



What are the main risk factors for falls amongst older people and what are the most effective interventions to prevent these falls?

March 2004

ABSTRACT

This report is HEN's response to a question from a decision-maker. It provides a synthesis of the best available evidence, including a summary of the main findings and policy options related to the issue. Fall prevention programmes can be effective in reducing the number of people who fall and the rate of falls. Targeted strategies aimed at behavioural change and risk modification for those living in the community appear to be most promising. Multifactorial intervention programmes that include risk factor assessment and screening have been shown to be effective. However, no screening tools have been rigorously validated across countries and further work is needed in this area.

HEN, initiated and coordinated by the WHO Regional Office for Europe, is an information service for public health and health care decision-makers in the WHO European Region. Other interested parties might also benefit from HEN.

This HEN evidence report is a commissioned work and the contents are the responsibility of the authors. They do not necessarily reflect the official policies of WHO/Europe. The reports were subjected to international review, managed by the HEN team.

When referencing this report, please use the following attribution:

Todd C, Skelton D. (2004) *What are the main risk factors for falls among older people and what are the most effective interventions to prevent these falls?* Copenhagen, WHO Regional Office for Europe (Health Evidence Network report; <http://www.euro.who.int/document/E82552.pdf>, accessed 5 April 2004).

Keywords

ACCIDENTAL FALLS
ACCIDENT PREVENTION
AGED
RISK FACTORS
EVIDENCE-BASED MEDICINE
DECISION SUPPORT TECHNIQUES
EUROPE

Address requests about publications of the WHO Regional Office to:

- *by e-mail* publicationrequests@euro.who.int (for copies of publications)
permissions@euro.who.int (for permission to reproduce them)
pubrights@euro.who.int (for permission to translate them)
- *by post* Publications
WHO Regional Office for Europe
Scherfigsvej 8
DK-2100 Copenhagen Ø, Denmark

© World Health Organization 2004

All rights reserved. The Regional Office for Europe of the World Health Organization welcomes requests for permission to reproduce or translate its publications, in part or in full.

The designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Where the designation "country or area" appears in the headings of tables, it covers countries, territories, cities, or areas. Dotted lines on maps represent approximate border lines for which there may not yet be full agreement.

The mention of specific companies or of certain manufacturers' products does not imply that they are endorsed or recommended by the World Health Organization in preference to others of a similar nature that are not mentioned. Errors and omissions excepted, the names of proprietary products are distinguished by initial capital letters.

The World Health Organization does not warrant that the information contained in this publication is complete and correct and shall not be liable for any damages incurred as a result of its use. The views expressed by authors or editors do not necessarily represent the decisions or the stated policy of the World Health Organization.

Summary	4
The issue	4
Findings.....	4
Policy considerations	4
Introduction	5
Sources for this review.....	5
Findings.....	6
Incidence of falls and associated outcomes	6
Risk factors	7
Assessment of risk	10
Prevention of falls and injuries	10
Costs and prevention of falls.....	14
Gaps in evidence and conflicting evidence	15
Generalizability	15
Current debate on populations and strategic approaches.....	16
Successful multifactorial strategies	17
Recent guidelines and health service frameworks.....	18
Conditions to support successful strategies.....	19
Conclusions	21
References	22
Acknowledgements	28
Glossary.....	28

Summary

The issue

Older people make up a large and increasing percentage of the population. As people grow older they are increasingly at risk of falling and consequent injuries. A fall may be the first indication of an undetected illness. The prevention of falls is of major importance because they engender considerable mortality, morbidity and suffering for older people and their families, and incur social costs due to hospital and nursing home admissions.

Findings

Approximately 30% of people over 65 fall each year, and for those over 75 the rates are higher. Between 20% and 30% of those who fall suffer injuries that reduce mobility and independence and increase the risk of premature death. Fall rates among institution residents are much higher than among community-dwellers.

Fall prevention programmes can be effective in reducing the number of people who fall and the rate of falls. Targeted strategies aimed at behavioural change and risk modification for those living in the community appear to be most promising. Multifactorial intervention programmes that include risk factor assessment and screening have been shown to be effective. However, no screening tools have been rigorously validated across countries and further work is needed in this area.

The use of physical and pharmacological restraints leads to more severe injuries from falls. Patients with cognitive impairment in hospital after a fall have not benefited from multifactorial interventions, but cognitively impaired residents of care facilities have responded to tailored fall prevention. It seems likely that fall prevention programmes can be cost effective, although more research is required.

Policy considerations

Unless concerted action is taken, the number of falls is likely to increase over the next 25 to 30 years. A number of interventions targeted to individuals have been shown to work, but population-based strategies have not been properly evaluated. This points to the need for monitoring and further evaluation.

Health and social care agencies need to work together to prioritize fall prevention as part of their overall strategy for promoting healthy ageing. Coherent multidisciplinary programmes can be developed at the national level. These should be implemented with national data collection mechanisms to evaluate interventions by outcome (e.g. fall/fracture rates) rather than process (people seen) or structure (clinics set up). Effective interventions used in a multifactorial programme include:

- home-based professionally prescribed exercise, to promote dynamic balance, muscle strengthening and walking
- group programmes based on Tai Chi-type exercises or dynamic balance and strength training as well as floor coping strategies
- home visits and home modifications for older people with a history of falling
- medication review, particularly for those on four or more medicines and withdrawal of psychotropic medications where feasible.

