

## Clinical Study

# The Epidemiology of Fractures Caused by Falls Down Stairs

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Received 9 May 2013; Accepted 5 June 2013

Academic Editors: C. M. Maylahn and J. M. Ramon

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Fractures sustained from a fall down stairs have received little attention in the orthopaedic literature. We have undertaken a study of these fractures to determine their epidemiology and to compare it to that of fractures caused by a standing fall. All new patients presenting with a fracture between July 2007 and June 2008 were prospectively identified. Falls down stairs caused 261 fractures and were the fifth commonest mode of injury in all ages but the second commonest in those aged 65 years or over. Patients in this category were significantly younger than those with a fracture from a standing fall (54.6 yrs versus 64.9 yrs,  $P < 0.001$ ). Fractures of the ankle (odds ratio (OR) 1.9,  $P < 0.001$ ), talus (OR 3.0,  $P = 0.04$ ), calcaneus (OR 9.7,  $P < 0.001$ ), midfoot (OR 6.9,  $P < 0.001$ ), toe phalanges (OR 12.0,  $P < 0.001$ ), scapula (OR 4.6,  $P = 0.002$ ), and proximal ulna (OR 2.4,  $P = 0.04$ ) were significantly more likely to result from a fall involving stairs. When grouped together, the odds of any foot or ankle fracture resulting from a fall down stairs were approximately double when compared with a fall from standing (OR 2.1,  $P < 0.001$ ). There was a trend towards increased fracture incidence from falls down stairs with worsening social deprivation ( $r = 0.63$ ,  $P = 0.05$ ). A fall down stairs poses a substantial risk of fractures of the foot, ankle, and scapula. When examining patients with this mechanism of injury, these fracture types should be excluded.

## 1. Introduction

There has been no previous study of the fractures caused by falls down stairs in adults. Wyatt et al. documented 51 fatal injuries caused by falls down stairs over a five-year period in the south east of Scotland, highlighting the danger of stairs, especially for the elderly [1]. With the projected increase in the proportion of elderly in the population [2], it is possible that falls down stairs may become more frequent. In the paediatric literature, stairway-related injuries have received some attention, with the majority noted to be minor injuries of the head and neck [3–5]. In contrast to falls from standing height, falls down stairs have the potential to cause greater skeletal injury, largely influenced by the height of the fall and the number of stairs involved [6].

Socioeconomic deprivation is known to have an influence on the incidence of fractures from falls from standing height [7], the outcome of joint replacement surgery [8], and the prevalence of chronic medical conditions such as heart disease [9]. As yet, the influence of deprivation on fractures caused by falls down stairs has not been examined.

The purpose of this investigation was to determine the epidemiology of fractures caused by falls down stairs, paying attention to the influence of socioeconomic deprivation. The secondary aim was to compare these fractures with those resulting from falls from standing height.

## 2. Materials and Methods

All new in-patients and out-patients presenting acutely with skeletal injury to the Royal Infirmary of Edinburgh Orthopaedic Trauma Unit were prospectively identified over a one-year period (July 1, 2007 to June 30, 2008). A dedicated trauma fellow (SAA) collected all demographic, clinical, and injury data, and all fracture diagnoses were made from plain radiographs by experienced orthopaedic trauma surgeons. In Edinburgh, adolescent patients aged between 12 and 14 years are treated in both the adult and paediatric trauma hospitals. This study was therefore confined to patients aged 15 years or older. We defined falls down stairs as a fall down three stairs or more. Falls down two stairs or fewer were regarded as simple falls from standing height. All fractures

TABLE 1: Mechanism of injury.

