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Population-based interventions for the prevention of fall-related injuries in older people

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ABSTRACT

Background

Fall-related injuries are a significant cause of morbidity and mortality in older populations. Summary information about countermeasures that successfully address the risk factors for fall-related injuries in research settings has been widely disseminated. However, less available is evidence-based information about successful roll out of these countermeasures in public health programmes in the wider community. Population-based interventions in the form of multi-strategy, multi-focused programmes are hypothesised to result in a reduction in population-wide injury rates. This review tests this hypothesis with regard to fall-related injuries among older people.

Objectives

To assess the effectiveness of population-based interventions, defined as coordinated, community-wide, multi-strategy initiatives, for reducing fall-related injuries among older people.

Search methods

We searched the Cochrane Injuries Group Specialised Register, CENTRAL (The Cochrane Library), MEDLINE, EMBASE, National Research Register, AgeInfo, PsycInfo and Web of Knowledge. We also searched the internet, carried out handsearches of selected journals and checked the reference lists of relevant papers to identify any further studies. The latest search was conducted in May 2007.

Selection criteria

Studies were independently screened for inclusion by two review authors. Included studies were those that reported changes in medically treated fall-related injuries among older people following the implementation of a controlled population-based intervention.

Data collection and analysis

Data were independently extracted by two review authors. Meta-analysis was not appropriate due to the heterogeneity of the included studies.
Main results

Out of 35 identified studies, six met the criteria for inclusion. There were no randomised controlled trials. Significant decreases or downward trends in fall-related injuries were reported in each of the included studies, with the relative reduction in fall-related injuries ranging from 6% to 33%.

Authors’ conclusions

Despite methodological limitations of the evaluation studies reviewed, the consistency of reported reductions in fall-related injuries across all programmes support the preliminary claim that the population-based approach to the prevention of fall-related injury is effective and can form the basis of public health practice. Randomised, multiple community trials of population-based interventions are indicated to increase the level of evidence in support of the population-based approach. Research is also required to elucidate the barriers and facilitators in population-based interventions that influence the extent to which population programmes are effective.

Plain Language Summary

Population-based programmes for the prevention of fall-related injuries in older people

Injuries caused by falls are common in older people and can cause serious medical problems. Older people who live in institutions, such as assisted care facilities and nursing homes, and people over 80 years old are particularly likely to fall and injure themselves. Serious injuries include bone fracture, a head injury or tears to the skin (lacerations) that often require hospital treatment. Hip fractures almost always require hospitalisation and many community-dwelling individuals do not recover their ability to walk or carry out daily activities of living, which impacts greatly on their ability to live independently and their quality of life. Population (epidemiological) studies show that hip fractures are the most serious fall-related injury in older people, with 15% dying in hospital and a third not surviving beyond one year afterwards. A number of countries have prepared guidelines to prevent falls in the elderly. Effective interventions are available to prevent falls and include increased physical activity and hip protectors. Strategies targeted at fall prevention include regulation, education, environmental change and population or community-based coordinated programmes. A population-based intervention programme shares ownership of the injury problem with the whole community, experts and community members. Joint responsibility is taken for determining priorities and appropriate interventions are widely promoted.

The review authors could not find any randomised controlled trials on prevention of injuries from falls that involved whole communities. Six evaluation studies (prospective, controlled community trials) with well-matched control communities consistently reported reductions in fall-related injuries across the programmes used. This provides support for a population-based approach as a basis of public health practice. The relative reduction in fall-related injuries ranging from 6% to 75%, in studies conducted in Australia, Denmark, Norway, Taiwan and Sweden over up to eight years. Three of the studies were based on the World Health Organization Safe Communities model of safety and injury prevention.

Limitations were the exact nature of the population-based intervention used, how it could be generalised to other communities and trial methodologies.

Background

Fall-related injuries are among the most serious and most common medical problems experienced by older people (Elkington 2002; Hayes 1996). Prospective studies have reported that 30% to 60% of community-dwelling older adults fall each year, with approximately half of them experiencing multiple falls (Rubenstein 2002). The incidence rises steadily after middle age and tends to be highest among individuals of 80 years of age and over (Kingma 2000; Rubenstein 2002; Sattin 1990; Scott 1999), with half of women and a third of men aged 85 years and older falling annually (Cummings 2002; Peel 2002).

Between 5% and 10% of community-dwelling older adults who fall each year sustain a serious injury, such as a fracture, head injury or serious laceration (Rubenstein 2002). The incidence of
falls among older people living in institutions is up to three times higher than for those living in the community. For nursing home residents, a higher proportion of falls is associated with injury (Thapa 1996).

Morbidity

Studies in the USA report that, among elderly people, falls account for approximately 10% of visits to emergency departments and 6% of urgent hospitalisations (Tinetti 2003). It has been reported in Australia that for people aged 65 years and over who present to an emergency department, 18% present as a direct consequence of a fall and over half of these patients (58%) are subsequently admitted to hospital (Bell 2000). Fractures are the most common fall-related injury requiring treatment at emergency departments (Bell 2000) and admission to hospital (Peel 2002). The high rate of admission is largely due to hip fractures, which almost always result in hospitalisation and consume a high proportion of orthopaedic beds (Cummings 2002). Among community-dwelling individuals with fall-related hip fractures, between 25% and 75% do not recover their pre-fracture level of function, in ambulation or activities of daily living (ADL) (Magaziner 1990), and remain at high risk for falls and a second fracture (Sherrington 1998). Reports of the number with permanent disability, in those surviving initial hospitalisation, range from 32% to 80% (Braithwaite 2003). Since any loss of ability to live independently in the community has hugely detrimental effects, quality of life is profoundly threatened by falls and hip fractures (Salkeld 2000).

Mortality

Internationally, injuries are a leading cause of death in older adults and falls constitute a high proportion of these accidental deaths (Rubenstein 2002). In Australia, mortality from falls accounted for 2% of all deaths in Australians aged 65 year and over (AIHW 2002a) and are the leading cause of injury deaths. The death rate from unintentional falls is substantially higher in people aged 75 years and older compared with the 65 to 74 year age group, for both men and women (AIHW 2002b). Fracture of the neck of the femur is the most common diagnosis in older people for the underlying cause of accidental fall-related deaths (Cripps 2001). Epidemiological studies show that hip fractures are the most serious fall-related injury in this age group, with 15% of these patients dying in hospital and a third not surviving beyond one year after fracturing their hip (Rose 1999).