Authors¹ of this HEN synthesis report are:

Dr Dawn Skelton

Project Co-ordinator - Prevention of Falls Network Europe
School of Nursing, Midwifery and Health Visiting
Coupland III
University of Manchester
Oxford Road
Manchester, M13 9PL
United Kingdom
Tel: +44-161 275 8225
E-mail: Dawn.Skelton@man.ac.uk

Professor Chris Todd

Professor of Primary Care and Community Health and Dean of Research
School of Nursing, Midwifery and Health Visiting
Coupland III
University of Manchester
Oxford Road
Manchester, M13 9PL
United Kingdom
Tel: +44-161-275 5336
E-mail: Chris.todd@man.ac.uk

Introduction

A fall is usually defined as “an event which results in the person coming to rest inadvertently on the ground or other lower level, and other than as a consequence of the following: sustaining a violent blow, loss of consciousness, sudden onset of paralysis, or an epileptic seizure” (1).

Falls and fall-related injuries among older people are major issues for health and social care providers in Europe and indeed the world, because of the rapid increases in life expectancy observed during the twentieth century (2). Falls are the most serious and frequent home accident among older people. They are a major reason for admission to hospital or a residential care setting, even when no serious injury has occurred (2,3). Fall-induced injuries are increasing more rapidly than can be accounted for by the increase in the elderly population (4,5).

Epidemiological research into falls and fall-related injuries has been effected by a series of conceptual and methodological problems. Although the majority of hip fractures resulting from falls come to the attention of health professionals, less severe injuries may not result in medical attention. Given that the majority of falls do not come to the attention of any medical service (6), incidence figures for falls in the community setting are largely dependent on self-reported recall of events. Despite these issues, there are a number of broad conclusions about fall incidence that can be drawn from the literature.

Sources for this review

This synthesis has concentrated on identifying evidence that emerges from published systematic reviews of the literature (3,7,8,9,10,11), general reviews (12,13,14,15,16,17,18) and key studies published in English. Due to the short time for completion and breadth of the question, this cannot be

¹ Dr Skelton and Professor Todd are co-ordinators of the Prevention of Falls Network Europe (ProFaNE), European Commission contract QLRT-2001-02705. The content of the manuscript does not represent the opinion of the European Community and the Community is not responsible for any use that might be made of the information presented in the text. Contact <http://www.profane.eu.org>

seen as a rigorous systematic review, but seeks to identify key issues that will be of importance to policy makers. Information on ongoing studies, issues for implementation, gaps in the literature and policy implications were informed by a United Kingdom and European working group on falls prevention, the UK Department of Health Working Party on Effective Interventions to Reduce Injury and Prevention of Falls Network Europe (ProFaNE).

A revised Cochrane review of fall prevention strategies is due to be published in 2004 and should be read alongside this report.

Findings

Incidence of falls and associated outcomes

The following section presents epidemiological information about those who fall, summarized from a variety of studies in different countries. There is geographic variation in fall injury rates across countries and across Europe (19), but this summary outlines the extent of the problem and potential risk factors that will help focus any fall prevention programme.

Community Dwelling Older People

- Thirty percent of people over 65 and 50% of those over 80 fall each year (20).
- Older adults who fall once are two to three times as likely to fall again within a year (20).
- Approximately 10% of United Kingdom ambulance service calls are to people over 65 who have fallen. About 60% of cases are taken to hospital (21).
- Twenty to thirty percent of those who fall suffer injuries that reduce mobility and independence and increase the risk of premature death (22,23). Somewhat fewer fallers who require medical attention suffer fractures (24,25). At one year follow up, 20% of frequent fallers are in hospital, in full time care or have died (26).
- Older adults are hospitalized for fall-related injuries five times more often than they are for injuries from other causes (27). Falls are the leading cause of injury deaths among people 65 and older; half occur in their own home (2,26).
- For women over 55 and men over 65, the age-specific death and admission rates for injury increase exponentially with age. More than one-third of women sustain one or more osteoporotic fractures in their lifetime, the majority caused by a fall (28). Lifetime risk of fracture in men is approximately half that observed in women. Fracture is recorded as the cause of more than 50% of serious accidental injury admissions and 39% of fatal injuries.

Older people in residential care facilities

- Approximately 50% of older people in residential care facilities fall at least once a year (29); up to 40% fall more than once a year (30,31).
- Falls are recorded as a contributing factor in 40% of admissions to nursing homes (1,30,31).
- The incidence of falls in institutional settings is 1.5 falls per bed per year (29).
- The incidence of falls can double after older people are relocated to a new environment and then return to baseline after the first three months (30).
- Among people 85 and older, 20% of fall-related deaths occur in residential care settings (32).

Fractures as a result of falls

- While the proportion of falls resulting in fracture is low, the absolute number of older people suffering fractures is high, placing heavy demands on health care systems.
- Approximately 10% of falls result in serious injury (1,33), of which 5% are fractures (1,25, 33).
- The most commonly associated age-related fractures are wrist, spine, hip, humerus, pelvis.
- Hip fractures comprise approximately 25% of fractures resulting from falls in the community (33,34).
- The incidence of hip fracture is higher in residential settings, with rates of up to 81 per 1000 person years reported (35,36). At least 95% of hip fractures are caused by falls (25,33).

