Part I

Epidemiology and Risk Factors for Falls

1

Epidemiology of Falls and Fall-Related Injuries

Stephen R. Lord, Catherine Sherrington, and Cameron Hicks

In this chapter, we examine the epidemiology of falls in older people. We review the major studies that have described the incidence of falls, the locations where falls occur, and falls sequelae. We also examine the costs required to treat and manage fall-related injuries. Before addressing these issues, however, it is helpful to briefly discuss three important methodological considerations that are relevant to all research studies of falls in older people: how falls are defined, how falls are counted, and what constitutes an older person.

The Definition of a Fall

In 1987, the Kellogg International Working Group on the Prevention of Falls in the Elderly defined a fall as 'unintentionally coming to the ground or some lower level and other than as a consequence of sustaining a violent blow, loss of consciousness, sudden onset of paralysis as in stroke or an epileptic seizure' [1]. Since then, many researchers have used this or very similar definitions of a fall. The Kellogg definition is appropriate for studies aimed at identifying factors that impair sensorimotor function and balance control, whereas broader definitions that include dizziness and loss of consciousness are appropriate for studies that also address cardiovascular and neurological causes of falls such as syncope, postural hypotension, and transient ischaemic attacks.

The Prevention of Falls Network Europe (ProFaNE) collaborators, in conjunction with international experts in the field and using consensus methodology, adopted a simpler definition to include falls that occur from all causes, i.e. 'an unexpected event in which the participant comes to rest on the ground, floor or lower level' [2]. A comparable definition has also been adopted by the World Health Organization.[1] This simple definition is appropriate for multi-centre studies requiring a core data set or for situations where details of falls are

[1] www.who.int/news-room/fact-sheets/detail/falls

unrecorded (routine surveillance data/accident records) or where a high proportion of participants cannot provide reliable information about their falls (i.e. those with delirium and cognitive impairment).

Although falls are often referred to as accidents, it has been shown statistically that fall incidence differs significantly from a Poisson distribution [3]. This implies that causal processes are involved in falls and that they are not merely random events.

Falls Ascertainment

The earliest published studies on falls were retrospective in design, in that they asked participants whether and/or how many times they had fallen over a defined period of time – usually 12 months. This approach has limitations in that participants have only limited accuracy in remembering falls over a prolonged period [4]. Prospective designs, in which participants are followed up for a period, again usually 12 months, to more accurately determine the incidence of falling, have also been conducted. Not surprisingly, these studies have usually reported higher rates of falling. In community studies, despite new technologies designed to detect falls (see Chapter 13), ascertaining falls by self-report remains the most feasible method. Methods used to record falls in prospective follow-up periods include monthly or bi-monthly mail-out questionnaires [5, 6], weekly [7] or monthly falls calendars [8], and monthly telephone interviews [9].

The ProFaNE collaborators recommend that falls should be recorded using prospective daily recording and a notification system with a minimum of monthly reporting [2]. Telephone or face-to-face interview should be used to obtain missing data and to ascertain further details of falls and injuries. Specific information about the circumstances of any falls can also be determined with additional questions on falls diary forms. Current studies are providing the option for calendars to be completed online. Telephone interviews gain the same information as mail-out questionnaires and falls diaries but may require many calls to contact active older people. In research studies fall data should be summarized as: number of falls, number of fallers/non-fallers/frequent fallers, and fall rate per person years [2] with the rate of falls often being used as the primary outcome. In trials it is recommended that staff collecting fall data be masked to group allocation.

However, even with the most rigorous reporting methodology, it is quite likely that falls are under-reported and that data regarding circumstances surrounding falls are sometimes incomplete or inaccurate. After a fall, older people are often shocked and distressed and may not remember the predisposing factors that led to the fall. Denial is also a factor in under-reporting, as it is common for older people

to lay blame on external factors for their fall, and not count it as a 'true' one. Simply forgetting falls leads to further under-reporting, especially in those with cognitive impairment. New technologies now allow for automatic detection of falls and remote monitoring of fall risk in daily life. However, despite encouraging results in controlled settings, these technologies are not yet ready for clinical use – see Chapter 13.

In residential aged care settings, the use of online incident monitoring systems maintained by nursing staff can provide an ancillary method for improving the accuracy of recording falls. In a study of intermediate care (hostel) residents in Sydney, Lord et al. [5] found that systematic recording of falls by nurses increased the number of falls reported by 32%. In hospitals, falls monitoring systems are now commonly used, but trials of fall prevention intervention often supplement these with additional methods such as medical records audits and verbal reports from staff [10].