Cost

Investigations undertaken in the UK (Scuffham 2003), the USA (Englander 1996) and Australia (Moller 2003) show the substantial economic burden that falls in older people impose on health and social services. Moller estimated that, with population ageing, the total health costs attributable to fall-related injuries in people over 65 years will increase almost threefold in the next 50 years and require dramatic increases in additional hospital bed days and nursing home places. Total health system costs of injuries for Australia in 1993 to 1994 were estimated at 8.3% of total health expenditure. Of all the injury categories, unintentional falls were responsible for the highest proportion of healthcare expenditure, at 31% of health system costs. This was more than double the health system costs for motor vehicle crashes (Mathers 1999). The total estimated cost of inpatient separations to Queensland hospitals (based on 465,530 occupied bed days) was AUS$289.6 million in 1997 to 1998, of which AUS$145 million were accounted for by falls (Qld Health 2000). Falls in older people alone account for half the hospital costs of injury (Qld Health 2002). In the USA, hospitalisation accounts for 44% of direct healthcare costs for hip fracture patients. Direct costs do not include long-term consequences of these injuries, such as disability, decreased productivity or reduced quality of life (CDC 2003). The current cost of treating a hip fracture case in Australia is in the vicinity of $20,000 to $50,000 (Diamond 2003).

Falls prevention

While the epidemiology of falls among older people has been investigated extensively over the past 50 years, it is only in the last decade that there have been coordinated attempts to address the issue of falls prevention in older people. Guidelines to prevent falls in the elderly have recently been published in the UK (Feder 2000), USA (Guidelines 2001) and Canada (Scott 2001). Research evidence for effective strategies to reduce falls and injurious fall rates among older people has been examined in a number of systematic reviews (Gillespie 2004; NARU 2000; NZ NHC 1997; Norton 1997; Nuffield 1996; Scott 2001). The conclusion of the Cochrane review (Gillespie 2004) is that interventions that are likely to be effective in the prevention of falls are now available. Less well documented, however, is the evidence for effectiveness of interventions intended to prevent fall-related injuries. A factor contributing to the limited research in this area is that, in epidemiological terms, an injurious fall is a relatively rare event. This results in the need for studies with long-term follow up and a large sample size to provide the statistical power to identify changes between a control and an intervention community group in terms of fractures or serious injuries (NARU 2000). More research is, therefore, needed to determine whether the strategies targeting fall prevention will translate to fall injury prevention (Moller 2002). Further research is needed to also confirm that these strategies,
shown to be efficacious under research conditions, can be effectively implemented in large-scale community trials.

**Population-based falls prevention programmes**

There remains a confusion in the literature on falls related to the meaning of the terms countermeasure, strategy, multi-strategy (or multifaceted strategy), intervention and prevention programme. However, there is a clear consensus that there are several levels at which the prevention of fall-related injury can be considered, and a number of different opportunities to choose between at each level. The clearest terminology is outlined by Christoffel 1999, where 'countermeasure' refers to the specific proximal protective factor (increased physical activity, hip protectors etc); 'strategy' refers to the means by which this protective factor is promoted (for example regulation, education, environmental change); and 'population-based intervention' (also called 'community-based') is the coordinated programme of activity in which the strategies and countermeasures are implemented in whole communities. For the purpose of this definition, institutional residences (for example nursing homes, assisted care facilities) are included in the meaning of community.

The existence of efficacious falls-injury countermeasures is not in itself a complete response to the problem of falls. Reduction of fall-related injury, as measured by population-level indicators, requires that these countermeasures are introduced into, and become embedded within, the social and physical structures of community function. Population-based intervention programmes are the means by which this is achieved (Tinetti 1989). The population-based intervention is characterised by Moller 1991 as one where there is a shared ownership of the injury problem and its solution, by experts and community members, and joint responsibility for determining the priorities and interventions that are appropriate; an understanding of injury that acknowledges a complex causal web embedded in social and organisation structures; a coordinated multi-strategy response, and an emphasis on optimising community involvement (Moller 1991).

In the context of falls prevention, population-based intervention programmes identify one or more countermeasures for the prevention of fall-related injury and promote the widespread uptake of these countermeasures through use of one or more health promotion strategies. While a population-based intervention might conceivably involve just a single strategy, Tinetti 1989 and Christoffel 1999 advocate that a multi-strategy approach is preferred. Of particular importance in population-based interventions, is that the whole community is the focus of the intervention rather than individuals within the community, and that the multiple strategies coalesce into an overall programme of activity. Thus population-based interventions differ dramatically from the environment in which falls countermeasure research studies of randomised controlled trials are generally conducted.

**OBJECTIVES**

To assess the effectiveness of population-based interventions, defined as coordinated community-wide, multi-strategy initiatives, for reducing fall-related injuries among older people.

**METHODS**

**Criteria for considering studies for this review**

**Types of studies**

- Prospective controlled community trials where the unit of analysis is the entire community.
- Historical controls without a contemporary comparison were not included.

**Types of participants**

Primarily people aged 65 years and over.

**Types of interventions**

Population-based interventions to reduce fall-related injury among older people: in the form of a coordinated programme using multi-strategy initiatives to implement the countermeasures in an entire community or a large part of a community.

**Types of outcome measures**

The review made two comparisons for each included study:

- pre versus post-intervention medically treated fall-related injury incidence in the intervention community
- the change in incidence of fall-related injury reported as having been treated by a medical practitioner in the intervention community versus the control community (to account for secular changes in injury rates not attributable to the intervention)

Studies were excluded if no objective injury rates were available for analysis or if comparable data were not available for the control community.

**Search methods for identification of studies**

The searches were not restricted by language or publication status.
**Electronic searches**

The following electronic databases were searched:
- Cochrane Injuries Group Trials Register (searched May 2007);
- CENTRAL (The Cochrane Library 2007, Issue 2);
- MEDLINE (1950 to May week 1) 2007);
- CINAHL (1982 to 2007);
- PsycINFO (1966 to May, 2007);
- EMBASE (2002 to week 18, May 2007);
- AgeInfo (2002 to May 2007);
- Social Science Citation Index (2002 to May, 2007);
- National Research Register (Issue 2, 2007).