	(n)	(%)	Mean age (SD) (years)	M/F ratio (%)	≥65 yrs age (%)
Simple falls	3843	55.9	64.9 (SD 20.7)	30/70	57.6
Sport	1000	14.6	28.0 (SD 12.4)	82/18	1.7
Direct blow/assaults	867	12.6	33.5 (SD 16.0)	77/23	2.7
Road traffic accidents	359	5.2	39.1 (SD 17.1)	79/21	8.9
Falls down stairs	261	3.8	54.6 (SD 20.6)	38/62	35.6
Falls from a height	250	3.6	38.0 (SD 15.6)	78/22	5.6
Spontaneous	40	0.6	66.7 (SD 17.6)	25/75	60.0

The number (*n*) and frequency (%) of fractures sustained by Edinburgh adults, arranged in decreasing order of frequency according to the responsible mode of injury are shown. The mean age, gender ratio, and proportion of patients affected aged 65 years or more are also shown.

sustained by falls down stairs and falls from standing height were retrospectively identified from the trauma database.

For the purposes of accurate epidemiological analyses we restricted our study to patients residing in our geographical catchment area. All patients resident in this area, but who sustained a fracture elsewhere and then returned for local followup, were included in the analysis. Patients initially treated locally who lived out of our primary catchment area were excluded. The mid-year 2007 population estimates, based upon 2001 census data, indicated that the adult population aged 15 years or more in our primary catchment area was 545,081 [10]. Social deprivation was assessed using the Carstairs score [11], which is derived from residential postal codes. The Carstairs score is a z-score based on overcrowding, male unemployment, social class, and car ownership. It has been extensively used to examine social deprivation in orthopaedic surgery [7, 8, 12] and other branches of medicine [9, 13]. The Carstairs score can be used to divide the population of Scotland into five equal quintiles, with Quintile 1 (Q1) being the most affluent and Quintile 5 (Q5) being the most deprived.

### 3. Statistical Analysis

Statistical analyses were performed using SPSS Statistics 20.0, (SPSS Inc., Chicago, Illinois, USA). Student's *t*-test was chosen when comparing two groups of continuous data (patient age). The chi-square and Fisher's exact tests were used when comparing for categorical data (fracture type). The Pearson correlation coefficient (*r*) was used to describe the strength of a linear relationship between fracture incidence and social deprivation. A *P* value <0.10 determined a statistical trend, with a *P* value <0.05 defining significance. Arithmetic mean values were expressed with the standard deviation (SD). Odds ratios (OR) were calculated for specific fracture types according to the causative mechanism of injury.

### 4. Results

During the study period, 6872 fractures occurred in Edinburgh's residents, representing an overall fracture incidence of 125/10,000/yr. A fall down stairs caused 261 (3.8%) fractures in 238 patients (5/10,000/yr). Ninety-nine (37.9%) fractures occurred in men (mean age 51.3 yrs, SD 20.2 yrs). Women suffered 162 (62.1%) fractures and were noted to represent



FIGURE 1: The fracture distribution curve for fractures resulting from falls down stairs in Edinburgh's men and women.

a significantly older group (mean age 56.6 yrs, SD 20.6 yrs) than men ( $P = 0.04$ , *t*-test). Twenty-six patients (10.9%) presented with more than one fracture. The resultant fracture distribution curve for fractures sustained after a fall down stairs is shown in Figure 1 and follows a type I distribution, as described by Court-Brown and Caesar [14]. In both genders, the age-adjusted incidence of fractures resulting from falls down stairs increased with advancing age.

Falls down stairs were the fifth most common cause of acute fracture in Edinburgh's residents. Over a third of affected patients in this group were aged 65 years or more (Table 1). However, patients with fractures from a simple fall represented an even older group (64.9 yrs, SD 20.7 yrs, versus 54.6 yrs, SD 20.6 yrs,  $P < 0.001$  *t*-test).

Table 2 shows the distribution of fracture types resulting from falls down stairs in comparison to simple falls from standing. Notably, fractures of the proximal femur and proximal humerus were less likely to occur following a fall down stairs than from a simple fall. Conversely, fractures of the ankle, hindfoot, midfoot, and scapula were more likely to result from a fall involving stairs. Indeed, if all fracture types around the foot or ankle region were analysed together

TABLE 2: Fracture types from falls down stairs or standing in all ages.

