REVIEWS OF SOCIO-DEMOGRAPHIC FACTORS RELATED TO FALLS AND ENVIRONMENTAL INTERVENTIONS TO PREVENT FALLS AMONGST OLDER PEOPLE LIVING IN THE COMMUNITY

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**Introduction**

Older people make up a large and increasing percentage of the population of countries worldwide. As people grow older they are increasingly at risk of falling and suffering injury from falling. Falls are also associated with serious social and psychological consequences, as people lose confidence and become isolated and restrict their activity. A fall may be the first indication of undetected illness. Repeated falls often herald a decline in an older person’s functional ability. It is estimated that at least 30% of people aged 65 and over living in the community fall each year, with 20% of these falls requiring medical attention and around 5% resulting in fractures [1, 2.] A fall is commonly cited as the event which precipitates admission to a nursing home, or other institutional care [2]. Thus understanding the causes of falls and how to intervene effectively to prevent falls amongst older people are important goals for researchers, clinicians, and policy makers. In this paper we look at two neglected areas; the environment in which older people live and fall, and the socio-demographics of falling.

This overview of falls and socio-demographic variables and falls and the environment comprises two main sections based on two reviews of the literature undertaken at the end of 2006 and beginning of 2007. The first review looks specifically at the socio-demographic factors associated with falls; in particular investigations of socio-economic status and ethnicity as risk factors for falling and treatment for injurious fall. The second review looks at the relationship between environment and falls and specifically focuses on the degree to which environmental modification interventions have been effective in reducing falls amongst older people.

In preparing these overviews we have been guided by a very specific remit - to review the state of knowledge about falls and falls prevention amongst older people (aged 65 years and more). With this in mind the central the question to be addressed are:

- How do socio-demographic variables (such as age, gender, ethnicity, and socio-economic status) relate to the incidence of falls?
- To what degree is the environment a risk factor for falls, and how effective is environmental modification as a means of reducing falls amongst older people?

**Review methods**

In both reviews we have used systematic review methods to identify papers reporting primary studies for inclusion in the review. Both reviews have also been augmented by referring to other recent systematic reviews in the literature. These reviews therefore cannot be seen as rigorous systematic reviews, but they have used the method of systematic reviewing to identify literature and to provide a model for synthesizing results so as to identify key issues for report and comment.

**Overview of review methods: Socio-demography**

Relevant articles were identified and retrieved from an electronic search of Ovid MEDLINE, EMBASE, PsycINFO, CINAHL, British Nursing Index, and Web of Science. The Cochrane Library was searched using an adapted version of the search strategy. All electronic searches were undertaken in November 2006 and dated from the first issue of the respective database. Searches of web resources were undertaken in
January 2007 using the ProFaNE Fall Prevention Google custom search engine (http://www.profane.eu.org/search/Falls PreventionSearch.php)

The search strategy was devised in accordance with guidelines and recommendations of the Cochrane Collaboration [3] and the UK Centre for Reviews and Dissemination [4]. Our aim was to design and execute a search strategy with high sensitivity and relatively low specificity. The search was however restricted by language of publication to English, but not by study design nor by quality. The search terms included: “falls”, “older”, “elderly”, “senior”, “ethnicity”, “race”, “white”, “black”, “Caucasian”, “African American”, “Hispanic”, “socioeconomic (status)”, “socio-demographic”, “class”, “sex”, and “gender”. Wild cards were used to enable variants on the basic term.

**Overview of review methods: Environment**

The methods used were developed to undertake a full systematic review of the literature exploring the impact of environmental assessment and modification on falls amongst older people living in the community [5]. Although, the full systematic review is not complete, and a meta-analysis is yet to be undertaken on the extracted data from reported trials, the material presented in the section on the environment is drawn from this fuller work.

The search terms for the review include: “accidental falls”, “older”, “senior”, “elderly”, “randomised controlled trial”, “controlled clinical trial”, “environment”, “hazard modification”, “safety”, “home visits”, “home assessment” and “occupational therapy”. The databases searched include MEDLINE, EMBASE and CINAHL, and the years reviewed for this review were 1996-2007. The full systematic review and meta-analysis once completed will cover a longer period.

The review presented here is thus informed by the fuller review that is underway and also the reviews undertaken by Lord et al [6], and the Cochrane Review by Gillespie et al [1].
Review 1: Socio-demographic variables and falls

Generally it has been reported that one in three or one in four older people fall each year; for women 36%, for men 27% [7, 8]. Indeed these rates have become almost dogma in the area of falls prevention research. But as our review below reveals it is becoming clear that these rates are not universal, but essentially are based on data from Caucasian older people, living in relatively affluent urbanised areas of the developed countries of the northern hemisphere and the Antipodes.

In order to investigate socio-demographic variables we have focused on age, gender, ethnicity, and socio-economic status. However, there are a number of definitional and measurement issues to be addressed before we proceed.

Age: We tend to think of age and its measurement as being relatively non-problematic, the number of days months and years since birth. But for some societies such exact counting from birth is not relevant, and dates of birth may not be known or be inexact, to say nothing of differences in calendar. In this report we will not treat this notion as problematic, but will simply depend on reports of age from our reviews.

Gender and sex: Sex and gender are often used in the literature interchangeably and thus incorrectly. Sex refers to a biological entity; gender to social construction, and includes social, cultural or psychological dimensions. Since gender is what people report (not sex) and since this review of the literature depends on social discourses, rather than direct observation of biology, we will use the term gender, regardless of what term the authors of the papers reviewed themselves use.

Socio-economic status: Socio-economic status (SES) can be measured in a number of ways. The most common schemes relate to income, ownership of goods, type of and/or ownership/tenancy status of residence, classification of occupation, and educational attainment. In addition ecological measures of socio-demography exist, normally based on aggregate measures for the district in which individuals live and calculated on the basis of such variables as rurality, housing density, accessibility of health and social services, income, employment, health and disability, education, skills and training, housing and services, living environment etc. Such ecological measures can be used as surrogates for individual data and are normally allocated on the basis of electoral or census districts associated with zip or postcodes. We report socio-economic status as reported by the authors themselves, but this may cause difficulty when it comes to synthesizing data since different schemes are in use. Because of difficulties that exist in collecting high quality socio-demographic data, along with inter-generational and international differences in occupation, income and (e.g.) white good ownership, one of the commonest used surrogates for socio-economic status is educational achievement or years of education.

Race and ethnicity: The literature, especially that derived from the USA, has a tendency to use the terms race and ethnicity interchangeably. The concepts of race and ethnicity however are hotly debated. Ethnicity refers to “a multi-faceted quality
that refers to the group to which people belong, and/or are perceived to belong, as a result of certain shared characteristics, including geographical and ancestral origins, but particularly cultural traditions and languages. The characteristics that define ethnicity are not fixed or easily measured” [9]. Race on the other hand is at least historically a biological concept, used to divide species (including humans) into sub-species, mainly on the basis of visible physical characteristics, but increasingly on the basis of genetics. Race as a way to divide up humanity into groups has been widely discredited not least because of the atrocities that have been committed by those motivated by racist beliefs. According to Bhopal [9] no racial classification systems have stood the test of time, but contemporary US research emphasizes social origins over the biological. Since the term race is so associated with injustice and how people look we will not use it in this report. However, we will have to report ethnicity using the terms used by the authors we review, and on occasion they use terms such as “White” and “Black” which are clearly derived from the concept of race on the basis of skin colour- but we take them as indicators of ethnicity. We follow Bhopal’s [9] glossary to define the terms referring to ethnicity.

In the review table we are careful to describe how socio-demographic data were derived for each study.

When considering the nature of a fall and how it is identified and measured there is surprisingly little agreement in the literature except in very general terms [10]. We have attempted to clarify the definition of fall used within each paper reviewed in our tabulation of the data.

In undertaking the review of falls and demography we have used a wide search strategy. As one of the most important outcomes for falling is injury and fracture, we included these in our initial searches. However, this approach resulted in a number of studies being identified, which upon more careful inspection were not appropriate for inclusion because they presented no data on falls, only data on fractures. However, this search strategy did identify some papers which focused on fracture, but included falls data as a risk factor for fracture. These studies have been included in the review. What we have not done in this review is include literature that relates osteoporosis to socio-demographic variables and thus to fractures. This literature is reasonably well developed and has been the subject of a number of reviews [11, 12, 13]. Central to the findings of these reviews is that osteoporosis (or at least osteoporotic fracture) increases with age, is more prevalent amongst women than men, appears to differ by geographic region, with populations further from the equator having higher rates than those closer to the equator, and there are differences between ethnic groups with Black and Asian populations having lower rates than White populations, but as Jordan and Cooper [12] point out that this variation cannot be explained by race-specific variation in bone density. Furthermore the rates of osteoporotic fracture have been observed to change quite markedly in populations during the latter part of the 20th Century, suggesting that mechanisms relating to diet and lifestyle play important roles. Unpicking the complex interaction between ethnicity, geography, socio-demographics, lifestyle and behaviour, health variables, osteoporosis,
falls and fracture is beyond the scope of the present review, so we have kept our focus more narrowly on falls.

