to the fall being supervised in all instances, our results do highlight appropriate supervision as an important part of a holistic approach to keeping older patients safe.

Falls that were reported as having occurred between the periods from two and three in the afternoon and nine and ten at night were associated with increased fracture odds in hospital after adjusting for other variables in the multiple logistic regression model. These periods potentially intersect nursing shift changeover times. As previously posited in this paper, the reduced availability of supervision could be a factor influencing the risk of fall-related fracture outcomes during such periods. We also identified relationships between falls in certain time periods and fractures in the residential care settings. These were falls between seven and eight in the morning, four and five in the afternoon and between seven and eight at night. Although convergence was not readily identifiable between all of these periods and any single daily activity routine or known physiological phenomena, a composite influence of underlying factors may be an explanation. Due to the relatively high odds of fracture from falls during these periods in residential care settings, further investigation is warranted.

Our results suggest that patients who suffered serious falls were less likely to have been screened for their risk of falling upon admission. While such an association has not been previously discussed in the literature, there are possible mechanisms through which falls risk screening could preferentially prevent injurious falls. Theoretically, patients identified to be at risk of falling may receive interventions more frequently that those patients whose risk has not yet been established. If some of these interventions have a greater effect in preventing falls associated with fracture, it would explain our results. An example of this would be the completion of mobility assessments for patients identified to be at risk of falling. Patients who receive mobility assessments would be safer while mobilising thereby reducing the risk of falls while walking, which is a type of fall associated with fractures in our data. It should be noted that there is considerable heterogeneity in falls risk screening processes across Queensland Health facilities with a mixture of validated falls risk screening tools, formal and informal clinical judgment based approaches being employed.

A parsimonious adjusted model proved elusive for both hospital and residential care data sets, with a number of variables retaining p-values equal to or less than 0.05. Despite this, the final model explained only a modest proportion of the overall variance in the outcome variable. While this could be indicative of Type I error or a high degree of random chance governing fracture phenomena, it is at least partly due to the recognised multifactorial nature of fall-related fractures. A comprehensive explanatory model would require the inclusion of other independently predictive intrinsic variables such as diagnosis, frailty, cognitive and mobility status in addition to the variables we considered here.

A recent landmark study examining causative mechanisms for falls in older people highlighted tripping as a frequent cause of falls in institutional settings (21). In our study fFalls due to tripping were also strongly independently predictive of fractures in both hospital and residential care settings. when considered individually. A Consequently, lthough falls due to tripping did not retain statistical significance after being adjusted for other factors in the hospital model, there is a se results signify the need for greater emphasis on managing low-level trip hazards for older people and improving their ability to safely negotiate institutional hospital environments.

Limitations

There are a number of important limitations to our study, several of which are known shortcomings of cross-sectional research with routinely collected incident data (220, 231). As our sample was extracted from a voluntary incident reporting system, it is recognised that many unreported incidents would be missing from analysis. Admittedly, a reporting bias towards injurious falls might also introduce an unknown degree of skew. Variations in incident reporting culture are unavoidable in large heterogeneous organisations such as Queensland Health, which consists of numerous facilities spread across large geographical areas and servicing diverse populations. These variations in reporting can be a substantial confounder for cross-sectional studies such as this where data is aggregated across multiple sites.

We recognise that by using 'fracture' as the outcome variable, we are aggregating fracture types with potentially dissimilar known differences in fracture injury mechanisms (24). This approach could and therefore conceal underlying divergences in risk factors. ClearlyAdditionally, there is some suggestive evidence that activities preceding fracture producing falls vary depending on the resultant fracture type (253).

Another potential confounder is that most falls in health facilities are unwitnessed by staff. In our sample, fewer than twenty-five per cent of hospital falls and sixteen per cent of residential care falls were reported as having been witnessed. It is likely that details relating to these unwitnessed incidents are based on information collected from patients or residents themselves, other observers, and the reporter's investigation of the circumstances surrounding the fall. It is possible that any extrapolation on the part of reporters could introduce error and negatively influence veracity of the data.

An important weakness of our study is the inability to account for the effect of exposure rates with this approach. In this study, we identified fall-related predictors of fracture outcomes by comparing falls resulting in fracture with falls that did not. While this approach is useful in identifying fall types that are associated with high injury risk, it is not possible to estimate the overall risk of fall-related fracture associated with particular activities or situational factors. For example, while our data allows us to compare the odds of a fracture outcome from falls during mobilization with the odds of fracture from other fall types, we cannot comment on the overall risk of fall-related fracture during mobilisation without the addition of information on exposure rates and activity-related fall rates. Nevertheless, such cumulative estimates of risk were outside the scope of the present study and could be the focus of future work.