The full search strategies are presented in Appendix 1.

**Searching other resources**

The following journals were handsearched:
- Injury Prevention (1995 to 2007);

We searched the reference lists of the eligible studies and any review articles for further potentially eligible articles. Content experts in the field were contacted in an effort to identify any unpublished studies. National registers of ongoing trials were searched.

**Data collection and analysis**

There were four stages of the review process.

1. **Stage 1. Identification of studies for inclusion**

Abstracts from electronic searches, handsearched journals, reference checks and unpublished studies identified through personal contact with content experts were screened, based on inclusion criteria, by an experienced reviewer.

2. **Stage 2. Selection of studies for inclusion**

Relevant studies selected from the process in Stage 1 were independently assessed against the inclusion criteria by two additional review authors.

3. **Stage 3. Quality assessment**

The investigation of methods used in the implementation of population-based interventions is a new field of exploration in injury research and few instruments are available to assess methodological quality. Traditional quality scoring was not undertaken. However, a quality assessment process was performed independently by the two review authors who assessed studies for inclusion, with disagreements resolved via discussion amongst all six review authors. This process was based on four of the seven criteria used for the quality assessment of controlled before-and-after trial designs, as described in Data Collection Checklist described by the Cochrane Effective Practice and Organisation of Care Review Group (EPOC). The criteria chosen were those that are relevant to community trial designs and specifically gauge the appropriateness of: baseline measurements, characteristics of the control site, protection against contamination between sites and reliability of outcome measures. The following three EPOC quality criteria for controlled before-and-after designs were not deemed relevant for this review: blinded assessment of primary outcome, follow up of professionals (protection against exclusion bias) and follow up of patients.

4. **Stage 4. Data extraction and synthesis of results**

Data were independently extracted from the included studies by the two review authors who had performed stages 2 and 3, using standardised forms. Disagreements were resolved via detailed discussion with all review authors. It was anticipated that the data would be available as measures of association (for example odds ratios, relative risks) linking programme interventions and changes in injury rates. If not presented as such, an attempt was made to calculate these measures using either published data or data made available through contacting relevant authors.

No subgroup analyses were planned. Sensitivity analysis was not performed because no meta-analysis or formal statistical summary values were calculated. However, methodological quality of individual papers were considered in the final discussion and conclusion.

**RESULTS**

**Description of studies**

See: Characteristics of included studies; Characteristics of excluded studies.

Thirty-five studies were considered for the review of which six met the criteria for inclusion. These studies described the results of population-based interventions conducted in Australia (Kempton 2000), Denmark (Poulstrup 2000), Norway (Ytterstad 1996), Sweden (Lindqvist 2001; Svanstrom 1996) and Taiwan (Lin 2006). Three of the studies (Lindqvist 2001; Svanstrom 1996; Ytterstad 1996) were based on the World Health Organization Safe Communities model of safety and injury prevention (WHO 1999). This model originated in Sweden and has since been adopted in many countries as a medium for harnessing community enthusiasm and effort to target all injuries for all members of the community.

The remaining 29 studies were excluded for the following reasons: the definition of a population-based intervention was not satisfied...
Outcomes were fall-related hospital visits (n = 8); no injury outcomes were assessed (n = 12); injury outcomes were not objectively measured (n = 2); changes in injury rates over time were not measured (n = 2); no appropriate community control was used for comparison (n = 4) and age categories were not separated for fall injuries (n = 1).

The 'Stay on Your Feet' programme was a multi-strategy, population-based intervention to prevent falls among older people living in a large rural coastal region of New South Wales in Australia (Kempton 2000). Outcomes were fall-related hospital visits of study area residents and were reported for five years, from 1990/1991 to 1994/1995. The population aged 60 years and over in the intervention area was approximately 80,000. A control community with approximately 62,000 inhabitants in the targeted age range received no intervention; the control community was situated in a rural coastal region separated from the intervention site by a large geographical distance. The four-year intervention targeted knowledge, attitudes, behaviours, medication use, footwear, home hazard reduction and other risk factors related to falls for non-institutionalised people aged 60 years and over. It was delivered via a mix of community education utilising brochures, posters, television and radio; policy development and through the engagement of local clinicians and other health professionals. The intervention was funded by the government health department, with a total cost of approximately AUD$600,000.

Poulstrup 2000 reported the results of a prospective intervention to prevent fall-related injuries amongst community-dwelling elderly people residing in five municipalities in Vejle County, Denmark. Outcomes were all fall incidents that led to contact with local hospitals, either for casualty treatment or hospital admission. Injuries were registered for nine months prior to the programme and for 18 months after its initiation. The intervention area had a population of 12,905 inhabitants aged over 65 years dwelling in the community. The control area, which received no intervention, consisted of four municipalities in the same county with 11,460 community-dwelling inhabitants aged over 65 years. The intervention consisted of educational advice, home visits, physical hazard removal, control of inappropriate medication, treatment of psychiatric and somatic illnesses and promotion of physical and mental activity. The existing health personnel structure was used to deliver the intervention with all district nurses, general practitioners and home helpers trained to identify risks and appropriate management of falls in the elderly. Limited resources were made available for home visits and follow up, anticipating that the intervention model could then be readily applied to additional sites with minimal cost expectations.

Fall-related fractures among the elderly was a priority area for a WHO Safe Communities injury prevention programme implemented in Harstad, a Norwegian city with 22,000 inhabitants (Ytterstad 1996). A hospital-based recording system was used to prospectively record fall-related outcomes. The study period had a duration of eight years, from 1985 until 1993, with the first three years providing baseline data before the intervention was initiated in 1988. Two controls were used for comparison: six municipalities surrounding Harstad, which were increasingly exposed to the same interventions; and a separate community, Trondheim, which received no intervention. Trondheim was located 1000 km away from Harstad and had a population of 135,000 inhabitants. Although Trondheim is a much larger city than Harstad, the authors reported similar demographic characteristics regarding age structure of the population, income levels, employment base and other socioeconomic factors. An injury prevention group, which was established in 1985 and was represented by hospital, public and private organisations, was the driving impetus behind the intervention. The intervention consisted of education advice, home visits by health professionals to high-risk individuals, promotion of physical activity and safe footwear, environmental modifications, home hazard reduction and engagement with local media, community agencies and services. Coordination between existing agencies was emphasised as a major component of the intervention. No information related to funding or overall cost of the programme was provided. However, it was stated that individuals met the costs for home hazard reduction themselves although they were charged only a third of normal costs due to the provision of a skilled pensioner service. A local garage provided low-cost boot spiking (a process similar to spiking of automobile tyres) to individuals, to create safer footwear in icy conditions. Voluntary organisations also played a large role in disseminating information and reaching the elderly population.