- Approximately half of all fallers who fracture their hips are never functional walkers again and 20% will die within six months (23).

Non injurious falls

- Most non-injurious falls (75%-80%) are never reported to health professionals (37).
- Depression, fear of falling and other psychological problems – “post-fall syndrome” – are common effects of repeated falls (12,25,33). Loss of self-confidence as well as social withdrawal, confusion and loneliness can occur, even when there has been no injury.
- A non-injurious fall can still be fatal if the person is unable to get up from the floor and cannot summon help. Lying on the floor for more than 12 hours is associated with pressure sores, dehydration, hypothermia, pneumonia, and death (38). Almost 50% of people who fall require help to get up after at least one fall, but only 10% of falls result in a lie of greater than one hour.

Risk factors

Prevention strategies for falls at the population level have yet to be properly studied. It is therefore important to identify those people most at risk of falling in order to maximize the effectiveness of any proposed intervention. Published studies have identified specific risk factors for falls and related injuries. However, direct comparison of studies is hampered by a number of methodological issues, including the use of different study populations, lack of clarity and consistency in definitions, variability in periods of follow up, and the inevitable difficulties of retrospective recall of events. Furthermore, there is a complex causal interaction between risk factors and fall occurrence.

Risk factors for falls can be broadly classified into three categories: intrinsic factors, extrinsic factors and exposure to risk. The following section presents potential risk factors in each of these categories, but it is recognized that falls often result from dynamic interactions of risks in all of the categories and that univariate consideration of the individual risks presented here ignores confounding (where one risk factor may explain another if evaluated in a multivariate manner).

Intrinsic risk factors:

- A history of falls is associated with increased risk (22,25,34).
- Age: the incidence of falls increases with age (39,40).
- Gender: for the younger old, fall rates for men and women are similar, but among the older old, women fall more often than men (39,40), and are far more likely to incur fractures when they fall.
- Living alone: it may imply greater functional ability, but injuries and outcomes can be worse, especially if the person cannot rise from the floor. Living alone has been shown to be a risk factor for falls, although part of this effect appears to be related to certain types of housing older people may occupy (41).
- Ethnicity: evidence from the United Kingdom and the United States suggests Caucasian ethnic groups fall more frequently than Afro-Caribbeans, Hispanics or South Asians (34,42), but there are no papers reporting ethnicity variations for continental Europe.
- Medicines: benzodiazepine use in older people is associated with an increase of as much as 44% in the risk of hip fracture and night falls (43). There is a significant increased risk of falling with use of medications such as psychotropics, class 1a anti-arrhythmic medications, digoxin, diuretics (44), and sedatives (25). With the expanding evidence base for medications in chronic disease management, the number of prescribed medications has increased. Risk is increased significantly if a person is on more than four medications, irrespective of type (12, 40, 45) in all

but one trial (46). The use of four or more medications is associated with a nine-fold increased risk of cognitive impairment (47,48) and fear of falling (42).

- Medical conditions: circulatory disease, chronic obstructive pulmonary disease, depression and arthritis are each associated with an increased risk of 32% (46). The prevalence of falling increases with rising chronic disease burden (46, 49). Thyroid dysfunction leading to excess circulating thyroid hormone, diabetes (50) and arthritis (34) leading to loss of peripheral sensation (48) also increases risk. The prevalence of cardiovascular related causes of falls in the general population is not known (3), but dizziness is common in fallers. Depression and incontinence are also frequently present in populations of fallers (2,3).
- Impaired mobility and gait: the decline in strength and endurance after the age of 30 (10% loss per decade) and muscle power (30% loss per decade) result in physical functioning dropping below the threshold where activities of daily living become difficult and then impossible to carry out – this can occur in early old age for those who have been sedentary most of their lives (51). When strength, endurance, muscle power and hence function declines sufficiently, one is unable to prevent a slip, trip or stumble becoming a fall. Muscle weakness is a significant risk factor for falls, as is gait deficit, balance deficit and the use of an assistive device (3). Any lower extremity disability (loss of strength, orthopaedic abnormality or poor sensation) is associated with increased risk (25,29,53,54). Difficulty in rising from a chair is also associated with increased risk (34,45).
- Sedentary behaviour: fallers tend to be less active and may inadvertently cause further atrophy of muscle around an unstable joint through disuse (51). Those cutting back on normal activities because of a health problem in the 14 days previous to fall are at increased risk (20). Those who are inactive fall more than those who are moderately active or very active, but do so in safe environments (13). However, muscle function is so strongly associated with physical activity that it is hard to demonstrate that physical activity and loss of function have unique contributions.
- Psychological status - fear of falling: Up to 70% of recent fallers and up to 40% of those not reporting recent falls acknowledge fear of falling (25,38,55). Reduced physical and functional activity is associated with fear and anxiety about falling. Up to 50% of people who are fearful of falling restrict or eliminate social and physical activities because of that fear (25). Strong relationships have been found between fear and poor postural performance (56), slower walking speed and muscle weakness (57), poor self-rated health and decreased quality of life (55). Fear of falling predicts falls at one-year follow-up, and vice-versa (42). Women with a history of stroke are at risk of falls and fear of falling (42). Taking four or more medications also independently predicts fear (42). However, many older people do not adequately appreciate their risk status.
- Nutritional deficiencies: a low body mass index suggesting malnutrition is associated with increased risk (49). Vitamin D deficiency is particularly common in older people in residential care facilities and may lead to abnormal gait, muscle weakness, osteomalacia and osteoporosis (58,59).
- Impaired cognition: cognitive deficit is clearly associated with increased risk, even at a relatively modest level (short of florid dementia). For example, five or more errors on a short mental status questionnaire (25), score <26 (49) or <24 (54) on the Mini-Mental State Examination (60) is associated with increased risk. Immediate memory has been demonstrated to be an independent risk factor for falls in those over 75 as part of the Longitudinal Aging Study Amsterdam (61). Nursing home residents with diagnosed dementia fall twice as often as those with normal cognition but there was no difference in severity of injury between the groups (62).