Table 1 presents the findings of our review of socio-demographic variables and falls. We include 30 papers in the review, published between 1994 and 2006. Of these papers, 15 report on studies conducted in countries of the Americas, 8 on studies conducted in Asia, 4 in Europe, 2 in the Middle East, and 1 in Oceania.

**Fall definition:** Of the 30 papers reviewed 17 provide some definition of what is meant by a fall, but 13 either failed to provide any definition, or in 4 cases referred to use of ICD codes. This lack of definition of terms is similar to the report of Hauer et al [44] who report that half of the published randomized trails they reviewed provided no definition of a fall. Likewise the definition of fall provided by those who did define this term differed, although 15 of the definitions required the faller to come to rest on the ground or lower level and often referred to lack of volition. Twenty of the papers report falls over the previous 12 month period, usually based on single interview/questionnaire administration asking if the respondent has fallen in previous year. Two papers report one study following up over a three year period using the much more rigorous approach of a weekly falls diary. These methodological differences make direct comparison of results problematic and preclude any robust meta-analysis or other robust synthesis of the data on falls prevalence. It is recommended that future research adopts standardized definitions and methods to permit future direct comparisons of results using instruments and definitions recommended by the ProFaNE group [10, 44].

**Age:** There is a clear and robust finding across all the studies review in relation to age. Fall rates for both men and women increase with age. Typically the odds ratios associated with age appear modest, in the region of 1.03-1.05 per annum, but this implies quite substantial changes in risk over for example a 5 year period. Thus in the studies reviewed, we observe reported prevalence of falls ranging from a low of 8% for people in their mid sixties to in excess of 50% for those aged 85 and above. However, differences in methods of recording falls, analysis and data presentation make it difficult to compare the data.

**Gender:** It is clear from the review that the prevalence of falling is generally higher amongst women than it is amongst men. For example, Aoyagi et al [18] report age adjusted risk ratios of about 2 in their sample for risk amongst women compared to men. However, in some studies reviewed the relative risk is more modest (e.g. Gill et al [32] report OR=1.27) or even approximates unity (e.g. Pluijm et al [41]). What is clear is that gender is not modifiable, and that large scale robust epidemiological studies of falls related injuries (e.g. Stevens and Sogolow [35]) repeatedly demonstrate that women have more falls injuries than men, with more attendant suffering, morbidity and mortality.

**Socio-economic Status:** Surprisingly little is known about the association of falls with socioeconomic status. One might assume that poorer individuals would be at a greater risk of falls, given their increased likelihood of chronic diseases, polypharmacy, greater disability and functional limitations. However, limited data, not included in our review,
suggest that the picture is more complex than this. The Women’s Heart and Health study [45] found that socioeconomic differences in falling were modest (±3%). However, an ecological study from Wales [46] examining hospitalisation rates found a 19% increase in admission for the most deprived area (measured by deprivation quintile) compared to the most affluent quintile but the pattern was non-linear. This increased risk amongst poorer areas may reflect differences in fall severity rather than incidence per se. Data from the UK on fractures note a more than doubling of 30 day mortality risk for elderly patients admitted with fracture neck of femur from unskilled and semi-skilled occupational backgrounds versus those from professional and managerial backgrounds [47].

The literature reviewed in Table 1 provides at most scant evidence that there is a relationship between socio-economic status and falls. None of the papers reviewed were powered on the basis of investigating SES in relation to falls. SES data, when they are collected at all, appear to have been collected primarily so as to permit description of the sample rather than as an explanatory variable, or to permit analysis to be adjusted for the variable so as to remove any confounding of SES. A number of different variables have been collected making synthesis impossible. We thus depend on a few studies in the review which have collected occupational or educational data. The evidence on SES as measured by educational achievement or years of education completed is contradictory. The analyses of the LASA study [26, 41, 48] suggest that higher SES, as represented by more education, is part of a risk phenotype for falls. Hanlon et al [24] also suggest that greater level of education is associated with higher falls risk. However, Gill et al [32] find more education amongst Australian community residents to be protective and lower income to be associated with increased risk, but others [14, 28] report no relationship between years of education and fall risk. Work from Hong Kong is particularly contradictory. Ho et al [15] report previous work in a blue collar occupation is protective whilst Chu et al [30] report no effect of SES as measured by previous occupation.

The work of West et al [29] whilst based on ecological measurement of SES and falls data from routine health service data provides important insight. In their large scale robust study these authors found that there was 10% higher admission for falls amongst the most deprived. They discuss their findings in terms of the possibility that a minor fall has bigger impact on an individual with multiple co-morbidities and/or poor living environment than it would on someone who has good health, social and financial resources.

There are at least two reasons why there may not be a simple linear association with socioeconomic status. First, individuals who live into old age may be “healthy survivors”. Thus poorer individuals who may have been at greater risk of falls may have been selectively removed from any cohort by premature mortality from other diseases. Second, as elegantly shown by data from the Longitudinal Aging Study Amsterdam, there is more than one phenotype associated with an increased risk of recurrent falls [26]. They noted, using a tree-structured classification model, that there were 11 different risk groups, but the highest risks for recurrent falls were seen for participants with two or more functional limitations, participants reporting dizziness, and a “healthy” sub-group who had no falls history, had good grip strength, drank 18 or more units of alcohol per week, were highly
educated and physically active [26]. What is clear from this review is that much more research is warranted, but that there are real methodological challenges to measuring SES [49 – 53].

Ethnicity: The review reveals that papers reporting directly on comparisons in fall rates between ethnic groups where the survey specifically recruited in order to make these comparisons originate almost entirely from USA. The central comparisons made have been between people identified as Whites or Caucasians, Blacks or African-Americans and Hispanics or Mexican-Americans. Outside of the USA these ethnic comparisons appear for the most part to have been epiphenomena of the study. For example, Chan et al [16] report differences between Singaporeans of Chinese, Malay and Indian ethnic origins, but the sampling strategy and sample size does not suggest this was a central aim of the study, but an opportunity afforded by the sample recruited. Again there are problems with comparing across studies which have used different methods and defined ethnic groups in different ways - occasionally using poor (or frankly indefensible) methods of defining group membership. There is also the problem of confounding variables in sites where data have been collected. A good example is to be seen in the work reporting comparisons between native Japanese older community dwellers and Japanese-Americans and Caucasians [18]. These authors report much lower rates of falls amongst native Japanese than studies in USA and Europe (approximately half the risk) and note that rates for Japanese-Americans are similar to those living in Japan. However, both the native Japanese and the Hawaiian sample are or have been rural livers undertaking farming activities or other manual work. The rural rates reported by Aoyagi et al [18] are approximately half the rates observed amongst the urban Japanese sample reported by Yasumura et al [14]. So it is not clear whether the differences observed by Aoyagi et al [18] relate to ethnicity or to rurality. Similar confounding of ethnicity and other lifestyle or socio-economic issues may also be driving findings of lower rates compared to USA and Europe amongst people in studies in Hong Kong [15] and Taiwanese Chinese [27] and differences between old age populations in cities of USA, South America and the Caribbean [33]. Nonetheless there are some broad general trends to be found. Caucasians living in USA generally have higher falls injury admission rates, than other groups [21]. Whether these injury admissions are a function of falling more rather than more access to health services is difficult to ascertain. One clue in Ellis and Trent’s data [21] is that admission for “superficial injury” for both men and women is some 2 to 4 times higher amongst the Whites than the Hispanics and Asians/Pacific Islanders and about 20% higher than blacks. This is of interest because in the studies that make direct comparisons between self report fall rates of Caucasian-Americans, and African-Americans and Hispanic-Americans [20, 24, 31] the rates do not generally differ significantly. But there is conflicting evidence since Hanlon et al [24] report 23% reduction in single fall risk amongst African-Americans.

The relationship between falls and ethnicity remains wide open for research. Ethnicity (unlike race) is not a simple biological concept, but relates to a whole constellation of cultural practices (including religion), attitudes, beliefs, behaviours, and social structures. In many societies ethnicity (or at least being part of an ethnic minority group) is also associated with poverty, material deprivation, lack of access to resources and power.
There are clearly differences between groups living in the same societies in falls rates, as witnessed by the data from USA. Understanding how these factors are related to falls should be a priority if action is to be taken to remove inequality and reduce risk. It is of interest that there is a great paucity of published work (in the English language at least) from the Developing World; the Middle East, Asia, South and Latin America and the Caribbean, and Africa. Again studies using standardised methods to describe the epidemiology of falls would provide a first step in developing policy to prevent them. Standard methods to describe and collect ethnicity data should also be used [9, 54, 55].