The Definition of a Fall-Related Injury

The definitions of injurious falls have differed considerably in the literature, due primarily to whether or not minor injuries such as bruises, cuts, and abrasions have been classified as fall-related injuries. The ProFaNE collaborators recommend that due to difficulties in standardizing definitions and classifications of falls injury types, the most rigorous definition of a fall-related injury is radiologically confirmed peripheral fractures, i.e. fractures of the limbs and limb girdles [2]. More recently, it has been acknowledged that the definition of an injurious fall should be expanded to include traumatic brain injury. In recent years traumatic brain injuries due to falls have increased significantly, with associated increases in hospitalizations, disability and death [11].

The Definition of the Older Person

There is no consistency among studies as to what demographic group constitutes older people. The term is used for age groups starting from as low as 50 years. However, the most frequently used definition is people aged 65 years and over. Within this age band, commonly accepted subgroups are those aged 65–74 years, 75–84 years, and 85 years and older.

The Incidence of Falls in Older People

Community-Dwelling Older People

In 1977, Exton-Smith examined the yearly incidence of falls in 963 people over the age of 65 years living in England [12]. He found that in women, the proportion

that fell increased with age from 30% in the 65 to 69 years age group to over 50% in those over the age of 85. In men, the proportion that fell increased from 13% in the 65 to 69 years age group to approximately 30% in those aged 80 years and over.

Retrospective community studies in primarily Caucasian populations undertaken since Exton-Smith's work have reported similar findings, i.e. approximately 30% of older adults experience one or more falls per year [13–15]. Campbell et al. [13] analysed a stratified population sample of 533 participants aged 65 years and over and found that 33% experienced one or more falls in the previous year. Blake et al. [15] reported a similar incidence (35%) in a study of 1042 participants aged 65 years and over. In a large study of 2793 participants aged 65 years and over, Prudham and Grimley-Evans [14] estimated an annual incidence for accidental falls of 28%, a figure identical to that found in the Australian Dubbo Osteoporosis Epidemiology Study of 1762 older people aged 60 years and over [16].

Prospective studies undertaken in community settings have found higher fall incidence rates. In the Randwick Falls and Fractures Study conducted in Australia, Lord et al. [17] found that 39% of 341 community-dwelling women aged 65 years and over reported one or more falls in a one-year follow-up period. In a large study of 761 participants aged 70 years and over undertaken in New Zealand, Campbell et al. [18] found that 40% of the 465 women and 28% of the 296 men fell at least once in the study period of one year, an overall incidence rate of 35%. In the United States, Tinetti et al. [8] found an incidence rate of one or more falls of 32% in 336 participants aged 75 years and over. Similar rates have been reported in Canada by O'Loughlin et al. [9] in a 48-week prospective study of a random sample of 409 community-dwelling people aged 65 years and over (29%), and in Finland by Luukinen et al. [19] in 833 community-dwelling people aged 70 years and over from five rural districts (30%).

Fall rates also increase beyond the age of 65 years. Figure 1.1 shows the proportion of women who took part in the Randwick Falls and Fractures Study [17] who reported falling once, twice, or three or more times in a 12 month period.

The prospective studies that have reported the incidence of multiple or recurrent falls are also in agreement. The incidence of two or more falls in a follow-up year reported in five studies ranges between 11 and 21% (average 15%). Three studies have reported data for three or more falls, and all report an incidence of 8%.

Rigorous data regarding fall incidence in older people from non-Caucasian populations are now also available. Aoyaga et al. [20] studied falls and related conditions among 1534 (624 men, 910 women) community-dwelling people aged 65 years and over in Japan. They found that only 9% of the men and 19% of the women reported one or more falls in the previous year and similarly low incidence