Fracture type	Falls down stairs			Falls from standing			Odds ratio	P value (chi-sq)
	(n)	(%)	Mean age (yrs)	(n)	(%)	Mean age (yrs)		
Upper limb								
Clavicle	11	4.2	60.1	106	2.8	57.9	1.6	0.2
Scapula	7	2.7	65	23	0.6	60.4	<b>4.6</b>	<i>0.002</i>
Proximal humerus	17	5.4	65.3	417	10.8	70.7	<b>0.6</b>	<i>0.02</i>
Humeral diaphysis	3	1.2	57	43	1.1	63.8	1.0	0.8
Proximal radius	14	4.6	43.1	153	3.9	49.1	1.4	0.4
Proximal ulna	7	2.7	57	44	1.1	63.7	<b>2.4</b>	<i>0.04</i>
Ulnar diaphysis	3	1.2	59	12	0.3	45.5	<b>3.9</b>	0.07
Distal radius/ulna	53	20.5	53.6	803	20.9	65.5	1.0	0.9
Carpus	4	1.5	27	84	2.2	45.5	0.7	0.7
Metacarpal	11	4.2	40.4	132	3.4	48.9	1.2	0.6
Finger phalanges	7	2.7	52.3	154	4	56.9	0.7	0.4
Lower limb								
Pelvis	4	1.5	72	80	2.1	82.6	0.7	0.8
Proximal femur	19	6.2	77.7	770	20	81	<b>0.3</b>	<i>&lt;0.001</i>
Femoral diaphysis	3	1.2	81.7	60	1.6	77.9	0.7	0.8
Patella	4	1.5	61	41	1.1	60.9	1.4	0.5
Proximal tibia	4	1.5	58	42	1.1	64.8	1.4	0.5
Tibial diaphysis	2	0.8	38	23	0.6	56.6	1.3	0.4
Distal tibia	2	0.8	31.5	18	0.5	54.7	1.6	0.1
Ankle	49	18.5	56.4	414	10.8	54.2	<b>1.9</b>	<i>&lt;0.001</i>
Calcaneus	5	1.9	48.8	8	0.2	50.3	<b>9.7</b>	<i>&lt;0.001</i>
Talus	2	0.8	30	10	0.3	52	<b>3.0</b>	<i>0.04</i>
Midfoot	7	2.7	44.4	15	0.4	47.1	<b>6.9</b>	<i>&lt;0.001</i>
Metatarsal	12	4.2	45.7	280	7.3	66.8	0.6	0.1
Toe phalanges	11	4.2	37.3	14	0.4	49.5	<b>12.0</b>	<i>&lt;0.001</i>

The number (*n*) and frequency (%) of upper and lower limb fracture types encountered in Edinburgh adults resulting from falls down stairs or falls from standing height are shown. The mean age of those affected is shown. Calculated odds ratios (with *P* values, chi-square tests) represent the likelihood of a given fracture type resulting from a fall down stairs, rather than a fall from standing. Odds ratios in bold type reflect those demonstrating either statistical significance or a trend towards significance.

(distal tibia, ankle, talus, calcaneus, midfoot, metatarsus, and toe phalanges), the odds of them resulting from a fall down stairs were approximately the double when compared with a fall from standing (OR 2.1, *P* < 0.001 chi-sq).

Closer examination of Edinburgh's adults aged 65 years or more revealed that falls down stairs were the second most common cause of fractures after simple falls from standing, accounting for 4.2% of injuries. In this older adult subgroup (Table 3), the odds of suffering a fracture of the scapula, proximal ulna, ulnar shaft, ankle, or calcaneus following a fall down stairs were greater than those identified in Table 2.

During the study period, the Edinburgh's population catchment area contained a higher proportion of residents in socioeconomic Quintile 1 compared with Quintile 5 (Figure 2(a)). As illustrated in Figure 2(b), there was a statistical trend towards an increasing incidence of fractures from falls down stairs with greater social deprivation (*r* = 0.63, *P* = 0.05 Pearson). In particular, significantly greater odds of fracture were identified in Q5 patients when compared against patients from the other four quintiles (OR 4.1, *P* < 0.001 chi-sq).