A WHO Safe Community programme implemented in Motala in Sweden targeted injuries among the elderly as one of its priority areas (Lindqvist 2001). Fall-related injuries were targeted as part of this larger programme. Mortality rates and hospital admissions for fall injuries and all unintentional injuries in the elderly aged 65 years and over were reported for a one-year period pre-intervention (1983 to 1984) and for one year post-intervention (1989). The control area, a neighbouring municipality, received no intervention. The population for the intervention area and control area were approximately 42,000 and 27,000, respectively. Cross-sectorial participation in the identification and solutions for injuries amongst the elderly was the main emphasis of the intervention. A Safety Council for the Elderly, with representation from municipal and county authorities, pensioners' organisations, sporting organisations and the Red Cross, was responsible for promoting safety initiatives. Specific strategies employed included the use of mass media to disseminate information, education through community displays, home visits, community walking programmes and improvements to lighting in public places and the condition of roads and walkways. No information was provided related to costs or funding of the project.

The prevention of femoral fractures due to falls among the elderly was a priority for the Lidkoping Accident Prevention Programme, also a WHO Safe Community intervention (Swanstrom 1996). Lidkoping is an agricultural area that has a population of approximately 35,000. The incidence of femoral fractures among...
inhabitants aged 65 years and over was calculated and reported for a period of six years (1987 to 1992) for the intervention area and for two separate control areas; these were: Skaraborg county (population 270,000) and Sweden as a whole (population 1.2 million). The Old People’s Safety Group was established to coordinate the intervention and was represented by the Head District Nurse, hospital, municipal and Primary Health Care Services representatives and the Pensioners’ Council. The intervention itself included community education; safety equipment exhibitions; training for council services personnel, healthcare workers and new housing planners and environmental strategies removing fall hazards in the home and public spaces. Information related to costs and funding was not provided.

Lin and colleagues (Lin 2006) conducted a two-year population-based study to examine the effect of tai chi exercises on the incidence of injurious falls among elderly residents of Shin-Sher, a rural township in Taichung County, Taiwan. Residents in two adjacent villages (with an elderly population of 754) were offered the tai chi exercise program, which was conducted in existing public places six days of the week. Four other villages (total elderly population of 1318) in the township acted as control sites. All six villages were provided with an education fall prevention program in the second year of the study. This included poster displays, pamphlet distribution encouraging simple exercises and environmental modification. All elderly residents aged 65 years and over in the study region were invited to participate in the study. Study participants were asked to report all falls that resulted in an injury requiring medical care to the study researchers, by telephone or postcard. Telephone contact was made with each participant every three months to ensure all fall-related injuries were registered. Medical clinics within the area also provided information on injurious falls to the study researchers. Participation rates were 472 (63%) and 728 (55%) in the intervention and control sites, respectively, with 88 individuals participating in the tai chi program.

Risk of bias in included studies

Four of seven criteria outlined in the Data Collection Checklist described by the Cochrane EPOC Review Group were used to establish the methodological quality of included studies. These four criteria were:
- availability of baseline measurements,
- appropriate choice of control,
- protection against contamination between intervention and control site,
- reliability of outcome measures.

Table 1 details the results of the scoring of methodological quality for the included studies. The overall methodological quality was mixed. Only one study clearly demonstrated all four of the criteria (Ytterstad 1996).

Baseline measurements for injury incidence were available for all except one study. For this Swedish study (Svanstrom 1996), fall-related injuries were not available until three years after the programme had commenced and thus the results may have underestimated the true effect of the intervention. For the five studies in which baseline incidence rates were available, the duration of the baseline period ranged from nine months to three years. The appropriateness of the control community was unclear for one of the Swedish studies (Svanstrom 1996), in Lidkoping; and was either adequate or statistically controlled for in the five other studies. Two large geographical areas were selected as a control for Lidkoping: Skaraborg county (including Lidkoping) and Sweden as a whole. However, demographic comparisons between Lidkoping and these two areas were not reported. Baseline characteristics related to age, gender, comorbidities and previous fall history differed in the intervention and control communities for the Chinese study, however the statistical models used to interpret the results adjusted for these factors (Lin 2006).

Protection against contamination between intervention and control areas was not clear for the two Swedish studies (Svanstrom 1996; Lindqvist 2001). The control area for the Motala study was a neighbouring municipality and it is possible that inhabitants residing in the control area were exposed to parts of the intervention. Additionally, the treating annex hospital was shared by the two communities. Similarly it is unknown to what extent the control regions for the Lidkoping study (the whole county and Sweden) were exposed to safety interventions. Protection against contamination was considered to be adequate for the remaining three studies given the distances between intervention and control sites. Additionally, in the Australian study (Kempton 2000) the control site service area agreed to remain intervention free for the programme period. Attendance records of the tai chi classes indicated that a small number of residents from the control villages (five in total) attended the exercise programme intended for the intervention villages; however this number was considered inconsequential and represented less than 1% of the total number of participating residents.

The reliability of outcome measures was unquantified for four of the studies (Kempton 2000; Lin 2006; Poustrup 2000; Svanstrom 1996) and was rated to be adequate for the remaining two studies. International Classification of Disease codes (ICD-9) derived from administrative hospital databases were the source for fall-related injury data for the Australian ‘Stay on Your Feet’ programme. Inaccuracies often occur in administrative databases, and in this study the databases used were administered by two separate government states. The authors did not discuss the reliability of the databases in terms of either sensitivity or specificity. A new hospital-based injury surveillance system was developed specifically for the fall injury prevention programme implemented in Vejle, Denmark. This was deemed necessary after testing determined that the existing databases were highly unreliable. The new system involved scrutiny of every record by project personnel, but its reliability was
not tested.
The injury surveillance system for the Lidkoping study changed during the period of evaluation, with an ICD-9 system based on a hospital discharge register adopted from 1987 onwards. The authors acknowledge existing validity problems with administrative databases but argue that for injuries as specific as femoral fractures the validity is likely to be high.