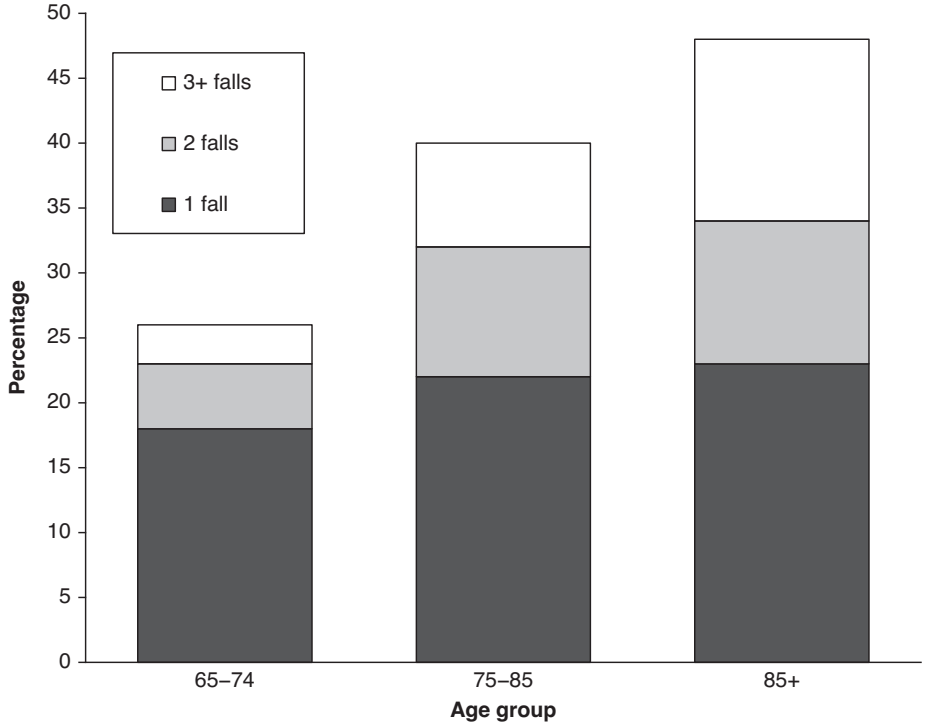

Figure 1.1 Proportion of older women who took part in the Randwick Falls and Fractures Study who reported falling, once, twice, or three or more times in a 12 month period. Diagram adapted from Lord SR, Ward JA, Williams P et al. An epidemiological study of falls in older community-dwelling women: the Randwick Falls and Fractures Study. *Aust J Public Health*. 1993;17:240–245.

rates have also been found in seven other large community studies undertaken in Japan [21]. As part of the Hawaii Osteoporosis Study, Davis et al. [22] attempted to identify neuromuscular performance measures and functional disabilities that could account for such differences in fall rates. They found that the Japanese women had faster walking speeds, chair stands, and performed better on a series of balance tests. On the other hand, the Caucasian women had greater strength, particularly at the quadriceps, and faster hand and foot reaction times. After adjusting for the neuromuscular test results and the number of functional disabilities, the odds ratio for the risk of falls remained essentially the same. It is possible that the better performances in the more functional strength and balance tests that translate more directly to activities of daily living could explain the lower risk of falls among Japanese women.

Kwan et al. [23] conducted a systematic review of fall incidence and fall risk factors in Chinese people living in China, Hong Kong, Macao, Singapore, and Taiwan. In the included 21 studies involving 25,629 people, fall rates ranged

between 14.7% and 34% per annum (median 18%), i.e. a consistently lower incidence of self-reported falls than in Caucasian older people. Subsequently, Kwan et al. [24] investigated why fall rates differ between Chinese and Caucasian older people. Falls were recorded prospectively in large community-dwelling samples of Chinese older people living in Taiwan, Hong Kong, and Australia, as well as Caucasian older people living in Australia. The standardized annual fall rates for the three Chinese cohorts were 0.21 in Hong Kong, 0.26 in Taiwan, and 0.36 in Australia, which were significantly lower than that of the Caucasian cohort at 0.70. The difference in fall rates was not due to better physical ability in the Chinese cohorts. However, the Chinese cohorts expressed more concern about falling and did more planned activity. These findings suggest increased concern is protective for falls in Chinese older people and manifest as more behaviours to lessen fall risk. Interestingly, such adaptations were partially lost in the Chinese older people who migrated to a 'Westernized' country.

Ellis and Trent [25] compared risks for falls and their consequences among 104,902 people from four major race/ethnic groups who were admitted to non-federal hospitals in California from 1995 to 1997. Rates per 100,000 for same-level hospitalized fall injuries for Caucasians (161) were distinctively higher than for African-Americans (64), Hispanics (43), and Asian/Pacific Islanders (35). Caucasians were also more likely to have suffered a fracture and to be discharged to long-term care, suggesting poorer outcomes and greater injury severity.