**Socio-demography: Discussion**

It is quite clear from this review that we still know very little about the relationship between socio-demographic factors and falls, except for the one overwhelming finding from the literature that the incidence of falls increases with age. Whilst there are now a number of studies in the literature in which data on falls and socio-demographic variables have been collected it is not possible to synthesise these data in any meaningful way since study designs differ widely and data have been collected in very different ways. For example, most studies reviewed depend on self report of falls recalled over the previous 12 month period, and few studies use the gold standard recommended technique of prospective falls diary. Other studies are based on data collected from surveillance systems and hospital databases following admission for fracture or other injury. The results of this review are in this way very similar to work on randomized controlled trials which found substantial variation in definitions and method of measuring falls [44]. Future studies need to use standardized methods of data collection which will permit comparison, data pooling, synthesis, and meta-analysis. We would recommend doing this by following ProFaNE definitions, recommendations and protocols [10, 44, 56, 57] (see also [www.profane.eu.org](http://www.profane.eu.org)). Only with more evidence robust can we expect clinicians and policy makers to make rational decisions about important issues such as resource allocation and prioritisation in order to tackle the epidemic of falling that we are likely to see world wide with the ageing of our populations.
Review 2: The Environment

Much of the epidemiological work around falling has focused on the identification of and reduction or amelioration of ‘internal’ or health related risk factors, such as chronic disease and impaired function. There is now a sizeable body of literature to support the use of interventions such as individualised strength and balance exercises, which target internal risk factors amongst a general older population living in the community. However, more recently, evidence about the effectiveness of environmental modification in reducing and preventing falls has started to emerge. It is this literature which is the focus of this part of the review.

The review has been written in five sections which aim to do the following:

i) clarify the scope of ‘environment’ and ‘environmental modification’ in relation to falls prevention

ii) present an overview of the evidence of the environment as a risk factor for falls

iii) describe the methods used to elicit the literature reported here

iv) present a review of this literature

v) identify potential directions in which research into environmental modification as a means of reducing falls amongst older people could be developed.

Definitions and scope

The ‘environment’ as understood within falls prevention is often implicitly taken to mean an older person’s home; that is the immediate surroundings in which the older person commonly eats and sleeps [58]. This description may include or may exclude property outside the physical building of the home, such as the garden, garage, outhouses etc. However, ‘environment’ can be interpreted more broadly to mean not just the immediate physical surrounds, but also the community within which one lives – leisure facilities, shops, public transport, public amenities such as libraries, health care facilities etc. Formal evaluations of interventions which also target the broader community environment are uncommon, but the findings of some of these studies are promising, and warrant further attention [59].

Although rarely considered in this way within the scope of falls prevention, ‘environment’ can also include country or culture, drawing more explicitly on the social model of disability in focusing on design, accessibility and environmental barriers and hazards [60]. Cultural practices such as family caregiving, and family values around and support for independent living of elders, for example, might impact on fall frequency, as might government legislation and policies (for example in relation to accessibility of public facilities). There is negligible research in this area although Gillespie et al [1] acknowledge the potential impact of organisational and policy contexts in their comment to the effect that apparently effective interventions may require re-evaluation within different health care systems.

The term ‘environment’ then potentially refers to a variety of different spaces, each of which present opportunities to reduce numbers of falls amongst older people in different
ways and within different contexts. The focus of this review will be largely on environmental modifications within the home environment, as this is the approach adopted within most published trials.

The term ‘environmental modification’ (or environmental adaptation) can also refer to interventions focusing within each of these three domains: the home, the local community and the cultural and policy context. In practice, the most frequent use of the term is to describe changes made to the immediate physical surroundings of the home. Rubenstein [2:pii40] includes the following in elucidating this facet of falls prevention:

elimination of “home hazards such as loose and frayed rugs, trailing electrical cords and unstable furniture … the importance of specific environmental improvements – adequate lighting, bathroom grab rails and raised toilet seat, secure stairway banisters, raising or lowering bed, and an easily accessible alarm system”

The environment has also been the focus of strategies to prevent falls within specific subgroups of older people, such as those within hospital or rehabilitation facilities or care/nursing homes. However, this literature has been excluded from this review because of the specific deficits and needs of those within such facilities, which mean that the interventions developed to reduce falls amongst these subgroups are not applicable amongst a general older population living within their own homes.

Evidence of environmental risk factors for falls
There are acknowledged challenges in retrospectively classifying falls according to their perceived cause, including lack of recall, multiple interactions of risk factors, lack of data about potential factors at the time of the fall and anxiety about the consequences by the older individual reporting the fall. However, Rubenstein [2] cites data deriving from twelve studies which identifies ‘Accident/environmental related’ reasons as the most common cause of falls in older people, responsible for between 30 to 50%. Whatever the veracity of the physical surroundings as the true cause, there is clearly a perception that the environment plays a significant role in many falls experienced by older people.

This is also reflected in the design of many falls prevention interventions. The apparent ‘face-validity’ of including home environmental checks and removal of hazards has meant that such strategies have consistently been included in multifactorial programmes. However, the association between environmental risk factors and falls causation whilst seemingly apparent is complex and can be difficult to illustrate.

First, there may not necessarily be a consensus about what constitutes a hazard: Carter et al [61], for example, illustrated that some hazards identified by health professionals have not been acknowledged as such by older people. This is likely to be a major factor in adherence to health professional recommendations.

Second, research suggests that the role which the environment plays in falls may be in part dependent upon the health status and mobility of older people. Weinburg and Strain
[62], for example, found that amongst a group of over 1000 older people, those who attributed their fall to environmental factors had higher self-rated health, and more outdoor falls, than those whose explanation for their fall featured ‘internal’ factors. Lord et al [6] also report papers reanalysing the findings of two case control studies exploring the relationship between environmental risk and falls [63, 64]. With reanalysis involving reclassification of older participants as ‘frail’ or ‘vigorous’, both papers report that whilst frail elders, as expected, had more falls, environmental factors played a greater role in the falls experienced by vigorous older people. Lord et al [6] suggest that vigorous older people are greater risk takers around potential environmental hazards than frailer people, and cite Studentski et al [65] in support of their assertion that environmental risk factors are likely to impact most on those with ‘fair’ mobility. Those with poor mobility avoid such risks, and those elders with good mobility are able to withstand them.

Finally, there seems to be a complex relationship concerning the association between identified environmental risk factors and number of falls, and also between hazards and injuries. Both Gill et al [66] and Sattin et al [67] found that whilst their research interventions resulted in fewer numbers of hazards, this was not accompanied by a concomitant reduction in the numbers of falls experienced. The picture appears to be even more confusing in relation to injuries, with the authors of a recent Cochrane review exploring the association between home environmental modification and injuries concluding that, for older people, ‘there is little high-level scientific evidence for modification of the built home environment as a method of reducing the risk of injury’ [58:p8]. However, the authors commented that there were methodological problems with many of the studies included in the review, including lack of power to detect effect size, inconsistency between trials about whether fall or injury rates were the primary outcome measure and, notably, low adherence rates to interventions. The review focused on injuries to different subgroups, including children, and whilst focusing on home modifications, included a trial conducted in a nursing home. Another complicating factor which makes interpretation of the findings of this review difficult is the inclusion of trials incorporating environmental modification as part of multifactorial interventions, along with studies in which it was the only intervention. Lyons et al [58] concede that it is difficult within many of the multifactorial trials to separate out the effect of the environmental component.

Review of environmental interventions to prevent falls amongst home dwelling older people
The various iterations of Cochrane reviews exploring effectiveness of falls preventions have consistently recommended the inclusion of some component of environmental modification within the context of multifactorial interventions. As the authors of the latest review note, much of the evidence is from the US, and findings can be difficult to interpret in terms of the mechanisms operating which bring about the positive effect. Gillespie et al [1:p14] note that ‘it may be that the details of the status of the participants, the context of the interventions and the details of content and presentation are critical’, and also argue for research to further explore the separate components.
The successful multifactorial programme designed and evaluated by Clemson and colleagues [59] attempts to provide more detail by highlighting the principles providing the theoretical underpinning to the programme, including enhancement of self-efficacy, decision-making theory and adult learning principles. This trial is also exciting in terms of the broader perspective to the environment addressed within the intervention programme, which included community safety (such as road crossing and use of public transport), and footwear.

Table 2 summarises the six studies which have explored the impact of environmental assessment and modification alone on the risk of a fall either as a sole intervention or as one arm within trials evaluating a variety of different strategies.

Of note for these trials is that within those which were effective [68, 73, 74] the interventions were delivered by therapists, most often occupational therapists, rather than nurses, or ‘trained assessors’. It is also noteworthy that the one other trial in which occupational therapists provided the intervention was underpowered. However we must be careful how we interpret this observation that therapists are effective at reducing falls, since there may be a number of other explanations, most notably the potential effect of publication bias, to say nothing of differences in the actual trial interventions.

Amongst the studies where a reduction in falls was demonstrated, the intervention was effective with a group identified in the literature as ‘at risk’, by virtue of having experienced previous falls or having a specific risk factor identified. For example, in Campbell et al’s [74] recently reported trial involving a multifactorial design including an environmental component, the intervention was successful only with the group of visually impaired elders.

In relation to effective falls prevention comprising environmental assessment and modification alone, Gillespie et al [1] also comment that the mechanisms responsible for reducing falls are also unclear, particularly given the finding within Cumming et al [68] that home environmental modification resulted in a reduction of falls outside. This effect was also noted by Campbell et al [74]. Further consideration of the impact of the occupational therapeutic perspective is provided in the following discussion section.