Injuries were self-reported in the Chinese tai chi study, with researchers contacting participants by telephone once every three months to ensure event capture. This self-report method was verified by reports from medical clinics serving the study area, however not all clinics provided the requested information to the researchers and it is possible some injury events were not captured.

**Effects of interventions**

The results of the review were mostly positive, with all six studies reporting a significant decrease or downward trend in fall-related injuries among older people following the implementation of the population-based intervention.

The Australian ‘Stay on Your Feet’ programme resulted in a significant 20% decrease in fall-related hospitalisations in the intervention area compared to the control community after adjusting for baseline fall-related injury rates (rate ratio (RR) 0.80, 95% CI 0.76 to 0.84) (Kempton 2000). This study also assessed the percentage of the community exposed to the intervention via cross-sectional surveys. It was estimated that about 77% of the targeted population had been in contact with at least one aspect of the intervention over the duration of the programme.

Following the intervention programme in Vejle, Denmark, there was a non-significant decrease in fall-related fractures in the intervention community compared to the non-intervention community of 15% (odds ratio (OR) 0.85, P = 0.23) (Poulstrup 2000). A significant decrease of 33% was recorded for lower extremity fractures (OR 0.63, P = 0.03), whilst a non-significant decrease was found for hip fractures (OR 0.55, P = 0.06).

There was a non-significant relative reduction of 9.7% (P = 0.2) in the incidence of all fractures in the intervention community comparing post-intervention to pre-intervention periods. In the six municipalities bordering the intervention community, there was a relative non-significant decrease of 2.6% (P = 0.58) in falls incidence over this period (Ytterstad 1996); in the comparison community there was a significant increase of 37% in fracture rates over this period (P=0.001).

In Motala, Sweden, a non-significant decrease in fall injuries across all age groups (65 years and over) occurred in the intervention community (OR 0.89, 95% CI 0.77 to 1.03) (Lindqvist 2001). This downward trend was significant only in the 75 to 79 year age group (OR 0.71, 95% CI 0.52 to 0.99). Injury rates were unchanged in the control community.

Following the population-based intervention in Lidkoping, Sweden, there was a significant reduction in the incidence of fall-related fractures in the intervention community (compared to the pre-intervention incidence) in the female population, by 6.6% per year (95% CI 0.00 to 2.9%); and a non-significant decrease amongst males, by 5.4% per year (95% CI -0.5 to 1.4%) (Svanstrom 1996). The incidence of injury rates did not change significantly in either of the two control areas although there was a non-significant decrease in the surrounding county.

Injuries from falls decreased among residents of both the intervention and control villages in Taichung County, China (Lin 2006). Due to the unexpected decline in falls in the control villages (by 44%) the decreases observed in the intervention villages (75% overall and 94% for those participating in the tai chi exercises) were not statistically different. The authors discussed the possibility that the educational campaign and regular telephone contact received by both intervention and control communities may have been more effective at increasing safety behaviours and modifications than had been anticipated.

**DISCUSSION**

This is the first published review of the effectiveness of population-based interventions for the prevention of fall-related injury among people aged 65 years and older. In contra-distinction to previous falls prevention reviews (Gillespie 2004), which included only randomised controlled trials where the individual was the unit of analysis and which focused on specific falls prevention countermeasures, the studies selected for this review were prospective, controlled community trials where the unit of analysis was the entire community. The review identified only six studies that met the selection criteria. The results of the review suggest that improvements (relative reductions of 6% to 33%) in the population-level injury indicators of fall-related injury can be achieved by the delivery of prevention programmes delivered at the population level.

Applying a population approach to injury prevention in the community can mobilise changes on a large scale, producing a normative effect and achieving a more permanent diffusion process (Green 1989). Further, as the predisposition to functional dependence and geriatric syndromes (including falls) have a shared set of predisposing factors, a broad health determinants model, if shown to be effective, is preferable to support health promotion in older populations (Tinetti 1995).

The findings of the review need to be considered in the context of four potential limitations. The first relates to whether the nature of the population-based intervention is sufficiently defined to guarantee consistency between applications, and their generalisability to other communities. In three of the studies included in this review, the intervention was in strict accordance with the WHO Safe Community model (the communities were formally designated WHO safe communities) and two of the remaining interventions...
were based on a similar conceptual framework. While the WHO Safe Community model does not prescribe the actual activities undertaken it does provide a definable set of criteria against which such interventions can be formally accredited. On the strength of the similarity of the conceptual basis for all interventions in the review, they could be considered essentially similar. However, a clear weakness of the reporting of the studies was the paucity of detail about the actual nature of the activities undertaken, and any attempt to generalise the success of the observed studies would be inhibited by the lack of information about barriers and facilitators in the implementation process.

The second relates to whether community trials are a sufficiently robust methodology to provide high-level evidence of intervention effectiveness. In order to ensure the highest possible level of evidence, studies selected for this review included only those with well-matched community controls. In a context where no cluster randomised trials involving multiple communities have yet been conducted, this constitutes the current gold standard practice. However, as there is no evidence in the literature that quantifies the relationship between variations in control community characteristics and changes in the size of the measured intervention effect, the appropriateness of the selected communities remains uncertain. Furthermore, a small number of communities were included in each trial (mostly one intervention and one control community) which confers a low level of certainty and statistical rigour to the interpretation of the results. A larger number of communities in each trial would eliminate this problem.

Third, reliable measurement of the fall injury outcomes over the period of the studies was critical to the valid quantification of the intervention effect. As noted in the comments in the ‘Methodological quality of included studies’ section, in most studies outcome data were obtained from administrative databases. The completeness and reliability of these databases to obtain epidemiological measures of injury incidence was not assessed by the authors of these papers.

Finally, there are several possible alternative explanations for the consistently observed study results which need to be acknowledged as threats to the validity of the conclusions of the review. These include positive publication bias, regression to mean and confounding by secular trends. Given the positive results of this review and the large potential benefit of the population intervention, multi-community trials which have a level of methodological rigour sufficient to overcome most of these concerns are thus arguably the next step in the clarification of the evidence in this field.

Authors’ Conclusions

Implications for practice

Despite methodological limitations of the evaluation studies reviewed, the consistency of reported reductions in fall-related injuries across all programmes support the preliminary claim that the population-based approach to the prevention of fall-related injury is effective and can form the basis of public health practice.