- Visual impairments: visual acuity, contrast sensitivity, visual field, cataract, glaucoma and macular degeneration all contribute to risk of falls (63,64) as do bifocal or multifocal lenses (65). Multifocal glasses impair depth perception and edge-contrast sensitivity at critical distances for detecting obstacles in the environment. Older people may benefit from wearing non-multifocal glasses when negotiating stairs and in unfamiliar settings outside the home (65).
- Foot problems: bunions, toe deformities, ulcers, deformed nails and general pain in walking increase balance difficulties and risk of falls (25). Footwear is also important (66).

Extrinsic risk factors

The size of the impact environmental factors have on the risk of falling among older people is uncertain. Some studies have reported that between 30% and 50% of falls among community dwelling older people are due to environmental causes and others that 20% of falls are due to major external factors (those that would cause any healthy adult to fall) (12,14). Older people often have problems slipping or tripping, lacking good balance or righting mechanisms for preventing the fall. Extrinsic risks include:

- environmental hazards (poor lighting, slippery floors, uneven surfaces, etc.) (14)
- footwear and clothing (14)
- inappropriate walking aids or assistive devices (67) .

Exposure to risk

Some studies suggest a U-shaped association, that is, the most inactive and the most active people are at the highest risk of falls (13,68). This reveals the complex relationship between falls, activity and risk. The type and extent of environmental challenges that an older person chooses to embrace interact with the person's intrinsic risk factors. One trial found that walking may increase the risk of falls (69), others found that increased physical activity was associated with a decreased risk of falls, but an increased risk of suffering a serious injury (38). It does, however, appear to be beneficial for those in residential care facilities to engage in moderate-to-high levels of activity with the use of a walking aid (68).

Some activities seem to increase the risk of falls, either by increasing exposure to risky environmental conditions (slippery or uneven floors, cluttered areas, degraded pavements), acute fatigue, or unsafe practice in exercise sessions (51).

Risk factor conclusions

As these studies were mainly exploratory in nature, with multiple testing of factors, it is difficult to determine the definitive risk factors for falling. However, it would appear that intrinsic factors are more important among people 80 and over (12), since loss of consciousness (suggesting a medical cause of fall) is more common in this group. Falls among older people under 75 are more likely to be due to extrinsic factors. Several studies have shown that the risk of falling – for both community and residential care-dwellers – increases exponentially as the number of risk factors increases (25,34,70). Robbins' model (40) considers only three risk factors (hip weakness, unstable balance and taking more than four medications) and reveals a risk of 12% in those with none of the factors to 100% in those with all three.

Care must be taken not to assume that risk factors seen in individuals in one setting are the same as those seen in another group of individuals in the same or different setting. Lord's findings (71), for example, indicate that there are different risk factors for falls for people living in residential care facilities who can and cannot stand unaided. He suggests that those who can stand unaided but have many fall risk factors constitute the highest priority group for fall interventions (71).

Assessment of risk

No screening tool has been used or validated Europe-wide to assess risk of falling among older people either in the community or in residential care facilities. Nonetheless, the following tools have been used in a number of trials and clinical settings:

- The STRATIFY risk assessment tool (72) is simple to complete and allows for the identification of inpatients at highest risk of falling, but has been validated for hospital inpatients only.
- A screening tool based on the PROFET study enables people attending the Emergency Department of a Hospital to be identified as high risk (73).
- Nandy (74) performed an analysis of the literature to produce a small set of questions that would identify those living in the community with a high risk of falls. The FRAT is a screening and referral community-based tool, which takes about five minutes to complete. It can be used by non-health care professionals, has a 97% specificity (in the United Kingdom) when a person ticks four out of the five questions, but it is not appropriate for use in hospital or residential care facilities.
- A fall-risk screening test was tested by Lips and colleagues prospectively in 1285 community dwellers over 65, showing that visual impairment, urinary incontinence, previous falls and either benzodiazepine use or functional limitations were useful in determining falls or recurrent falls, respectively (75). However, this tool is of unknown sensitivity and specificity.
- The Tinetti balance and gait scale (70,76) shows increased risk of falls if a person has more than six balance and gait abnormalities (70). This scale has 24 items and is therefore not practical for use as a tool in standard clinical practice. Furthermore, it does not cover a wide range of risk factors and needs specialist training to administer. The same applies to the Berg physiotherapy-based scale (77). Both scales have “functional reach” and “180 degree turn” as functional tests within the scales.
- The Physiological Profile Assessment (PPA) developed by Lord (14) takes 45 minutes to administer and considers gait, balance, vision, proprioception and vibration sense and strength, but omits assessments of medication, medical condition or home hazards. Again this tool requires formal training and is not practical for ordinary clinical screening.
- The ABS/BGS3 guidelines suggest the “Get Up and Go Test” (78) as a simple screening test for impaired strength or balance in people presenting with a first fall. In the case of a poor performance, a full assessment should be performed.
- The Mobility Interaction Fall Chart (79) has been shown to be predictive when combined with fall history or staff judgement in residential care facilities (80). This tool includes an observation of the ability to walk and simultaneously interact with another person or object, a vision test and a concentration rating.
- Finally, a recent paper looks at a classification tree for predicting risk of recurrent falling in community-dwelling older people using tree-structured survival analysis, which can identify subjects eligible for preventive measures in public health strategies (81).

More research is required to clarify the most appropriate tools for use in different settings, in terms of simplicity of use, applicability, sensitivity and specificity.

Prevention of falls and injuries

Over many years substantial epidemiological data have been collected that help identify specific causes and risk factors associated with falling. On the basis of the identified risk factors, various

diagnostic assessments have emerged. However, it was only a decade ago that any attempt was made to test formally the validity of the assumption that intervention could alter outcome.

A range of multifactorial fall prevention studies in community-dwelling older people have shown that between five and 25 people need to be treated to prevent one fall (14), which is highly favourable in comparison to many health screening programmes. There is evidence that slightly different interventions work in residential care facilities (82). Although strategies for hospital-based fall prevention programmes are widely implemented, there have been no adequate randomized controlled trials (RCTs) to assess their effects.

Feder's (12) review concluded that:

- Multifactorial interventions, including exercise, education and home modification should be a priority.
- Targeted exercise for the over 80s should be offered.
- Home assessment without referral and direct intervention is ineffective.
- Economic evaluation of the effectiveness of multifactorial interventions needs to be conducted.

The central conclusions from the Cochrane Collaboration's systematic review on fall prevention(9) are that:

- Protection against falling may be maximized by interventions targeting multiple risk factors in individual patients.
- Health care providers should consider health screening of at-risk older people, followed by targeted interventions for deficit areas.
- Home based exercise, Tai Chi, home hazard management and modification for those with a history of falls, withdrawal of psychotropic medication and multifactorial programs are all likely to be effective in preventing falls. These are associated with pooled relative risks of 0.34 to 0.80.
- Group-based exercise, nutritional supplementation, pharmacological therapy, home hazard modification for those with no history of falls, and fall prevention in institutional settings are of unknown effectiveness.

The Cochrane group will update their review later in 2004 with at least 26 new trials (including at least 14 RCTs).

The evidence for falls reduction is strongest in interventions that have selected high-risk populations and take a multi-faceted patient-centred approach to prevention (22,83,84,85). Specific interventions which have been shown to successfully alter outcome include review of medication and diagnosis and treatment of postural hypotension. Although not a common cause, syncope and carotid sinus syndrome can be modified (86). The evidence for home environment modifications alone remains poor (87,88). There is now considerable evidence that exercise is effective as part of a multi-faceted fall prevention intervention. The evidence for exercise-only interventions is not so clear (11), with some trials showing little or no effect on fall risks despite improvements in known risk factors such as strength. Interventions with balance training at the core of the exercise programme are most effective across a wide range of ages, including people with mild to major functional limitations (11).

Community dwelling older people have been the focus for most of the exercise-only interventions. In over 65s with poor strength and balance, modified group Tai Chi appears effective as a preventive measure (89,90), although over a 48 week period it was not beneficial in reducing falls in an older (70+) group with signs of frailty (91). In over 70s, a 15-week group-based exercise programme had a more significant effect on fall risks than a vision check or home safety check (87), but the effect was not as impressive as the same research group's next one-year trial (92). Participants aged over 65, with impairments in lower limb strength, poor balance or slow reaction time, had a 40% lower rate of falls

than those not taking part in a group-based exercise and home exercise plan lasting one year (93). A nine-month balance and strength-specific programme of group and home exercise in over 65 year old frequent fallers halved the rate of falls compared to controls (94,95). Even though it would be expected that home exercise alone might not be adhered to as well as group exercise, a year-long, partially supervised, home exercise programme was highly effective at reducing falls, but more cost-effective in over-80s (96,97).

There are concerns about increasing physical activity and exercise in older people with poor balance. One trial recommending walking to a group of fallers showed an increased risk of injury compared to a group that did not increase outdoor walking (69). It is likely that preparatory strength and flexibility training is needed before balance-challenging exercise commences and that an effective duration of exercise is necessary to see physiological training changes to match improvements in confidence (95). For example, the successful FaME group exercise programme did show a slightly higher risk of falling within the intervention period in the exercisers compared to the controls but there was no increase in injurious falls (95).