## 5. Discussion

Falls down stairs are an uncommon cause of fractures in adults of all ages, but we have shown that these falls are the second most common cause of fractures in the Edinburgh's population aged 65 years or older. Their overall incidence increases with advancing age, especially in men, although greater numbers are seen in women overall (Figure 1). We identified greater odds of sustaining certain fracture types from falls down stairs, when compared with simple falls from standing (Table 2). The odds of sustaining fractures of the scapula, ankle, and hindfoot were even still greater when analyses were confined to older adults (Table 3). In keeping with simple fall fractures, falls down stairs in our population are influenced by socioeconomic deprivation.

There has been no previous study of adult fractures caused by falls down stairs, but some effort has been made to look at injuries in general and deaths. There have been a number of studies illustrating the problem in children with particular reference to head and neck minor injuries and nonaccidental injury [4, 5]. The importance of stair injuries

TABLE 3: Fracture types from falls down stairs or standing in those of 65 yrs or older.

Fracture type	Falls down stairs		Falls from standing		Odds ratio	P value (chi-sq)
	(n)	(%)	(n)	(%)		
Upper limb						
Clavicle	4	4.3	50	2.3	1.9	0.2
Scapula	4	4.3	11	0.5	<b>9.0</b>	<i>0.002</i>
Proximal humerus	7	7.5	290	13.1	0.5	0.2
Humeral diaphysis	1	1.1	22	1	1.1	0.2
Proximal radius	2	2.1	36	1.6	1.3	0.4
Proximal ulna	4	4.3	26	1.2	<b>3.8</b>	<i>0.03</i>
Ulnar diaphysis	2	2.1	3	0.1	<b>16.2</b>	<i>0.01</i>
Distal radius/ulna	20	21.5	480	21.7	1.0	1
Metacarpus	2	2.1	43	1.9	1.1	0.7
Finger phalanges	3	3.2	65	2.9	1.1	0.5
Lower limb						
Pelvis	4	4.3	75	3.4	1.3	0.6
Proximal femur	16	17.2	707	31.9	<b>0.4</b>	<i>0.004</i>
Femoral diaphysis	3	3.2	54	2.4	1.3	0.5
Patella	1	1.1	23	1	1.0	1
Proximal tibia	2	2.1	22	1	2.2	0.25
Ankle	17	18.3	127	5.7	<b>3.7</b>	<i>&lt;0.001</i>
Calcaneus	1	1.1	2	0.1	<b>12.0</b>	<i>0.004</i>

The number (*n*) and frequency (%) of upper and lower limb fracture types encountered in Edinburgh adults (65 yrs old or greater) and resulting from falls down stairs or falls from standing height are shown. Calculated odds ratios (with *P* values, chi-square tests) represent the likelihood of a given fracture type resulting from a fall down stairs, rather than a fall from standing. Odds ratios in bold type reflect those demonstrating either statistical significance or a trend towards significance.