**Environment: Discussion**

There are a number of points of interest in the studies outlined in the previous section which warrant further discussion. The compliance or adherence to the recommendations made within each of the six studies included in Table 2 varied hugely from a minimum of 13% to a maximum of 90%. With such variation, it is difficult truly to evaluate the efficacy of the interventions: as Lyons et al [46:p9] succinctly express it: ‘Interventions which largely do not happen cannot be expected to substantially change outcomes’. Adherence to home modifications has previously been identified as a problem, and more research is required into older people’s values, expectations and behaviour around this area. A set of evidence-based recommendations aiming to improve adherence to falls prevention initiatives more generally has recently been developed and warrant formal evaluation [75].
Although many ‘checklist’ type approaches to environmental modification have been developed, evidence is starting to suggest that this approach to hazard risk reduction, within which the older person remains passive, is unlikely to be effective. As Connell and Wolf [76] point out, environmental hazards are not static entities, but occur through an interaction of behaviour and environment.

In part, the success of those trials in Table 2 which were effective could perhaps be attributed to the active client-centred practice of occupational therapists in recognising the dynamic of action occurring within a context, and motivated by values and needs. Occupational therapy models of practice provide a theoretical underpinning for occupational therapy interventions and include Person-Environment-Occupation (ie activity or task) frameworks [77, 78]. The goal of occupational therapy is to ‘maintain, restore or create a match … between the abilities of the person, the demands of her/his occupations in the areas of self-care, productivity and leisure, and the demands of the environment’ [79:p8]. Such models fit well with theories advanced in relation to the role of environment in falls causation [6], and would appear to be highly applicable within falls prevention. This active involvement of older people is cited by Cumming et al [68] as a possible explanation for the reduction of falls outside the home, whilst their intervention ostensibly targeted hazards inside the home. One of the challenges is as Gillespie et al [1] identify, actively to involve older people in falls prevention, perhaps through participation in the design of preventative programmes and strategies.

The success of environmental modifications in the prevention of falls seems to be particularly evident within subgroups of older people who are particularly at risk, such as those who have experienced previous falls, and those with impaired vision. This parallels a similar trend within evaluation of falls prevention initiatives more generally [1]. Further research is needed to enable better description of the mechanisms of environmental interventions, and to test specific forms of environmental interventions with particular subgroups.

Finally, economic evaluations of environmental modifications are woefully lacking, with Gillespie et al [1] citing only findings from Cumming et al [68] which state that the mean cost per fall prevented for those with a fall in the previous year was Aus$3980 (1997 prices, incorporating total health care resource use from randomisation to 12 months [80]). Campbell et al [74] estimated that their successful intervention, implemented with visually impaired elders, cost NZ$650 per fall prevented (2004 prices). For comparison purposes these estimates convert to US$3417 and US$406 per fall prevented at 2004 prices\(^1\). However, overall health economic estimates need to be updated and improved upon, and full economic evaluations are required if the cost effectiveness of environmental interventions is to be properly assessed.

References


   [http://www.york.ac.uk/inst/crd/report4.htm](http://www.york.ac.uk/inst/crd/report4.htm) (14/02/2007)


53. van Lenthe FJ, van Beeck EF, Gevers E, Mackenbach JP. Education was associated with injuries requiring hospital admission. *Journal of Clinical Epidemiology*, 2004; **57**: 945-953

54. Chaturvedi N, McKeigue PM. Methods for epidemiological surveys of ethnic minority groups. *Journal of Epidemiology and Community Health* 1994; **48**:107-111


66. Gill TM, Williams CS, Tinetti ME. Environmental hazards and the risk of non-syncopal falls in the homes of community living older people. Medical Care, 2000; 38: 1174-83.