The evidence is now mounting for prevention strategies within residential settings, with exercise, balance training (98) and environment modification central in most. Education of staff appears beneficial only in conjunction with other interventions (82). A recent RCT has also shown fewer falls in a group receiving vitamin D and calcium supplementation compared to a control group (99). There is still no strong evidence for prevention strategies in hospital settings.

Table 1 presents the authors' summary of evidence from individual trials for the key settings and key interventions reviewed. The strength of evidence is noted in parentheses and is determined using the Cochrane grading scheme:

- A. at least one RCT or a meta-analysis of RCTs directly concerned with reduction of falls
- B. at least one controlled study without randomization or evidence from at least one other type of quasi-experimental study or extrapolated recommendation from (A) when fall risk, rather than actual number of falls, was assessed
- C. evidence from non-experimental studies or extrapolated recommendation from (A) or (B)
- D. evidence from expert committees, clinical opinion or extrapolated recommendation from A, B or C.

Table 1: Summary of evidence to support interventions to reduce falls and injuries

Community dwelling older people (2,3,8, 38,83-85, 97, 100-102)

In older people living in their own homes, assessment of major risk factors and appropriate multifactorial interventions could include:

- gait training and advice on appropriate use of assistive devices (A)
- review and modification of medications, particularly psychotropics (A) (review without modification shows no benefit)
- exercise programmes, with balance training (A)
- treatment of postural hypotension (B)
- appropriate treatment of medical conditions including visual problems, cardiovascular disorders and cardiac arrhythmias (B)
- reduction or withdrawal of psychotropic medication (B)
- modification of environmental hazards (C).

However:

- Staff education programmes and self-management programmes without measures to implement recommended changes are not effective in community-based settings (A).
- Multifactorial Fall Prevention Measures do not appear to work in those attending hospital after a fall with cognitive impairment (A).

- Alone, vision checks and modification (A) and home assessment and modification (A) will not prevent falls; they must be part of multifactorial interventions.
- Assistive devices alone will not prevent falls (C).

Hospital inpatients (3, 8, 103-105)

Although widely implemented, strategies for reducing falls among inpatients have not been assessed in RCTs.

- There is no grade A or B evidence to recommend for or against multifactorial interventions in acute hospital settings. There is no evidence to support the use of physical or pharmaceutical restraints or bed sides in the prevention of falls and there is evidence of worse injuries as a result of falls when restraints are used (B).
- Alternative strategies to restraints (lower bed, mats on floor, safe-transfer and exercise training, alarm devices, etc.) have proved beneficial (B).
- There is weak evidence to support hospital discharge risk assessment and planning for older people; appropriate referral to continued health care in their own home or residential care facilities may be necessary (C).
- Bed alarms appear promising, but identification bracelets do not appear effective at reducing falls in the hospital environment (D).

Residential care dwellers (58,59,82,98, 99, 106-109,110)

In long-term care and residential care settings assessment for risk and appropriate multifactorial interventions for all residents (including those with dementia and cognitive impairment) there is some evidence to support:

- vitamin D and calcium supplementation (A)
- gait training and advice on appropriate use of assistive devices (B)
- review and modification of medication, especially psychotropic medications (B)
- nutritional review and supplementation (B)
- staff education programmes (B) (contrary to community-based evidence)
- exercise programmes for those at high risk (B)
- environmental modification (B)
- post-fall problem-solving sessions (B)
- hip protectors (C).

Exercise (83,87,89-98, 102,107)

Specific exercise programmes work best within a multifactorial fall-prevention programme but there is evidence that they work alone as well.

- Group-based balance exercise is effective in lowering risk in selected groups (people who are at risk and frequent fallers) (A) if led by an appropriately qualified professional.
- Individually tailored home-based exercise programmes administered by qualified personnel reduce falls in women over 80 living in the community, are cost effective at reducing both falls and injurious falls, and the effect is sustainable over 2 years (A).
- Balance training, such as Tai Chi, can reduce falls in people with mild strength or balance deficits (A).
- Group exercise is the most important part of a multifactorial community-based programme considering exercise, vision and home hazards (A).
- Successful exercise programmes have consistently been longer than 10 weeks duration. Exercise needs to be specific (dynamic balance, strength, endurance and gait training), progressive and sustained to have continuing benefit (C).
- Strategies for coping on the floor after a fall can be practised safely in a group environment (C).

Home hazard assessment (3,9,10,99,103,111-114)

Reviews have reached contradictory conclusions regarding the evidence for the effectiveness of home hazard assessments.

- Home assessment and modification as part of a multifactorial programme can reduce falls in frail older people with a history of falls (A).
- Assessment and modification of the home on its own, although feasible and widely implemented, appears ineffective in reducing falls or fall injuries amongst older people (A).

Hip protectors (115-121)

Hip protectors are a device used to disperse the impact of a fall. The available evidence for hip protectors demonstrates that:

- Hip protectors can substantially reduce hip fractures in older people in a residential care setting and frail older people in long-stay facilities or supported by outpatient care units while living at home but compliance and adherence remains low (A).
- Hip protectors do not reduce the incidence of a second hip fracture in community-dwelling older people (A).
- Hip protectors do not appear to affect the risk of falling nor do they reduce injury to any other part of the body apart from the hip (B).
- Adherence to hip protector wear is improved by staff education (B).
- Investigation of osteoporosis risk and appropriate interventions is an important complementary strategy to reducing fall incidence (D).