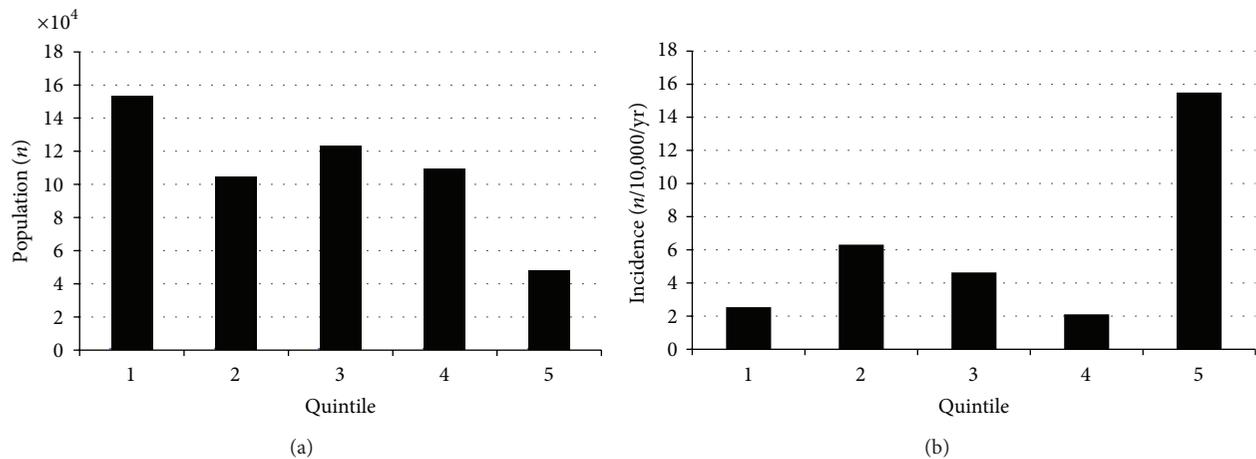


FIGURE 2: (a) The adult population of Edinburgh, arranged according to level of socioeconomic deprivation (according to the Carstairs index). (b) The incidence of fractures resulting from falls down stairs in Edinburgh's adults, according to level of deprivation.

in general on a national scale was highlighted by Roys in 2001, who estimated that 230,000 injuries and 497 deaths were caused by a fall on stairs in the United Kingdom in 1995 [15]. Wyatt et al. in 1999 showed that 51 adults in south east Scotland died from a fall down stairs over a five-year period and concluded that stairs represented a particular hazard for the elderly [1]. Nevitt et al. examined the consequences of falls in the elderly and showed that a nonsyncopal fall down stairs was associated with 2.2 times the risk of injury compared with a standing fall [16].

There is an awareness of the importance of fractures in elderly patients [17]. They are expensive and are often associated with considerable morbidity and mortality [18]. In addition, they can be difficult to treat as they often occur in osteoporotic bone. It seems probable that a large number of the very infirm will not climb stairs, but despite this, our data show that 35% of stair-related fractures occur in adults aged 65 years or more, reinforcing the importance of this area as a focus for injury prevention measures in older population groups.

Luetters et al. demonstrated the risk of foot and ankle fractures from falls down stairs [19]. They showed that stair climbing was one of a number of risk factors for foot fractures in individuals aged 45 years or more. Our results have shown that, when grouped together, fractures of the foot and ankle region represent a greater proportion of fractures from falls down stairs than falls from standing (OR 2.1,  $P < 0.001$  chi-sq). It must be remembered that the majority of foot fractures involve the metatarsus, often caused by a twisting injury or a simple fall [6]. With these injuries excluded, the odds of sustaining a nonmetatarsal foot and ankle fracture increased further following a fall down stairs (OR 2.9,  $P < 0.001$  chi-sq).

In a recent study, Court-Brown et al. [7] demonstrated the influence of social deprivation on the incidence of fractures from simple falls, and our results confirm that this influence also extends to fractures related to falls on stairs. Notably the greatest difference between patient groups was seen between Quintiles 4 and 5, with far less variation identified between the Quintiles 1, 2, and 3. In keeping with simple fall fractures, there seems to be a “deprivation threshold” in our population, beyond which the likelihood of fracture occurrence increases substantially. The reasons for this are presumably multifactorial. They may relate to the general health of deprived individuals, their patterns of behavior, or the type or quality of accommodation found in less affluent areas.

Unlike free falls, which can be categorised according to the height of the fall, it is not possible to easily classify or quantify falls down stairs. We arbitrarily chose to define a fall down stairs as a fall involving three or more stairs, but we accept that the way that a patient falls, slides, or tumbles down stairs is likely to influence the pattern of injuries sustained, as is the ability of the patient to protect himself or herself from injury.

## 6. Conclusion

Patients who present with a fracture from a fall down stairs are significantly younger than those who present with a fracture from standing height. It is the second most common mode of injury for fracture in those aged 65 years and over and is associated with social deprivation. We identified a greater likelihood of patients presenting with fractures of the foot, ankle, and scapula after a fall down stairs than in those falling from a standing height. These fracture types should be excluded when called to examine patients who present after such an injury.

## Conflict of Interests

There is no conflict of interests for any author regarding this paper.

## Authors' Contribution

All the authors contributed to the collection of data, the conceptual design, the data analysis and interpretation, and the preparation of the paper.

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