Implications for research

Cluster randomised, multiple community trials of population-based interventions are indicated to increase the level of evidence in support of the population-based approach. Research is also required to elucidate the barriers and facilitators in population-based interventions that influence the extent to which population programmes are effective.

Acknowledgements

The research reported in this publication is a project of Injury Prevention and Control (Australia) Ltd (www.ipca.com.au), supported by a grant from the Australian National Health and Medical Research Council. We would also like to acknowledge funding from the Victorian Health Promotion Foundation which was granted for the protocol development stage of this review.

References to studies included in this review

Kempton 2000 (published data only)

Lin 2006 (published data only)

Lindqvist 2001 (published data only)

Poulsstrup 2000 (published data only)

Svanstrom 1996 (published data only)
Svanstrom L, Ader M, Schelp L, Linstrom A. Preventing
References to studies excluded from this review

Alkalay 1984 (published data only)

Assantachai 2002 (published data only)

Bjerre 2000 (published data only)
Bjerre B, Schelp L. The community safety approach in Falun, Sweden - is it possible to characterise the most effective prevention endeavours and how long-lasting are the results?. Accident Analysis and Prevention 2000;32:461–70.

Brown 2004 (published data only)
Brown DS. Do leaves have to fall in their autumn? A falls prevention strategy in action in the South East of South Australia. Rural and Remote Health 2004;231 (online).

Casteel 2004 (published data only)

Clemson 2004 (published data only)

Deery 2000 (published data only)

Freiberger 2007 (published data only)

Haines 2004 (published data only)

Hendriks 2005 (published data only)

Hokby 1996 (published data only)

Hornbrook 1993 (published data only)

Jensen 2002 (published data only)

Larsen 2001 (published data only)

Loos 2001 (published data only)

Luukinen 2007 (published data only)

Mehoney 2007 (published data only)

Plautz 1996 (published data only)
**Population-based interventions for the prevention of fall-related injuries in older people (Review)**

**Additional references**

**AIHW 2002a**

**AIHW 2002b**

**Bell 2000**

**Braithwaite 2003**

**CDC 2003**

**Christoffel 1999**

**Cripps 2001**

**Cummings 2002**

**Diamond 2003**

**Elkington 2002**

**Englander 1996**

**Feder 2000**

**Gillespie 2004**

**Green 1989**

**Guidelines 2001**
Moller 1991

Kingma 2000

Magaziner 1990

Mathers 1999

Moller 1991

Moller 2002

Moller 2003

NARU 2000

Norton 1997

Nuffield 1996

NZ NHC 1997

Peel 2002

Qld Health 2000

Qld Health 2002

Rose 1999

Rubenstein 2002

Salkeld 2000

Sattin 1999

Scott 1999

Scott 2001

Scuffham 2003

Sherrington 1998

Thapa 1996

Tinetti 1989
Tinetti 1995

Tinetti 2003

WHO 1999

* Indicates the major publication for the study
### Characteristics of included studies  
*ordered by study ID*

#### Kempton 2000

<table>
<thead>
<tr>
<th>Methods</th>
<th>Controlled population-based intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants</td>
<td>Intervention: targeted non-institutionalised persons aged 60 years and over in a large rural region in NSW, Australia. Population aged over 60 approx 80 000. Control: Queensland Sunshine Coast. Population aged over 60 approx 62 000</td>
</tr>
</tbody>
</table>
| Interventions            | Stay on Your Feet Program (1991-1995)  
|                          | - small media brochures, posters and milk cartons  
|                          | - information through television and radio  
|                          | - community education  
|                          | - home hazard reduction  
|                          | - policy development  
|                          | - engagement of local clinicians |
| Outcomes                 | Fall-related hospital admissions and self-reported falls |
| Notes                    | Study was driven more by Area Health Services than the community per se |

#### Lin 2006

<table>
<thead>
<tr>
<th>Methods</th>
<th>Controlled population-based intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants</td>
<td>Intervention: elderly residents (aged 65 years and over) in 2 “tai chi villages” in the rural township of Shin-Sher, Taichung County, Taiwan (n=472). Control: Elderly residents in 4 control villages in Shin Sher (n=728)</td>
</tr>
</tbody>
</table>
| Interventions            | Tai Chi exercises and education on falls prevention  
|                          | All villages received the falls education program, however only the 2 intervention villages received the tai chi program |
| Outcomes                 | Self-reported injurious falls (that received medical care). Data was cross-checked against records from 6 of 9 medical clinics servicing the area |
| Notes                    | Not all elderly residents from the study villages participated in the study: participation rate was 472 / 754 (63%) for the intervention and 728 / 1318 (55%) for the control villages |
### Lindqvist 2001

<table>
<thead>
<tr>
<th>Methods</th>
<th>Controlled population-based intervention</th>
</tr>
</thead>
</table>
| Participants     | Intervention: targeted persons aged 65 years and over in Motala, Sweden. Total population approx 41,000  
Control: community matched on gender and age distribution, education, employment and income. Total population approx 26,000 |
| Interventions    | Motala Safe Community  
1987-1988  
Specific intervention activities included:  
- WHO Safe Community  
- injury prevention information provided in the media  
- safety education through community displays and media  
- home visits  
- environmental modifications: road and walkways improvements, lighting in public places |
| Outcomes         | Mortality rates and hospital admissions for fall injuries and all unintentional injuries |
| Notes            | Intervention period only lasted for 12 months. The intervention did emphasise fall injury reduction but in the context of overall injury reduction |

### Poulstrup 2000

<table>
<thead>
<tr>
<th>Methods</th>
<th>Controlled population-based intervention</th>
</tr>
</thead>
</table>
| Participants     | Intervention: targeted persons aged 65 years and over in a community in Denmark. Elderly population: 13,921  
Control: Community matched on gender and age distribution, marital status and numbers of home dwelling and institutionalised persons. Elderly population: 12,300 |
| Interventions    | Community-based intervention trial  
1985-1988  
Specific intervention activities included:  
- educational talks in local clubs and centres  
- mailed leaflets on falls risk factors  
- promotion of physical activity and diet  
- reduction in home hazards  
- nurse and GP home visits |
| Outcomes         | Hospital admissions for all fractures, lower extremity fractures and hip fractures |
| Notes            | |