Finally, Hanlon et al. [26] found that the hazard ratio of risk of fracture for people with more than two falls was significantly greater for African-American and American-Indian women compared to Caucasians, Hispanics and Asians, perhaps reflecting greater vitamin D deficiency. It is possible that differing levels of bone density, medical insurance, and family support may account for some of these differences observed among the groups or that despite no differences in the rate of falling between Caucasians and African-American women, ethnic differences in fracture risk may be due in part to the different ways in which they fall [27].

Seasonal Variations in Falls Frequency

It is possible that the ambient temperature may lead to a seasonal variation in the incidence of falls. People tend to hurry more in colder weather and mild hypothermia and slowed responses are more common. Equally, people tend to be less active in winter, the hours of daylight are shorter and vitamin D deficiency is more likely. There appears to be a seasonal variation in deaths from accidental falls, as illustrated in Figure 1.2 which shows annualized monthly ratios in England and Wales for 1993–1997 [27].

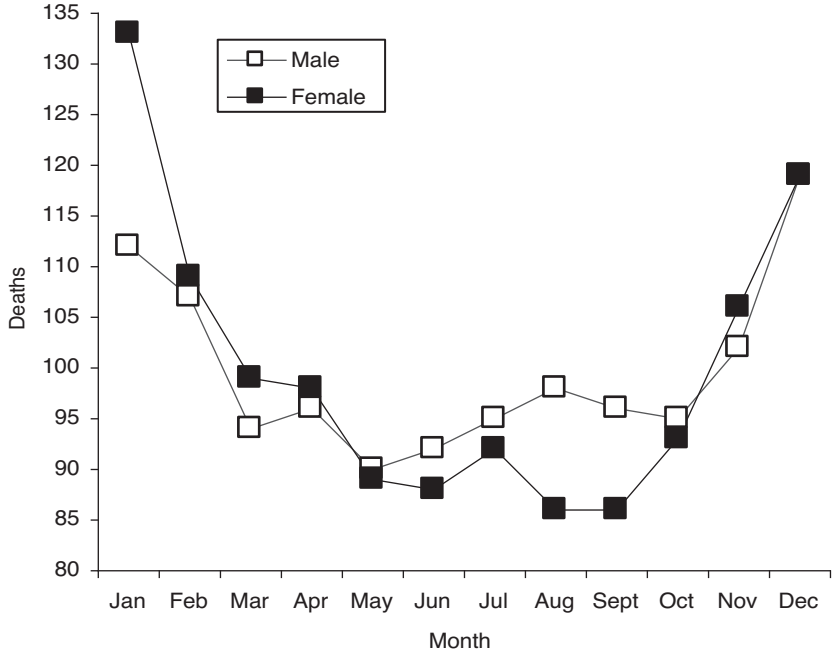

Figure 1.2 Deaths from accidental falls – annualized monthly ratios, 1993–1997. Adapted from Office for National Statistics. *1997 Mortality Statistics: Injury and Poisons*. 1999. London, The Stationery Office.

In a Finnish study, Luukinen et al. [28] found that the incidence of outdoor falls was higher in periods of extreme cold. However, there was no association between indoor falls and temperature, which they attributed to adequately heated houses. A similar study in the UK found that apart from the presence of ground frost, there was no significant association between the prevailing weather conditions and the incidence of hip fractures [29]. The precise effect of seasonal change on the epidemiology of falls is therefore somewhat unclear.

Secular Trends in Fall Injuries

Recent studies have examined routinely collected fall injury and death data as a means of assessing secular trends in fall incidence. In Australia, it has been reported that age-standardized hospitalization rates due to falls increased significantly by 3% per year for men and 2% for women over the 11 years between 2007 and 2017 [30]. Complementary studies have examined secular changes in fall injuries. These have found a decrease in the age-standardized rate of hip fractures of around 1% between 2007 and 2017 and a 7% annual increase in the age-standardized rate of traumatic brain injury over the same period [30]. US data also indicate that the age-adjusted death rate due to falls for people aged over 65

years increased by 31% between 2007 and 2016 and that age-standardized rates of traumatic brain injury are increasing [31]. Further research is required to elucidate why such secular trends in fall injury rates are occurring.

Residents of Residential Aged Care Facilities

Studies on the prevalence of falls have also been conducted in residential aged care facilities, where the reported frequency of falling is considerably higher than among those living in their own homes. For example, Luukinen et al. [32] estimate that among people aged 70 and over in Finland, the rate of falling in the residential care population is three times higher than that among those living independently in the community.