<table>
<thead>
<tr>
<th>Authors</th>
<th>Study objective</th>
<th>Location</th>
<th>Sample</th>
<th>Study design, socio-economic status (SES) and ethnicity measurements</th>
<th>Findings</th>
<th>Definition of falls given?</th>
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<tbody>
<tr>
<td>Yasumura et al</td>
<td>Examine rate of falls and correlates amongst elderly people living in the community in Japan</td>
<td>Tokyo, Japan</td>
<td>Random sample of community dwelling people aged 65-84 (gender: 439 men, 557 women)</td>
<td>Described SES variables, living with spouse, level of education and income reported. Interviews and home visits undertaken. Ethnic groups: Not defined.</td>
<td>12.8% of men and 21.5% of women reported one or more falls in previous year. Fall rate increased with age for men and women. Frequency of falls was modulated by risk factors such as age, gender, living with spouse, level of education, and income.</td>
<td>Falls defined as events that cause subjects to fall to the ground against their will. Participants asked about history of falls in last 12 months, and the frequency of falls.</td>
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<tr>
<td>Ho et al</td>
<td>Describe baseline characteristics for longitudinal follow up</td>
<td>Hong Kong</td>
<td>Stratified random sample of community dwelling older Chinese aged ≥70 years</td>
<td>No detail of method provided. Interviews and clinical variables undertaken. Gender groups: white collar vs blue collar. Ethnic groups: Elderly Chinese used as entry criterion.</td>
<td>Self-reported fall in last 12 months. OR for falls was 1.4 for women compared to men (95% CI 1.1-1.8) and also for those aged ≥80 compared to those aged &lt;80 years (95% CI 1.1-1.7). Gender and age were retained in the final logistic regression model, but occupation was not.</td>
<td>Falls defined as any event in which a subject falls to the ground against their will. Participants asked about history of falls in last 12 months.</td>
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<tr>
<td>Chan et al</td>
<td>Examine epidemiology of falls among Singaporean elderly community dwellers</td>
<td>Singapore</td>
<td>401 participants aged 60-90, mean age 68.8, roughly equal male and female</td>
<td>No detail of method provided. Interview and clinical health screening undertaken. Ethnic groups: Chinese (83%), Malay (7%), Indian (6%), Others (3%).</td>
<td>17.2% had at least one fall during previous year – 23% mean age; 7.8% of falls were of moderate or major severity. Age, gender, and occupational status were associated with an increase in falls. Mean age of fallers 70.2yrs, non-fallers 68.4yrs (age M 75yrs; OR = 2.5, 95% CI 0.95-3.65).</td>
<td>Falls defined as any event in which a subject falls to the ground against their will. Participants asked about history of falls in last 12 months.</td>
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<tr>
<td>Chan et al.</td>
<td>Koga, Japan</td>
<td>Assess whether gender makes a difference in risk factors for falls in community living elders in Japan</td>
<td>Self-administered questionnaire used to gather number of falls during past year, demographic data, disease and physical symptoms, and activities of the elderly. SES measures: Collected as part of questionnaire but specifics of method not described in paper. Paper reports age and gender only. Ethnic groups: No data on ethnicity presented.</td>
<td>746 participants aged 65-99 years</td>
<td>reduced falling and only 36.9% of the exercise group were female; the gender difference was statistically significant – OR=2.29, 95% CI 1.50-3.50. Malays more prone to falling – OR=2.66 (95% CI 1.21-5.86). No significant differences among the fallers in age, gender or ethnicity between single and recurrent fallers during the previous year, recurrent falls implies falling more than once. Accidental falls defined as falls due to an external hazard.</td>
<td>“An unintentional fall, where the body touches a floor or the ground”</td>
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<tr>
<td>4. Suzuki et al.</td>
<td>Koga, Japan</td>
<td>Assess whether gender makes a difference in risk factors for falls in community living elders in Japan</td>
<td>Self-administered questionnaire used to gather number of falls during past year, demographic data, disease and physical symptoms, and activities of the elderly. SES measures: Collected as part of questionnaire but specifics of method not described in paper. Paper reports age and gender only. Ethnic groups: No data on ethnicity presented.</td>
<td>746 participants aged 65-99 years</td>
<td>A higher number of women reported falling that men – 27% v. 19.4% (p&lt;0.05). 141 participants had fallen at least once in the previous year, 36 had fallen more than twice.</td>
<td>“An unintentional fall, where the body touches a floor or the ground”</td>
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<td>5. Aoyagi et al.</td>
<td>Mitsugi-gun, Hiroshima, Japan.</td>
<td>Compare prevalence of falls in Japanese living in Japan with Japanese Americans living in Hawaii, recruited in Hawaii Osteoporosis Study (HOS) and published studies of Caucasians.</td>
<td>Cross sectional prospective population survey mailed self completion questionnaire. Essentially same questionnaire used in Hawaii and Japan. SES measures: Collected as part of questionnaire but specifics of method not described in paper. Paper reports age and gender only. Ethnic groups: Native Japanese residents of Mitsugi-gun. Japanese-Americans resident of Oahu island (“of pure Japanese ancestry”). No further definition provided. Caucasians based on published studies from UK and USA. (Not clear that all participants in these latter studies were Caucasian.)</td>
<td>Target population 1827 people surveyed 1620 responders (89%) analysis based on 1534 community dwelling people aged ≥65 years (624 men mean age 73.4 and 910 women mean age 74.5) from rural area of Japan.</td>
<td>Self reported fall rates (one or more falls) over previous year were: Japanese native 9% men 19% women Japanese-American 11% men 17% women. Prevalence of falls increases with age for both populations. Risk ratios for any fall, one fall and two or more falls were approximately 2 for women compared to men. Some 62-64% of falls amongst native Japanese resulted in a reported injury of which approximately 13% were reportedly fractures. There was no difference in risk of falls for men or women between native and American Japanese, but comparison with published UK and USA data suggest Japanese have approximately half the risk of falling compared to Caucasians.</td>
<td>No definition provided. Survey instrument item “Have you experienced any falls in the previous 12 months?” Answer, number of falls and for those who reported fall, asked to describe circumstances and consequences of fall.</td>
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<tr>
<td>6. Schwartz et al [19]</td>
<td>San Francisco Bay area, California, USA</td>
<td>Determine frequency of falls and identify risk factors for falls among older Mexican-American women</td>
<td>Prospective cohort study with average follow up of 2.7 years</td>
<td>152 community dwelling Mexican-American Caucasian women aged 59 years or older</td>
<td>211 reported falls. 41% of women reported fall in previous year (95% CI 0.33-0.49). Rate of falls was 508 per 1000 person years (95% CI 440-577). Rate of injurious falls requiring medical attention was 79 per 1000 person years (95% CI 52-107). Older age was associated with an increased risk in falling (RR=1.33, 95% CI 1.10-1.60 for first fall and RR=1.29, 95% CI 1.02-1.62 for second fall).</td>
<td>Defined as “falling and landing on the floor or ground, or falling and hitting an object like a table or stair. Falls caused by overwhelming force, such as a moving vehicle, were excluded.” Participants probably not representative of population (p1378)</td>
</tr>
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<td>7. Means et al [20]</td>
<td>USA</td>
<td>Compare balance, mobility, recent falls, and injuries among elderly African American and White women</td>
<td>Cross-sectional study. Participants recruited from senior citizens’ community centres</td>
<td>180 White women (60%) and 118 African American women (40%), aged 65 or over, community dwelling and mobile</td>
<td>Number of falls and fall related injuries were similar across the two ethnic groups – history of recent falls White women 32.8%; African-American women 32.2%; fall related injuries White women 20.1%; African-American women 15.4% (p=0.33). African-American women had poorer balance and mobility scores on obstacle course test, higher BMI, took fewer medications, were less active, and had poorer muscle strength scores. In regression these variables did not predict falls.</td>
<td>Number of self reported falls in previous 12 months. Fall defined as “any involuntary change from a position of partial or full bipedal support (standing, walking, bending, reaching etc) to a position of no longer being supported by both feet, accompanied by (partial or full) contact with the ground or floor.”</td>
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<td>Ellis &amp; Trent</td>
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<td>Ethnic groups: Identified from computerized hospital discharge summaries and population estimates as above. No detail of how ethnicity ascribed provided. Report classification as White, Hispanic, Black, Asian/Pacific Islander.</td>
<td>Asian/Pacific Islander females: 96, 286, 852, 1540 Hip fracture rates highest among White females (71 per 100,000, 95% CI 69.2-72.3) and lowest among Asian/Pacific Islander males (11 per 100,000, 95% CI 8.7-13.0) Hip fracture rates higher among females than males for all ethnic groups</td>
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<tr>
<td>9. Kressig et al [22]</td>
<td>Atlanta, USA</td>
<td>Determine whether there are associations between demographic, functional, behavioural characteristics and activity related fear of falling among older adults transitioning to frailty who have previously fallen. Cross-sectional analysis in a prospective cohort recruited for intervention study. (Baseline only reported here) SES measures: Collected as part of recruitment into intervention study, but details of method, not described in paper (“trained evaluators collected demographic…data”). Age, gender, education Ethnic groups: Not defined how identified. Caucasian (81%), African-American (17%), other (2%).</td>
<td></td>
<td>287 (17 male) people aged 70 and older, who had fallen in past year. (NB recruited from total sample of 1791 people approached, 311 enrolled in study). All participants had reported history of fall in previous year as entry criterion.</td>
<td>Increased fear of falling in African-Americans v. Caucasians (OR=2.2 on FES (95% CI 1.2-4.1), 2.7 on ABC scale (95% CI 1.4-5.1)) No association with age. Increased fear of falling amongst those who did not complete high school (FES OR=2.4 (95% CI 1.3-4.5), ABC=2.6 (95% CI 1.4-4.9)). Ethnicity remains predictive of fear (ABC) in regression model (OR for African American=2.0, 95% CI 1.3-2.5)</td>
<td>Measured Fear of Falling as opposed to falls – used FES and ABC measures. Fall in previous year an entry criterion.</td>
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<tr>
<td>10. Young et al [23]</td>
<td>USA</td>
<td>Examine relationship between risk factors associated with first hip fracture and time to first fracture. Note this study of fracture rates includes falls history as a risk factor. Examination of data from Longitudinal Study on Aging (LSOA), comparison of characteristics of hip fracture group with those of non-hip fracture group. SES measures: Collected as part of longitudinal survey, but details of method not described in paper. Age, gender, living arrangements Ethnic groups: Not defined how identified. Caucasian versus Black (all other ethnic groups not clear).</td>
<td></td>
<td>Total study sample was 7,153, age range 70-99, predominantly (91%) Caucasian, 61% female</td>
<td>Hip fracture group were older (p=.001), more likely to be female (p=.001), and more likely to be Caucasian (p=.001), these factors were all associated with less time to first fracture. Relative risk 1.4x higher for a Caucasian female aged over 85 compared to a Black male aged 70-84. With falls history this relative risk goes up to 19.8 and time to first fracture is 124 days sooner. No data on relationship between falls and socio-demography per se reported.</td>
<td>Measured hip fracture using ICD codes 820.0 to 820.9 Data based on home visit interviews and telephone follow up interviews. Falls history zero one two or more self reported falls in 12 months previous. No details of falls definition given.</td>
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<td>11. Hanlon <em>et al</em> [24]</td>
<td>USA</td>
<td>Examine relationship of ethnicity to falls</td>
<td>Secondary analysis of data from Duke Established Populations for Epidemiological Studies of the Elderly (EPESE). Baseline in-home interviews to assess socio-demographics, health related behaviours, health status etc. Falls in the past 12 months assessed 3 years later by self-report</td>
<td>1049 African-Americans and 1947 White participants, age 72.34 +/- 5.82 (over-sampled African Americans who represent 3.5% of the weighted proportion of EPESE)</td>
<td>22.2% reported one or more falls in previous 12 months when asked 3 years after baseline. 20.2% of African-Americans and 23.2% of Whites African-Americans less likely than Whites to have any fall (OR=0.77, 95% CI 0.62-0.94), but no ethnic differences for multiple falls (OR=0.9, 95% CI 0.64-1.26) African-Americans had a 23% decreased risk of experiencing any falls in the preceding year and a 10% decreased risk of experiencing two or more falls Increased age associated with more falls (OR=1.04 per year, 95% CI 1.02-1.06) Greater level of education associated with more falls (OR=1.49, 95% CI 1.05-2.12 for 13+ years compared with 8 or less years for any falls and OR=1.69, 95% CI 1.10-2.60 for two or more falls). Rurality and income no effect.</td>