Within the limitations listed here, our results would be useful in the development of future intervention strategies to address the problem of injurious falls in hospital and residential care settings.

FUNDING DISCLOSURE

This investigator-initiated study was seed-funded by an $8,000 internal research grant from the Queensland Health Patient Safety Centre, which contributed towards off-line research time for the principal investigator. The principal investigator commenced a five-year Queensland Health research fellowship during the latter stages of this study, which supported part of the time spent in manuscript preparation and finalisation.

CONFLICTS OF INTEREST

None declared.

Table 1 Fall-related field definitions[λ]

Type of fall	
Slip	Fall or loss of balance occurring from loss of traction on surface
Trip	Loss of balance usually while walking resulting from portion of foot or lower limb contacting an obstacle.
Legs gave way	Involuntary loss of mechanical support in the leg or legs
Dizziness	Loss of equilibrium, for example, a spinning sensation, or light-headedness, or a feeling you are about to fall
Faint	Loss of consciousness
Overbalance	Movement of the body beyond its base of support
Activity at time of fall	
Walking	*(No definition provided)*
Standing	Standing without other overt activity
Sitting to Standing	Moving from a sitting position to a standing position, eg rising from bed or chair or toilet
Standing to sitting	Moving from a standing to sitting position, eg lowering to a bed, chair or toilet
Standing from lying position	Moving from a lying to standing position, eg getting out of bed
Standing to lying position	Moving from lying to standing, eg getting in to bed
Rolling out of bed	Rolling out of bed on to the floor
Sitting	Sitting without other activity
Seating to seating	Transferring from one seated position to another, eg chair or toilet to wheelchair
Reaching for object while seated	*(No definition provided)*
Reaching for object while standing	*(No definition provided)*
Function attempted by patient at time of fall	
Toileting	All activities involved in getting to and using the toilet
Bathing or showering	All activities involved in bathing or showering, including getting to the shower
Resting	Includes movement to the location of rest
Exercising	Activity undertaken for therapeutic or recreational purposes, eg. going for a walk, or a part of treatment program
Grooming or dressing	Includes activities such as brushing hair or teeth, dressing, etc
Use entertainment	Includes activities such as picking up a book or turning on the TV

λ Source: Queensland Health PRIME Clinical Incident Data Dictionary v 4.1 2008

Table 2 Characteristics of study sample: Falls and fall-related fracture

	Hospital	Residential Care Facilities
Reported falls	24,218	8,980
Mean age (SD)	70.14 (17.28)	80.48 (10.65)
Median age	74.35	82.37
Gender (Male %)	57	54
Reported fractures (% reported falls)	229 (0.94)	74 (0.82)
Mean age (SD)	75.83 (15.21)	82.63 (9.99)
Median Age	78.98	85.33
Gender (Male %)	33	44

Table 3 Univariate analysis of fall-related predictors of fracture outcomes in hospital and residential care settings

	Hospital		Residential care	
Variable	O/R[a,c] (95% CI)	*p*-value[b]	O/R[a] (95% CI)	*p*-value[b]
Activity Factors				
Reaching in standing	0.67 (0.34-1.31)	0.251	2.64 (1.13-6.16)	0.024*
Rolling out of bed	0.29 (0.10-0.78)	0.015*	0.86 (0.26-2.76)	0.802
Sitting	0.23 (0.08-0.62)	0.004*	0.40 (0.09-1.67)	0.214
Walking	1.96 (1.50-2.56)	<0.001*	2.04 (1.27-3.27)	0.003*
Type of Fall				
Trip	2.06 (1.32-3.22)	0.001*	3.88 (1.90-7.94)	<0.001*
Slip	0.70 (0.49-0.98)	0.043*	0.57 (0.27-1.20)	0.143
Function Factors				
Resting	0.40 (0.22-0.73)	0.003*	0.33 (0.10-1.05)	0.062
Person Factors				
Age between 40 and 60	0.46 (0.27-0.78)	0.004*	0.29 (0.04-2.21)	0.238
Age over 80	1.51 (1.16-1.96)	0.002*	1.27 (0.74-2.16)	0.377
Male Gender	0.37 (0.28-0.50)	0.000*	0.67 (0.40-1.12)	0.132
Spatial/Environmental Factors				
Bedside	0.63 (0.46-0.84)	0.002*	0.45 (0.14-1.44)	0.179
Bedroom areas other than bedside	1.36 (1.00-1.85)	0.048*	1.50 (0.93-2.42)	0.091
Corridor/Hallway	2.39 (1.58-3.62)	0.000*	0.88 (0.38-2.02)	0.770
Other areas – Not classified	1.24 (0.45-3.35)	0.671	3.08 (1.11-8.55)	0.031*
Temporal Factors				
1600-1700	0.92 (0.43-1.97)	0.844	2.12 (1.03-4.35)	0.040*
1900-2000	0.92 (0.41-2.07)	0.848	2.86 (1.35-6.05)	0.006*
Other factors				
Risk screened/assessed at admission	0.66 (0.48-0.92)	0.015*	0.41 (0.16-1.04)	0.061