Prospective studies conducted in nursing homes have found 12-month fall incidence rates ranging from 30% to 56%. In an early study, Fernie et al. [33] studied 205 nursing home residents for 12 months and found 30% of the men and 42% of the women had one or more falls. Other studies have reported higher fall incidence rates in older people living in residential care facilities. Lipsitz et al. [34] found that 40% of 901 ambulatory nursing home residents fell two or more times in six months, and Yip et al. [35] found that 56% of 126 nursing home residents fell at least once in a year.

Two other studies have calculated fall incidence rates across a number of nursing homes. Rubenstein et al. [36] summarized the findings from five published and two unpublished studies on the incidence of falls in long-term care facilities. They calculated that the incidence rate ranged between 60% and 290% per bed, with a mean fall incidence rate of 170% or 1.7 falls per person per year. Thapa et al. [37] conducted a 12-month prospective study in 12 nursing homes involving 1228 residents. They report that during the 1003 person-years of follow-up, 548 residents suffered 1585 falls.

Fall rates are also high in residents living in intermediate-care hostels. Lord et al. [5] found a yearly fall incidence rate for one or more falls of 52%, and for two or more falls of 39% in a hostel population of older people. Tinetti et al. [38] also found a high incidence of falling in 79 persons admitted consecutively to intermediate care facilities – 32% fell two or more times in a three-month period.

In the Fracture Risk Epidemiology in the Elderly (FREE) study, 1000 residents from 26 nursing homes and 17 intermediate-care hostels were followed prospectively for a mean period of 15 months to ascertain risk factors for falls [39]. In this period, 621 residents fell at least once: 214 fell once only, 102 fell twice, 77 fell three times, 55 fell four times, and 173 fell five or more times. There were 2554 falls in all (5.45 falls/1000 resident bed days), with 786 falls (30.9%) resulting in an injury. Interestingly, there were non-linear associations between physical functioning

and falls in this group, and the fall rate was significantly higher in intermediate-care residents (65%) compared with the nursing home residents (58%).

Other studies have examined fall incidence in residents of apartment-style retirement villages. Liu et al. [40] found a relatively high proportion (61%) of 96 residents fell over a 12-month period. In a randomized controlled trial examining the effects of group exercise on fall incidence, Lord et al. [41] found that 44% of 199 residents of self-care apartments in the control arm of the study fell on one or more occasions during the one-year trial – a rate that is comparable to community-dwelling people of similar age (age range: 62–92 years, mean: 77 years).

Particular Groups

Older people who have suffered a fall are at increased risk of falling again. In a prospective study of 325 community-dwelling persons who had fallen in the previous year, Nevitt et al. [7] found that 57% experienced at least one fall in a 12-month follow-up period and 31% had two or more falls. Not surprisingly, falls are also more prevalent in frail older people, in those who have difficulties undertaking activities of daily living, and in those with particular medical conditions that affect posture, balance, and gait. Northridge et al. [42] reported that when community-dwelling persons were classified as either frail or vigorous, frailer people were more than twice as likely to fall as vigorous people. Similarly, Speechley and Tinetti [43] reported 52% of a frail group fell in a one-year prospective period compared with only 17% of a vigorous group.

Falls are a common presenting condition in hospital emergency departments. Close et al. [44] found 20% of patients aged 65 years and over attending an emergency department had a primary diagnosis of a fall, and Davies et al. [45] reported an even higher percentage (44%) for this age group. Falls also occur frequently when older people are in hospital. Rates vary from approximately 2% in general hospitals where lengths of stay are relatively short [46, 47] to 27% in an acute hospital geriatrics ward [48].

With regard to medical conditions, Mahoney et al. [49] found that 14% of older patients fell in the first month after discharge from hospital following a medical illness. Fall rates are also increased in people with diseases that result in sensory and motor impairments such as stroke, Parkinson's disease, and cognitive impairment. Forster and Young [50] found that 73% of older stroke patients fell within six months of hospital discharge. Jorgensen et al. also present evidence that fall rates remain high in this group [51]. In a prospective study, they found that 23% of 111 community-dwelling people with long-standing stroke fell one or more times in a four-month period, and that this rate was double that found in 143 age- and sex-matched controls. Annual fall incidence rates above 60% in community-dwelling people with Parkinson's disease have been reported in several studies