<td>No definition of fall. Participants asked if they had had a fall in the past 12 months and those who answered yes how many times they had fallen and if they had passed out or fainted with any of these falls. (Syncopal falls excluded).</td>
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<td>12. de Rekeneire <em>et al</em> [25]</td>
<td>Pittsburg and Memphis, USA.</td>
<td>Investigate relationship between falls and risk factors in healthy older people</td>
<td>Baseline data from a follow up study of healthy 70-79 year olds investigating health ageing and body composition. SES measures: No description of how demographic data collected reported. Age 70-79 (no mean reported), gender, 1447 men, 1515 women. Ethnic groups: No data on ethnicity reported. There are “White” and “Black” persons in the study but no information on how ethnicity ascribed nor numbers in groups is provided.</td>
<td>3,075 well functioning, White and Black men and women aged 70-79 recruited. No further descriptive data on demography of sample provided.</td>
<td>24.1% of women and 18.3% men reported at least one fall in previous 12 months. Highest rate was amongst white women (26%) but no comparative data are presented nor statistical tests for this assertion. White men had 1.4 times risk of falling compared to Black men (OR=1.4, 95% CI 1.2-1.6).</td>
<td>Asked if fallen in past 12 months and if yes how many times. No further definition provided.</td>
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<tr>
<td>13. Stel <em>et al</em> [26]</td>
<td>Amsterdam, Netherlands</td>
<td>Develop a classification tree for predicting the risk of recurrent falling in community dwelling</td>
<td>Analysis of Longitudinal Ageing Study Amsterdam prospective cohort. Interview with clinical, anthropometric and performance data. SES measures: Data collected during home visits using standardised instruments but no details given of how demographic data collected in this paper. Paper reports age, gender, education in years, level of residential</td>
<td>1,365 participants with a mean age of 75.3 (range 64.8-88.6)</td>
<td>Baseline characteristics show that in one risk model recurrent fallers have higher education levels than non and once fallers (p=.02), to be more likely to live in an urbanized area (p=.002), and to be older (p&lt;.001)</td>
<td>Defined as “an unintentional change in position resulting in coming to rest at a lower level or on the ground”. Over 3 year period respondents completed weekly falls diary.</td>
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<td>Stel et al</td>
<td>continued</td>
<td>older persons</td>
<td>urbanisation.</td>
<td>120 community dwelling persons aged 65 and over. 60 people in each group</td>
<td>19% reported one or more falls in previous year. No analyses related to socio-demographic variables collected reported.</td>
<td>Based on self report number since previous researcher visit. Defined as losing one’s balance such that one’s hands, arms, knees, bottom or body touch or hit the ground or floor.</td>
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<td>Ethnic groups: No data on ethnicity presented.</td>
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<td>14. Huang et al</td>
<td>Taiwan</td>
<td>Examine the effectiveness of a home visit falls prevention strategy for Taiwanese community dwelling elders</td>
<td>Randomised trial of individualized multi-factorial intervention delivered during home visits with experimental and comparison group using pre- and post-intervention design. (Baseline only reported here)</td>
<td>120 community dwelling persons aged 65 and over. 60 people in each group</td>
<td>19% reported one or more falls in previous year. No analyses related to socio-demographic variables collected reported.</td>
<td>Based on self report number since previous researcher visit. Defined as losing one’s balance such that one’s hands, arms, knees, bottom or body touch or hit the ground or floor.</td>
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<td>SES measures: Data collected during home visits using standardised questionnaires but no details given of how demographic data collected. Paper reports age, gender, occupation (blue versus white collar), education (literate versus illiterate), level of satisfaction with financial status, housing type, marital status, number of persons living in household,</td>
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<td>Ethnic groups: Residents of Hsin-Chu county, northwest Taiwan. No further definition provided.</td>
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<td>15. Reyes-Ortiz</td>
<td>Southwestern</td>
<td>Estimate prevalence of falls and associated risk factors in Mexican-American people aged 72 and over</td>
<td>2 year cohort study. Socio-demographic characteristics measured at baseline and self-reported falls measured two years later. Data taken from interviews of a population based epidemiological study (Hispanic EPESE)</td>
<td>1,391 Mexican-Americans aged 72 and older</td>
<td>31.8% reported one or more falls. 17.6% reported one fall. 14.2% reported two or more falls. 36% women reported a fall. Female gender was predictive of falls (OR=1.45, 95% CI 1.13-1.86) Age 80+ was predictive of falls (OR=1.52, 95% CI 1.17-1.98) Fallers were also more likely to be unmarried (p&lt;.001) No association for education</td>
<td>Participants were asked “During the past 12 months how many times did you fall and land on the floor or ground?”</td>
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<tr>
<td>et al</td>
<td>States of USA</td>
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<td>SES measures: Self report measures collected as part of interview; age, gender, marital status, and education in years.</td>
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<td>Ethnic groups: Hispanic- described as Mexican-Americans. No further definition provided.</td>
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<td>16. West et al</td>
<td>Trent, UK</td>
<td>Determine relationship between hospital admissions for fall and</td>
<td>Ecological study of routinely collected hospital admissions data for falls and hip fracture in people over 75, 1992-1997. Linked at electoral ward level with characteristics from census data</td>
<td>42,293 admissions for falls and 17,390 for hip fracture, from 858 electoral wards</td>
<td>For people aged over 75 years the mean admission rate for falls was 26.7 per 1000 per year. 10% higher admission rate for falls for most deprived compared with most affluent (RR=1.10, 95% CI 1.01-1.19), with apparent gradient through levels of deprivation (adjusted for proportion of males, ethnicity, rurality and distance</td>
<td>Used ICD-9 and 10 diagnosis codes E880, E888, W00-W19 for falls and S72 for fractured neck of femur.</td>
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<td>SES measures: Hospital; electronic records</td>
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<td>West et al</td>
<td>Trent health service administrative region of England.</td>
<td>hip fracture, and area characteristics such as socio-economic deprivation identified age, gender, and postcode. Postcode used to link to (i) ecological measure of material deprivation (Townsend score of electoral ward) (ii) Carstairs rurality score and (iii) percentage of Asian and Black residents in electoral district.</td>
<td>in Trent health service administrative region of England.</td>
<td>from hospital. The admission rate for hip fracture was 10.9 per 1000 per year. There was no significant association between SES admissions and fractures (RR=1.05, 95% CI 0.95-1.16)</td>
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<td>17. Chu et al [30]</td>
<td>Hong Kong</td>
<td>Estimate the incidence and predictor variables for falls in a Chinese population resident in Hong Kong</td>
<td>Population based cohort study with 1 year follow up. Collected demographic and clinical risk factor data and prospective collection of falls data every 2 months by telephone interview. Sample randomly selected by district and household units. SES measures: Home interviews using structured questionnaire undertaken with older people themselves and other household members, but details of method and questions not described in this paper. Age, gender. Previous occupation (white collar versus blue collar), education (versus no education), marital status. Ethnic groups: Not defined how identified but being Chinese was used as inclusion criterion.</td>
<td>1517 ambulatory community dwelling older people (≥65 years)</td>
<td>401 falls amongst 294 fallers (19.3%), 270 falls per 1000 person years, 4.75% recurrent falls. Falls more common in females and those aged 85+. Independent predictors of falls were history of falls, advanced age, Parkinson’s disease, knee extension power and gait speed. No effect of socio-economic status as measured by either previous occupation or educational attainment was observed. Comparison made to published rates for predominantly Caucasian populations suggest fall rates of Hong Kong Chinese approximately half those of Caucasian studies (but may be artifact of method).</td>
<td>“A fall is defined as an event which results in a person coming to rest unintentionally on the ground or other lower level, not due to any intentional movement, a major intrinsic event (e.g. stroke) or extrinsic force (e.g. forcefully pushed down, knocked down by a car).”</td>
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<td>18. Faulkner et al [31]</td>
<td>Pennsylvania, USA</td>
<td>Examine ethnic differences in fall rates and circumstances in older community dwelling Caucasian and African-American women</td>
<td>Prospective population based study of osteoporotic fracture with analysis of incident falls and nested retrospective analysis of fall circumstances over 5.7 years SES measures: Collection method not described in this paper, but epidemiological study with interviews and clinical measures. Age, gender. Ethnic groups: Not defined how identified. Caucasian women (n=1665), African-American (n=156).</td>
<td>1,821 women aged 76 +/- 5 followed up prospectively in study of osteoporotic fractures. Characteristics of 338 falls collected on sub-sample of 197 women who fell</td>
<td>Women reported 4,547 falls in 9,508 person years, averaging 0.48 falls per woman annually (95% CI 0.43-0.53) Higher age adjusted fall rates in Caucasians but not statistically significant (RR=1.30, 95% CI 0.93-1.83) In women younger than 75 fall rates were similar in Caucasians and African Americans (RR=1.17, p=0.46), in those aged 75 and older fall rates were 50% higher in Caucasians (RR=1.50, 95% CI 0.90-2.49) Fall risk increased in age in Caucasians but not in African-Americans. Caucasians more likely to fall outdoors than African-Americans (OR=1.6, 95% CI 1.0-2.7)</td>
<td>Defined as “landing on the floor or ground or falling and hitting an object like a table or a chair”</td>
</tr>
<tr>
<td>Authors</td>
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</table>
| Gill et al   | South Australia                  | Examine characteristics of community dwelling older adults who fell within previous 12 months | Telephone interviews of random sample of community dwelling adults aged ≥65 years. (Telephone numbers selected at random for households and most recent birthday over 65 years interviewed) | 2,619 community dwelling adults aged 65 and over (70.5% response rate) 1,138 males, 1,481 females. 96% report speaking English at home. 10% born in non-English speaking country. | 29.8% had experienced a fall within the previous 12 months; average number of falls was 2.2  
Age and lower income associated with increased risk. In univariate analysis OR=1.42, 95% CI 1.19-1.69 for not married compared to married and OR=0.42, 95% CI 0.25-0.72 for not speaking English at home. No effect of dwelling type. In multivariate analysis OR for age 65-69=1.0, 70-74=1.23, 95% CI 0.96-1.57, 75-79=1.36, 95% CI 1.05-1.76, ≥80 =1.46, 95% CI 1.11-1.90  
No significant effect of income except those who refused to state income had 54% increased risk, 95% CI 1.19-2.00.  
Higher education OR=0.63, 95% CI 0.43-0.94 for degree or higher, compared to secondary education only OR=0.77, 95% CI 0.63-0.94 for living with someone versus living alone.  
OR=0.59, 95% CI 0.43-0.82 for birth in non English speaking country versus Australia. | No definition of fall provided. Asked whether respondent had fall in last 12 months, and “did they feel they were at risk of another fall”. |
| Reyes-Ortiz et al | Latin America, the Caribbean, and Southwestern USA | Estimate the prevalence of and risk factors for falls among community dwelling elders in these areas of the USA | Analysis of data from two epidemiological studies of the elderly: one longitudinal (data taken from one wave) and one cross-sectional; Hispanic-EPESE and SABE project survey from 7 Latin American and Caribbean cities.  
SES measures: Self report measures collected as part of interview; age, gender, marital status.  
Ethnic groups: H-EPESE group described as Hispanic, Mexican-Americans. No further definition provided and in SABE study no details of ethnicity reported. | 9,765 from Latin American and the Caribbean, aged 60 or older, 1,483 Mexican-Americans aged 71 or older | Fallers more likely to be older (OR=1.02, 95% CI 0.99-1.04) and to be female (OR=1.36, 95% CI 1.02-1.80-2.34, 95% CI 1.75-3.14)  
Range of falls close to that reported in other countries. Prevalence of falls varied from 21.6% to 34.0%. Prevalence of persons with multiple falls varied from 8.7% to 20.3%. Prevalence of reported falls varied widely by city of data collection.  
Total falls (prevalence of persons reporting falls in previous 12 months) by city.  
Santiago; Chile 34%  
Mexico City; Mexico 33.5%  
Sao Paulo; Brazil 29.0%  
Buenos Aires; Argentina 28.5%  
Monte Video; Uruguay 27%  