---

*Population-based interventions for the prevention of fall-related injuries in older people (Review)*  
Copyright © 2008 The Cochrane Collaboration. Published by John Wiley & Sons, Ltd.
### Svanstrom 1996

<table>
<thead>
<tr>
<th>Methods</th>
<th>Controlled population-based intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants</td>
<td>Intervention: targeted persons aged 65 years and over in Lidköping, Sweden. Largely agricultural community, total population approx 35 000. Control: comparisons were made with the whole county (pop 270 000) and the entire country (pop 1.2 million).</td>
</tr>
<tr>
<td>Outcomes</td>
<td>Hospital admissions (from discharge register) for femoral fractures</td>
</tr>
<tr>
<td>Notes</td>
<td>Injury surveillance systems changed during the period of evaluation, and no true baseline period exists as the evaluation took place in the context of an already existing injury prevention intervention begun in 1984. Therefore, results are probably under-estimated</td>
</tr>
</tbody>
</table>

### Ytterstad 1996

<table>
<thead>
<tr>
<th>Methods</th>
<th>Controlled population-based intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants</td>
<td>Intervention: targeted persons aged 65 years and over in Harstad, Norway. (pop 22 500). Control: Tondheim. (pop 135 000)</td>
</tr>
<tr>
<td>Interventions</td>
<td>Harstad Injury Prevention Study 1985-1993. Specific intervention activities included: - WHO Safe Community - local media coverage of program - educational talks to elderly - home visits by health professionals to high risk individuals - promotion of safe footwear and physical activity - promotion of home hazard removal - engagement with local community agencies and services</td>
</tr>
<tr>
<td>Outcomes</td>
<td>Hospital admissions for fractures and hospital related costs</td>
</tr>
<tr>
<td>Notes</td>
<td></td>
</tr>
</tbody>
</table>

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*Population-based interventions for the prevention of fall-related injuries in older people (Review)*

Copyright © 2008 The Cochrane Collaboration. Published by John Wiley & Sons, Ltd.
### Characteristics of excluded studies

**Reason for exclusion**

<table>
<thead>
<tr>
<th>Study</th>
<th>Reason for exclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkalay 1984</td>
<td>No control community was used for comparison.</td>
</tr>
<tr>
<td>Assantachai 2002</td>
<td>Injury rates were not objectively measured.</td>
</tr>
<tr>
<td>Becker 2003</td>
<td>There was no measurement of changes in injury rates over time</td>
</tr>
<tr>
<td>Bjerre 2000</td>
<td>Injury rates were not reported separately for the population of interest</td>
</tr>
<tr>
<td>Brown 2004</td>
<td>No control community was used for comparison.</td>
</tr>
<tr>
<td>Casteel 2004</td>
<td>The study did not meet the definition for a population-based intervention</td>
</tr>
<tr>
<td>Clemson 2004</td>
<td>No injury outcomes were assessed.</td>
</tr>
<tr>
<td>Deery 2000</td>
<td>No injury outcomes were assessed.</td>
</tr>
<tr>
<td>Freiberger 2007</td>
<td>No injury outcomes were assessed.</td>
</tr>
<tr>
<td>Haines 2004</td>
<td>The study did not meet the definition for a population-based intervention</td>
</tr>
<tr>
<td>Hendriks 2005</td>
<td>The study did not meet the definition for a population-based intervention</td>
</tr>
<tr>
<td>Hokby 1996</td>
<td>No injury outcomes were assessed.</td>
</tr>
<tr>
<td>Hornbrook 1993</td>
<td>The study did not meet the definition for a population-based intervention</td>
</tr>
<tr>
<td>Jensen 2002</td>
<td>There was no measurement of changes in injury rates over time</td>
</tr>
<tr>
<td>Larsen 2001</td>
<td>No injury outcomes were assessed.</td>
</tr>
<tr>
<td>Loos 2001</td>
<td>No injury outcomes were assessed.</td>
</tr>
<tr>
<td>Luukinen 2007</td>
<td>The study did not meet the definition for a population-based intervention</td>
</tr>
<tr>
<td>Mohoney 2007</td>
<td>The study did not meet the definition for a population-based intervention</td>
</tr>
<tr>
<td>Plautz 1996</td>
<td>No control community was used for comparison.</td>
</tr>
<tr>
<td>Powell 2000</td>
<td>No injury outcomes were assessed.</td>
</tr>
<tr>
<td>Reinsch 1992</td>
<td>Injury rates and severity were self-reported and therefore not objectively measured</td>
</tr>
<tr>
<td>Robertson 2001</td>
<td>The study did not meet the definition for a population-based intervention</td>
</tr>
<tr>
<td>Study</td>
<td>Findings</td>
</tr>
<tr>
<td>---------------------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>Robson 2003</td>
<td>No injury outcomes were assessed.</td>
</tr>
<tr>
<td>Sjosten 2007</td>
<td>The study did not meet the definition for a population-based intervention</td>
</tr>
<tr>
<td>Steinberg 2000</td>
<td>No injury outcomes were assessed.</td>
</tr>
<tr>
<td>Sze 2005</td>
<td>No injury outcomes were assessed.</td>
</tr>
<tr>
<td>Thompson 1996</td>
<td>No control community was used for comparison.</td>
</tr>
<tr>
<td>Tideiksaar 1992</td>
<td>No injury outcomes were assessed.</td>
</tr>
<tr>
<td>Wijlhuizen 2007</td>
<td>No injury outcomes were assessed.</td>
</tr>
</tbody>
</table>
DATA AND ANALYSES

This review has no analyses.