[a] Odds ratio (95% Confidence interval)
[b] Significance level
[c] – Reference value for all comparisons using odds ratios are 1.00; Each variable is compared against all other remaining variables within category. For example, within 'Activity Factors', odds for facture during falls while 'reaching in standing'

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are expressed as a ratio against odds for fracture after falls related to all other activity variables. Hospital and residential care results are presented in parallel but have been analyzed separately.
*Significant variable (p equal to or less than 0.05)

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Table 4 Adjusted Odds Ratios– Hospital fractures

Logistic regression — Number of obs = 17016; Wald $chi^2(10)$ = 101.60; Prob > chi^2 = 0.0000; Log pseudo-likelihood = -911.42064; Pseudo R^2 = 0.0554

Variable	O/R (95% CI)	*p*-value
Witnessed by staff	0.51 (0.33-0.79)	0.003
Risk screened/assessed at admission	0.60 (0.41-0.89)	0.012
Standing	2.08 (1.22-3.55)	0.007
Walking	1.86 (1.32-2.62)	<0.001
Resting	0.52 (0.27-0.97)	0.043
Male gender	0.42 (0.30-0.58)	<0.001
Corridor/hallway	2.10 (1.23-3.58)	0.006
Age between 40 and 60	0.52 (0.27-0.98)	0.046
Age 80 and over	1.44 (1.05-1.99)	<0.001
1400-1500 hours	1.97 (1.09-3.54)	0.023
2100-2200 hours	1.73 (1.01-2.97)	0.044

Table 5 Adjusted Odds Ratios - Residential care fractures

Logistic regression — Number of obs = 8973; Wald $chi^2(10)$ = 62.61; Prob > chi^2 = 0.0000; Log pseudo-likelihood = -406.85361; Pseudo R^2 = 0.0510

Variable	O/R (95% CI)	*p*-value
Reaching in standing	3.51 (1.44-8.56)	0.006
Walking	2.11 (1.24-3.58)	0.006
Trip	2.89 (1.35-6.17)	0.006
Bedroom areas other than bedside	1.88 (1.15-3.07)	0.011
Other areas – Not classified	3.19 (1.15-8.85)	0.025
0700-0800	2.56 (1.08-6.07)	0.033
1600-1700	2.59 (1.24-5.39)	0.011
1900-2000	3.33 (1.55-7.14)	0.002

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STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract ✓
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found ✓
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported ✓
Objectives	3	State specific objectives, including any prespecified hypotheses ✓
Methods		
Study design	4	Present key elements of study design early in the paper ✓
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection ✓
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants ✓
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable ✓
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group ✓
Bias	9	Describe any efforts to address potential sources of bias ✓
Study size	10	Explain how the study size was arrived at ✓
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why ✓
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding ✓
		(*b*) Describe any methods used to examine subgroups and interactions ✓
		(*c*) Explain how missing data were addressed ✓
		(*d*) If applicable, describe analytical methods taking account of sampling strategy ✓
		(*e*) Describe any sensitivity analyses ✓
Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed ✓
		(b) Give reasons for non-participation at each stage N/A
		(c) Consider use of a flow diagram N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders ✓ (where available)
		(b) Indicate number of participants with missing data for each variable of interest Not possible for size of dataset
Outcome data	15*	Report numbers of outcome events or summary measures ✓
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included ✓
		(*b*) Report category boundaries when continuous variables were categorized ✓
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses ✓

Discussion		
Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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