Havana; Cuba 24.1% | Falls assessed by asking either “have you fallen down in the last 12 months? How many times?” or “during the past 12 months, how many times did you fall and land on the floor or ground?” |
<table>
<thead>
<tr>
<th>Authors</th>
<th>Location</th>
<th>Study objective</th>
<th>Study design, socio-economic status (SES) and ethnicity measurements</th>
<th>Sample</th>
<th>Findings</th>
<th>Definition of falls given?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reyes-Ortiz et al</td>
<td>continued</td>
<td>Evaluate the prevalence (lifetime and 12 month) of fractures and associate these with socio-demographic variables.</td>
<td>Population based cross sectional survey SES measures: Self report measures collected as part of interview; age, gender, socioeconomic level using classification of National Agency of Research Institutes (based on household assets and education of head of household). Ethnic groups: Skin colour as observed by the interviewer.</td>
<td>Systematic stratified household sampling strategy- from 1530 sampled households 3100 interviews from 3214 eligible individuals.</td>
<td>28.3 % reported lifetime fracture; 2.3% fracture within last 12 months.39.9% of fractures attributed to falls, 23% of fractures attributed to fall for men; 62% for women. Socio-demographic data not analyzed in relation to fall fractures. Note also all adult age groups included.</td>
<td>Fall as one of five possible reported causes of last fracture. All age groups reported.</td>
</tr>
<tr>
<td>Siqueira et al</td>
<td>Pelota, Brazil</td>
<td>Evaluate the prevalence (lifetime and 12 month) of fractures and associate these with socio-demographic variables.</td>
<td>Analysis of data from nationally representative sample of emergency department visits for whole of 2001 using diagnostic codes related to falls on National Electronic Injury Surveillance System-</td>
<td>Systematic stratified household sampling strategy- from 1530 sampled households 3100 interviews from 3214 eligible individuals.</td>
<td>22.560 cases examined, of people aged 65 and over. Estimate that 1.64 million US citizens aged over 65 are treated for falls related injuries every year. 70.5% of cases were women For all parts of the body women’s injury rates exceeded those of men (RR=2.2, 95% CI 1666.4-2549.1 for fracture, 1.1-1.8 for all other injuries). Women aged &gt;85 years have 5 times the incidence of falls related injuries requiring emergency room attendance than those aged 65-69</td>
<td>No definition provided; used physicians’ diagnoses at time of attendance to emergency department.</td>
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<tr>
<td>Stevens &amp; Sogolow</td>
<td>USA</td>
<td>Examine gender differences for non-fatal unintentional fall related injuries among older adults</td>
<td>Analysis of data from nationally representative sample of emergency department visits for whole of 2001 using diagnostic codes related to falls on National Electronic Injury Surveillance System-</td>
<td>Systematic stratified household sampling strategy- from 1530 sampled households 3100 interviews from 3214 eligible individuals.</td>
<td>22.560 cases examined, of people aged 65 and over. Estimate that 1.64 million US citizens aged over 65 are treated for falls related injuries every year. 70.5% of cases were women For all parts of the body women’s injury rates exceeded those of men (RR=2.2, 95% CI 1666.4-2549.1 for fracture, 1.1-1.8 for all other injuries). Women aged &gt;85 years have 5 times the incidence of falls related injuries requiring emergency room attendance than those aged 65-69</td>
<td>No definition provided; used physicians’ diagnoses at time of attendance to emergency department.</td>
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<tr>
<td>Abolhassani et al</td>
<td>Iran</td>
<td>To describe the incidence of injurious falls and fractures in Iran.</td>
<td>Use of national fracture dataset- Iranian Multicentre Study of Accidental Injuries. Over 4.5 months researchers searched emergency departments and hospital wards in all hospitals in 65 cities for people admitted for injury. This paper reports finding for falls related injuries.</td>
<td>Systematic stratified household sampling strategy- from 1530 sampled households 3100 interviews from 3214 eligible individuals.</td>
<td>2186 patients (1372 males, 814 females) admitted to hospitals for injurious falls 572 hip fractures. For people &gt;50 years of age annual incidence of injurious fall were 237.1 per 100,000 person years and for hip fracture 93.6 per 100,000 person years respectively. Odds ratios for hip fracture reported for those aged &gt; 50 indicate no differences between males and females, nor urban versus rural, nor place of fall indoors/outdoors home/away. Being married was protective (OR=0.61, 95% CI 0.45-0.83)</td>
<td>Fall defined as unexpected event in which a person falls to the ground from an upper level or the same level.</td>
</tr>
<tr>
<td>Authors</td>
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<td>24. Becker et al</td>
<td>USA</td>
<td>Examine characteristics of elderly patients admitted to hospital with osteoporotic fractures</td>
<td>Retrospective note review. Data abstracted from records of consultations, laboratory results and DEXA data on patients admitted with fragility fractures. SES measures: Data on age and gender abstracted from clinical notes. No details of method provided. Ethnic groups: Data on ethnicity abstracted from clinical notes. No details of method provided.</td>
<td>185 patients, 83% female, mean age 78, range 48-99</td>
<td>There were significant differences between ethnic groups in mean number of falls risk factors recorded in notes (Blacks 3.8, Hispanics 3.5 Whites 2.8, p&lt;0.01).</td>
<td>Did not measure falls – patients were those admitted with fragility fractures. No clear description of how risk factors for falls were ascertained beyond “comprehensive consultation”</td>
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<td>25. Halil et al</td>
<td>Ankara, Turkey</td>
<td>Investigate occurrence and clinical and social correlates of falls in elderly people in Turkey (as an exemplar of a developing country)</td>
<td>Cross-sectional study including comprehensive geriatric assessment and falls history of people attending a specialist geriatric outpatient department. SES measures: No details of how socio-demographic data were obtained are reported. Data presented on age, gender, educational status (illiterate (24%), literate no schooling completed (21%), first school completed (29%), high school graduate (16%), university graduate (10%)), living alone versus not alone. No other details of method provided. Ethnic groups: Not reported. No details of method provided beyond “being of Turkish nationality” used as inclusion criterion.</td>
<td>2322 Turkish people referred for geriatric assessment to outpatients; aged 65 and over, mean age 71.8 +/- 6.8</td>
<td>28.5% with at least one fall reported over previous 12 months. Female gender was an independent falls risk predictor (OR=1.548, 95% CI 1.24-1.98) Age 75+ and living alone were associated with increased falls in univariate analysis but not in regression. Social gradient based on educational attainment reported but no correlation with falls reported.</td>
<td>Defined as “unintentionally coming to rest on the ground or a lower level regardless of the occurrence of loss of consciousness”. People questioned about fall history in previous year.</td>
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<td>26. Horton</td>
<td>South East England, UK</td>
<td>To examine social constructions of falling as they relate to age and gender.</td>
<td>Qualitative study using grounded theory. SES measures: Data on gender reported but no details of how ascertained provided. Age 65 or over as study criterion but no detail of method provided. Ethnic groups: All described as “White British”. No details of how this was ascertained given</td>
<td>Convenience sample of 40 people aged &gt;65 all “White British” with self reported history of 2+ falls in previous 12 months.</td>
<td>Males differed from females. Men talked more in terms of risk and portrayed themselves as responsible and rational. Women tended to blame themselves (carelessness) or others.</td>
<td>Self reported fall defined as “an event which results in a person coming inadvertently to rest on the ground”</td>
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<td>Horton continued</td>
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<td>Examine the frequency and nature of falls and fall-related injuries among older women in India</td>
<td>(either self defined or defined by researcher’s observation.)</td>
<td>82 community dwelling older women and 63 women living in institutionalized Long Term Care facilities (age range 58-98)</td>
<td>54% reported falling in the past year, an average of 2.6 times. More of the institutionalised participants fell (64%) compared to community dwellers (45%) (p&lt;0.05).</td>
<td>Fallen within last year but no details or definition provided.</td>
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<tr>
<td>27. Johnson [40]</td>
<td>Kerala, India</td>
<td>Examine the frequency and nature of falls and fall-related injuries among older women in India</td>
<td>Field survey measuring background characteristics, health status and falls profile. SES measures: Self report measures collected as part of face to face interview; age, gender, marital status, and education (no school, 1-12 years school, college and beyond) monthly income dichotomized to above or below 1500 Rupees (living minimum).</td>
<td>82 community dwelling older women and 63 women living in institutionalized Long Term Care facilities (age range 58-98)</td>
<td>54% reported falling in the past year, an average of 2.6 times. More of the institutionalised participants fell (64%) compared to community dwellers (45%) (p&lt;0.05).</td>
<td>Fallen within last year but no details or definition provided.</td>
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<td>28. Pluijm et al</td>
<td>Amsterdam, Netherlands</td>
<td>Develop risk profile for to identify recurrent falling in community dwelling older persons</td>
<td>Analysis of Longitudinal Ageing Study Amsterdam prospective population cohort. Interview with clinical, anthropometric and performance data. SES measures: Data collected during home visits using standardised instruments but no details given of how demographic data collected in this paper. Paper reports age, gender, education in years, level of residential urbanisation.</td>
<td>1,365 participants with a mean age of 75.3 (range 64.8-88.6)</td>
<td>Incidence of recurrent falls over 3 year follow up was 24.9% in women, 24.4% in men. In univariate analysis education level &gt;11 years OR=1.36 and living in highly urbanized area OR=1.43. The risk model devised includes education level and if the person has both a high education (&gt;11 years) and consumes &gt;18 alcohol units per week their risk is much higher. However it is noteworthy that in the multiple regression models that whilst education per se has OR as high as 1.23 confidence intervals cross unity.</td>
<td>Defined as “an unintentional change in position resulting in coming to rest at a lower level or on the ground” Over 3 year period respondents completed weekly falls diary. Recurrent faller defined as a person who fell at least twice within a six month period during the 3 year follow-up.</td>
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<td>29. Reyes-Ortiz et al [42]</td>
<td>Southwestern USA</td>
<td>Examine relationship between church attendance and fear of falling in Mexican-Americans</td>
<td>Data taken from home surveys of a population based epidemiological study (Hispanic EPESE) SES measures: Self report measures collected as part of interview; age, gender, marital status, and education in years.</td>
<td>1341 non-institutionalised Mexican-Americans aged 70 and over</td>
<td>Lower fear of falling associated with being married (bivariate analysis, p&lt;0.001) Increased fear of falling with increasing age (p=0.006) and being female (OR=2.5, 95% CI 1.97-3.18) 31.6% reported history of falling in previous year.</td>
<td>For falls asked “how many times during the past 12 months did you fall and land on the floor?” Fear of Falling measured by asking how afraid of falling on a scale of 1 (not at all afraid) to 4 (very afraid)</td>
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<td>Study Reference</td>
<td>Setting</td>
<td>Study Design</td>
<td>Methodology</td>
<td>Sample Size</td>
<td>Fall Prevalence</td>
<td>SES Measures</td>
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<td>Speechley et al. [43]</td>
<td>Southwestern and Central West Ontario Canada</td>
<td>Assess the prevalence and strength of association of risk factors for falling in Canadian veterans of World War II and Korea and their caregivers</td>
<td>Self-report mail questionnaire assessing risk factors for falls and frequency of falls and injurious falls in the past 12 months</td>
<td>1,191 veterans and 1,398 caregivers, mean age 80, 58.6% male</td>
<td>Overall 35.5% reported 1+ falls in past 12 months, and 12.9% reported 1+ injurious falls in the past 12 months. Amongst veterans 39.8% reported one or more fall in previous year, for caregivers 29.7%. Crude ORs associating falls with financial strain ranged from 1.3, 95% CI 1.03-1.58 to 2.4, 95% CI 1.20-4.58, such that increase of falls risk was associated with increasing poverty.</td>
<td>Self complete questionnaire date of birth, gender, financial strain (in general how do your finances usually work out at the end of the month? (Response set money left over to not enough money to make ends meet). All served in Canadian forces during World War 2 or Korean War or were the care giver to someone who served.</td>
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Table 2. Randomised controlled trials which evaluate the impact of environmental assessment and modification on falls in community samples.