ADDITIONAL TABLES

Table 1. Methodological Quality of Included Studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Baseline measurement</th>
<th>Appropriate control</th>
<th>Contamin. protection</th>
<th>Reliable measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kempton</td>
<td>Done</td>
<td>Done</td>
<td>Done</td>
<td>Not Clear</td>
</tr>
<tr>
<td>Lin</td>
<td>Done</td>
<td>Done</td>
<td>Done</td>
<td>Not Clear</td>
</tr>
<tr>
<td>Lindqvist</td>
<td>Done</td>
<td>Done</td>
<td>Not Clear</td>
<td>Done</td>
</tr>
<tr>
<td>Poulstrup</td>
<td>Done</td>
<td>Done</td>
<td>Done</td>
<td>Not Clear</td>
</tr>
<tr>
<td>Svanstrom</td>
<td>Not Clear</td>
<td>Not Clear</td>
<td>Not Clear</td>
<td>Not Clear</td>
</tr>
<tr>
<td>Ytterstad</td>
<td>Done</td>
<td>Done</td>
<td>Done</td>
<td>Done</td>
</tr>
</tbody>
</table>

APPENDICES

Appendix 1. Search strategy

Cochrane Injuries Group Specialised Register

Searched 11 May 2007

(aged or older or elderly or senior* or old-age* or centenarian* or nonagenarian* or octogenarian*) and (Falls or faller* or falling or slip* or trip* or stumble* or tumble* or fell) and (strateg* or prevent* or intervention or program* or campaign* or evaluat*)

CENTRAL issue 2, 2007

#1MeSH descriptor Aged explode all trees
#2older or elderly or senior* or old-age* or centenarian* or nonagenarian* or octogenarian*
#3(#1 OR #2)
#4MeSH descriptor Accidental Falls explode all trees
#5Falls or faller* or falling or slip* or trip* or stumble* or tumble* or fell
#6(#4 OR #5)
#7MeSH descriptor Accident Prevention explode all trees
#8strateg* or prevent* or intervention or program* or campaign*
#9(#7 OR #8)
#10MeSH descriptor Wounds and Injuries explode all trees
#11injur or injured or injury or injuries or trauma* or wound* or fracture*
#12(#10 OR #11)
#13(#3 AND #6 AND #9 AND #12)
#14(#13), from 2002 to 2007
MEDLINE 2002 to 2007/ May, week 1
1.exp Aged/
2.(older or elderly or senior$ or old-age$ or centenerian$ or nonagenarian$ or octogenarian$).ab,ti.
3.1 or 2
4.exp Accidental Falls/
5.(Falls or faller$ or falling or fell or slip$ or trip$ or stumble$ or tumble$).ab,ti.
6.4 or 5
7.exp Accident Prevention/
8.(strateg$ or prevent$ or intervention or program$ or campaign$).ab,ti.
9.7 or 8
10.exp “Wounds and Injuries”/
11.(injured or injury or injuries or trauma$ or wound$ or fracture$).ab,ti.
12.10 or 11
13.3 and 6 and 9 and 12
14.(randomised or randomized or randomly or random order or random sequence or random allocation or randomly allocated or at random).mp. [mp=title, original title, abstract, name of substance word, subject heading word]
15.clinical trial.pt.
16.exp Evaluation Studies/
17.14 or 15 or 16
18.13 and 17
EMBASE 2002 to week 18 May, 2007
1.exp Aged/
2.(older or elderly or senior$ or old-age$ or centenerian$ or nonagenarian$ or octogenarian$).ab,ti.
3.1 or 2
4.exp falling/
5.exp home accident/
6.(Falls or faller$ or falling or fell or slip$ or trip$ or stumble$ or tumble$).ab,ti.
7.4 or 5 or 6
8.exp Accident Prevention/
9.(strateg$ or prevent$ or intervention or program$ or campaign$).ab,ti.
10.8 or 9
11.exp INJURY/
12.(injured or injury or injuries or trauma$ or wound$ or fracture$).ab,ti.
13.11 or 12
14.3 and 6 and 9 and 12
15.(randomised or randomized or randomly or random order or random sequence or random allocation or randomly allocated or at random).mp. [mp=title, abstract, subject headings, heading word, drug trade name, original title, device manufacturer, drug manufacturer name]
16.Clinical Trial/
17.exp evaluation/
18.15 or 16 or 17
19.14 and 18
Ageinfo 2002 to 2007 (searched 11 May, 2007)
1.Falls or Domestic accidents [keywords]
2.falls or faller* or falling or fell or slip* or stumble* or trip* [text]
3.1 or 2
4.strateg* or prevent* or intervention or program* or campaign* [text]
5.trial or study or evaluat* or random* [text]
6.3 and 4 and 5
PsycINFO 2002 to 2007 (searched 11 May, 2007)
1.explode “Elder-Care” in MJ,MN
2.older or elderly or senior* or old-age* or centenerian* or nonagenarian* or octogenarian*
3.#1 or #2
WHAT'S NEW

Last assessed as up-to-date: 15 May 2007.
Date | Event | Description
--- | --- | ---
11 July 2008 | Amended | Converted to new review format.

HISTORY

Review first published: Issue 1, 2005

Date | Event | Description
--- | --- | ---
16 May 2007 | New search has been performed | May 2007
Identification and assessment of 13 new publications for potential inclusion.

- 1 new publication was included
  - Lin 2006 (new study)

- 12 publications were excluded:
  - Becker 2003
  - Casteel 2004
  - Clemson 2004
  - Frieberger 2007
  - Hendriks 2005
  - Jensen 2002
  - Luukinen 2007
  - Mahoney 2007
  - Robson 2003
  - Sjosten 2007
  - Sze 2005
  - Wijlhuizen 2007

Conclusions of the review have not changed substantially.

CONTRIBUTIONS OF AUTHORS

Rod McClure was involved in the conception of the review, discussion amongst review authors and wrote the discussion section of the review.

Cathy Turner was involved in the conception of the review and discussion amongst review authors.

Nancye Peel contributed content expertise, discussion amongst review authors and wrote the introduction for the review.

Anneliese Spinks was involved in the conception of the review, searching and initial screening of potential articles, coordinating discussion with review authors and manuscript preparation.
Elizabeth Eakin selected articles for inclusion and performed data extraction and quality scoring for included articles. Karen Hughes selected articles for inclusion and performed data extraction and quality scoring for included articles.

**DECLARATIONS OF INTEREST**

None known.

**SOURCES OF SUPPORT**

**Internal sources**

- Injury Prevention and Control (Australia) Ltd, Australia.
- School of Population Health, University of Queensland, Australia.

**External sources**

- Cochrane Health Promotion and Public Health Field; Victorian Health Promotion Foundation, Australia.

**INDEX TERMS**

**Medical Subject Headings (MeSH)**

Accident Prevention [*methods*]; Accidental Falls [*prevention & control*]; Accidents, Home; Randomized Controlled Trials as Topic; Wounds and Injuries [etiology; *prevention & control*]

**MeSH check words**

Aged; Aged, 80 and over; Female; Humans; Male