Community-wide health promotion (122-124)

There is little direct evidence of the effectiveness of community-wide health promotion or education interventions for the prevention of accidents among older people, although there is some on risk factor reduction and quality of life (C), revealing the following:

- A community health programme reduced the rate of lower limb fractures in women but not in men (B).
- Recording falls, trips, slips and stumbles on a calendar appears to increase older people's awareness of environmental risks and reduces the rate of reported falling (B).
- Advice alone about fall risk factor modification (without measures to implement recommended changes) appears ineffective at reducing falls but does appear to improve self-efficacy scores, reduce fear of falling and improve attitudes towards falls (B).

Costs and prevention of falls

Falls create a large cost burden for both the public and private purse, regardless of how health and social care is funded. In 1999 falls cost the United Kingdom Exchequer £981 million (€1414 million) in National Health Service and Personal Social Service costs (125). These were not only direct costs of treatment and care, but also indirect costs of lost productivity from carers of those who fell and opportunity costs associated with use of resources which could otherwise have been effectively used in another way.

Few studies of the cost effectiveness of fall prevention strategies have been undertaken. Costs per person for a fall prevention programme can differ greatly. Based on evidence from New Zealand and Australia, the cost per fall prevented differs widely among programmes, from €80 to €880 per fall prevented by home-based exercise (96,97) to about €2700 per fall for home modification (126). For injury reduction, costs also differ widely for home based exercise, from €208 to €3654 (127) and home

modification costs were €9,500 per injury prevented. More work is needed to identify cost effective strategies in Europe (127).

Gaps in evidence and conflicting evidence

Although a great deal of research into risk factors and interventions to reduce falls has been done, there are still gaps in the evidence that need addressing (for reviews see references 2,3,9,14,38).

- No RCT has shown any fracture-reduction benefit of fall prevention, possibly because very large sample sizes are required.
- Work is needed to identify mechanisms to increase patient concordance with interventions (recruitment, uptake, acceptability, motivation, adherence) to reduce the risk of falls. There is limited knowledge concerning eastern and southern European populations and ethnic minorities.
- There is very limited research on the relationship between socioeconomic factors and fall risks and the relationship between such demographic variables and effectiveness of interventions remains unknown.
- There is a need to work more with older people on the presentation of information on risk factors and interventions to reduce falls.
- Few studies have assessed fall prevention in men or the relationship between ethnicity and the risk of having a fall or effectiveness of interventions in different ethnic groups.
- More investigation is needed to determine how falls and fractures can best be prevented in patients with cognitive impairment and dementia.
- Further research is required to understand the effects of transient risk factors such as orthostatic hypotension, dizziness and syncope and the effects of individualized interventions to reduce these factors.
- Research is required to identify the contribution of non-injurious falls and fear of falling to morbidity and particularly to functional dependence and institutionalization.
- Economic evaluation is needed to examine the long-term costs and consequences of risk reduction interventions in Europe in both younger and older old age, the cost effectiveness of dedicated teams with expertise in fall prevention and different systems of intervention (primary care, health promotion-based etc).

Generalizability

Cost effectiveness

Most large epidemiological studies and intervention trials have been undertaken in North America, Australia and New Zealand. Although smaller studies in European countries have revealed, for the most part, similar rates of falls and similar results with interventions, the benefits of the increased cost of assessment and intervention set against the cost and work load implications in European countries with different healthcare systems is unclear. Careful planning, resource mapping and perhaps some pilot work to assess cost/benefit may be necessary.

Cognitively impaired older people and those in residential care facilities

Randomized trials have studied a wide variety of older people – from very fit to very frail, with and without a history of falling – but their cognitive functioning is not often reported, nor evidence of concordance with the interventions. Most of the studies evaluating multifactorial interventions have been conducted in community settings and, in a number of cases, similar approaches in residential care settings have not been as successful. Multifactorial fall prevention measures do not appear to work in those attending hospital after a fall with cognitive impairment (101), but similar interventions in residential care facilities are effective (98, 107-109). It appears that interventions should not only be tailored to the individual but also to the particular setting. The culture and social structures across Europe differ widely and at present we have very limited understanding of the influence this may have in fall prevention.

Hip protectors

Hip protector effectiveness depends on the model, correct placement and adherence. Reduction in fracture rates has been shown with hip protector use in residential care facilities in Denmark, (121), England (118), Finland (115,119) and the Netherlands (120), but more research is needed in warmer climates to evaluate adherence. No specific research on the effectiveness of hip protectors in acute hospitals, nor in older people living in the community have been published, although they were part of a successful multifactorial intervention in a hospital environment (127). Work in the Netherlands and the United Kingdom suggests that many older people in the community are reluctant to wear hip protectors. Even among those who do try, adherence to the regimen of regular wear is very low (121). Adherence to wearing hip protectors in residential care facilities can be increased with staff training (110,112).