<table>
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<tr>
<th>Authors</th>
<th>Location</th>
<th>Sample</th>
<th>Intervention (including who provided it)</th>
<th>Findings</th>
<th>Definition of falls given?</th>
<th>Comments</th>
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<tbody>
<tr>
<td>Cumming et al</td>
<td>Australia</td>
<td>530 community dwelling people aged 65+ recruited whilst inpatients in two hospitals or attending outpatient clinics or day care centres</td>
<td>Routine provision including 1 hour home visit (with further visit if required) and supervision of implementation. Standardised home assessment used. Occupational therapist.</td>
<td>Not effective for participants who had not experienced a previous fall (36% intervention group versus 45% control group RR=0.81 95% CI 0.66-1.00) Reduced falls in people who had fallen in past year (42% intervention group versus 65% control group RR=0.64 95% CI 0.50-0.83)</td>
<td>Definition not specified Participants asked about history of falls in past 12 months Self completed calendars used for 12 months</td>
<td>Reduction in falls outside the home</td>
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<tr>
<td>Stevens et al</td>
<td>Perth, Australia</td>
<td>1737 people aged 70+ recruited from electoral roll and as a secondary recruitment strategy cohabiting with index recruit.</td>
<td>Home visit, education, free installation of safety devices. Trained nurse assessor.</td>
<td>Not effective in reducing falls (ARR=0.97, 95% CI 0.74-1.28)</td>
<td>Fall defined as ‘an event that results in a person unintentionally coming to rest on the ground, floor or other lower level’. 12 month follow up Self report using calendar.</td>
<td>Significant reduction in home hazards reported (process measure). (See Stevens et al [70])</td>
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<tr>
<td>Day et al [71]</td>
<td>Melbourne, Australia</td>
<td>1090 people, mean age 76.1 (SD 5.5) living in their own homes and able to make modifications, and in ‘good health’. Recruitment from Australian electoral roll</td>
<td>Walk through checklist (non standardised) for rooms used in normal week, administered prior to randomisation. Removal or modification of hazards with provision of materials and labour if required, plus advice. Trained assessor.</td>
<td>Not effective in reducing falls.</td>
<td>No definition of fall provided. History of falls ascertained. Self completed calendars used for 18 months.</td>
<td>Significant reduction in home hazards (Mean decrease from 10.2 to 7.4 intervention group versus 9.1 to 7.9 control group p&lt;0.001) (process measure).</td>
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<tr>
<td>Study</td>
<td>Location</td>
<td>Sample Size</td>
<td>Intervention Details</td>
<td>Outcomes</td>
<td>Notes</td>
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<tr>
<td>Pardessus et al [72]</td>
<td>Lille, France</td>
<td>60 people aged 65+ hospitalised for falling and able to return home</td>
<td>2 hour home visit with actual or mimed Activities of Daily Living (ADL), checks of mobility, transfers and stairs, modifications where possible, using standardised ADL and IADL scales, advice, and social support. Doctor and occupational therapist.</td>
<td>Not effective in reducing falls (mean 0.82 +/-0.22 control group versus mean 0.68 +/- 0.16 intervention group).</td>
<td>No definition of fall provided. Past falls ascertained. 12 month follow up. Monthly phone contact for first 6 months, then at 12 months. Underpowered for falls as outcome measure.</td>
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<tr>
<td>Nikolaus and Bach [73]</td>
<td>Germany</td>
<td>360 people, mean age 81.5 (SD 6.4) recruited whilst inpatients in a geriatric clinic, but discharged home.</td>
<td>Home visit to assess hazards, standardised checklist used, followed by at least one further visit, advice, facilitation of modifications and training in use of devices. Occupational therapists with nurse or physiotherapist.</td>
<td>Effective in reducing falls (31% reduction in fall rate for intervention group, IRR=0.69, CI 0.51-0.97)</td>
<td>Fall defined as ‘an event reported by a faller or a witness that resulted in a person inadvertently coming to rest on the ground or another lower level without loss of consciousness’. Participants asked if they had fallen during previous 12 months. Self report of fall during telephone interview/diary/both. Particularly effective in those with a history of multiple falls (37% reduction in fall rate for intervention group IRR=0.63, 95% CI 0.43-0.94)</td>
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<td>Campbell et al [74]</td>
<td>New Zealand</td>
<td>391 women and men aged 75+ with visual acuity of 6/24 or worse living in the community</td>
<td>Home safety assessment and modification designed for people with visual impairments. Standardised home safety checklist used to promote discussion and agree points of implementation. Occupational therapist.</td>
<td>41% fewer falls in participants in the intervention group compared with those not receiving the intervention. (Incidence rate ratio=0.59, 95% CI 0.42-0.83)</td>
<td>Falls defined as ‘unintentionally coming to rest on the ground, floor, or other lower level’. Falls in previous year ascertained. Self report calendars used for 12 months. No significant different between reduction of falls at home compared to those away from home.</td>
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