Emergency department guidelines

Practice guidelines in an emergency department did not alter documentation of fall risk factors or the implementation of practice guidelines (103). There were some recommendations covering staff responsibilities and education. The PROFET Trial (84) showed that clear roles and responsibilities and staff education allowing effective multifactorial assessment and referral into existing hospital and community-based services can effectively reduce falls.

Current debate on populations and strategic approaches

The strategic approach to falls and fracture prevention has three stages:

- Identification of high-risk groups of older people.
- Detailed assessment of high-risk older people to identify individual risk factors for falls or fractures.
- Intervention to reduce the identified risk factors (15,129).

Target populations

There is still considerable debate as to which groups (or individuals) to target with fall prevention strategies, and when and how quickly to intervene. Target populations include older people who seek medical attention for a fall, repeat fallers, older people discharged from hospital, those living in institutions or housebound, those experiencing gait or balance problems, and those with previous fragility fracture and risk factors for osteoporosis.

A lower limit for age of 70 years is normally proposed, since the risk of falling increases with age and most fall risk assessment tools and interventions have been evaluated in people over this age (16). Lower age limits might facilitate long-term reduction, but adherence would have to be higher than has been observed generally to date if interventions were to prove effective.

Which approach?

Several reviews (2,3,8,9,10,12,15,16,129) of fall-prevention strategies are, on the whole, consistent with each other and suggest two strategic approaches to fall prevention:

- An individual approach (high risk) prevents falls by identifying those most at risk of falling and directing them to appropriate programmes using a dedicated fall prevention service. Although this may be more expensive, it has the benefit of individualized risk assessment and appropriate referral and advice.
- A community approach (population shift) involves keeping streets and pavements clear and in good repair, making homes safer, educating older people on how to avoid risk in the home, encouraging physical activity and promoting awareness of risk factors for falls. Although this approach, if effective, is likely to reach the largest number of people and be the least expensive approach, it does not address individuals' risk factors and has no mechanism for ensuring an

appropriate implementation of the recommended intervention. However, there has not been a robust evaluation of such a population-based strategy.

Collection of data

The collection and dissemination of data is important in order to monitor and evaluate health programmes and permit targeting of resources. National data are fragmented and not always easy to compare. There are three major European Union projects (<http://www.cordis.lu/en/home.html>) aiming to review the current status of injury rates, injury recording and fall prevention. Participation in these programmes to encourage piloting of potential new strategies should be encouraged.

- EURORISC – European Review of Injury Surveillance and Control (ISC) – aims to develop a consensus statement of good practice on ISC and to recommend measures for its improvement over the next century.
- EHLASS – European Home and Leisure Accident Surveillance System – aims to collect data on home and leisure accidents with a view to promoting accident prevention, improving the safety of consumer products and informing and educating consumers, on national and local levels. Basic information is obtained from hospital emergency departments across the European Union, as well as from household surveys. Unfortunately no common EU-EHLASS report exists at this time, only a series of national reports (http://europa.eu.int/comm/health/ph_projects/Project_en.htm and <http://www.ecosa.org/csi/ecosa.nsf/news>).
- ProFaNE – Prevention of Falls Network Europe – comprises four work-packages: taxonomy and classification of falls, clinical assessment and management, assessment of balance function, and psychological aspects of falling. ProFaNE aims to disseminate good practice in taxonomy and clinical trial methodology as well as detailed clinical, assessment and management protocols for those at risk of falls. It also aims to identify how best to assess balance function and to develop psychological work across Europe in order to more fully understand the psychological consequences of falls, methods to reduce fear of falling and to increase adherence to fall prevention interventions. Ultimately the aim of the network is to undertake a multi-centre RCT of a multifactorial fall prevention intervention with peripheral fracture as the primary outcome. Details are available at www.profane.eu.org.

Successful multifactorial strategies

This section presents a non-exhaustive review of some multifactorial fall prevention strategies that have been implemented in countries around the world.

Australia

A prospective study of an intervention area, matched to a control area, the Stay on Your Feet (SOYF) Programme, showed that health promotion reduced the rate of fall-related hospitalization and increased awareness (123,130). The continuing health promotion intervention includes awareness raising, community education, policy development, home hazard reduction, media campaigns and working with health professionals. The programme addressed footwear, vision, physical activity, balance and gait, medication use, chronic conditions, and home and public environmental hazards. The programme targets 80 000 community-dwelling people 60 and over on the North Coast of New South Wales. A RCT ongoing in Australia suggests that a sustainable, low cost programme can be introduced through community-based organizations to reduce the incidence of slips, trips and falls in community-dwelling people over 50 during a one-year period. The prevention strategies included education and awareness-raising of fall risk factors, exercise sessions to improve strength and balance, home safety advice to modify environmental hazards and medical assessment to optimize health.

Denmark

A community health programme aimed at community-dwellers over 65 reduced the rate of lower limb fractures in women but not men (122). Written information was sent to all older people in the

intervention area and some had home visits and group meetings. It was estimated that 60% to 70% of older people were reached, using existing care staff.

Germany

In December 2002 the largest health care fund introduced fall prevention programmes to long-term care facilities in southern Germany, to be run and evaluated until 2005. This covers a long-term care population of more than 60 000. The council of physicians has also started a fall reduction campaign in the North-Rhine region with a population of 15 million. The programs include balance and strength exercise classes, education, advice on environmental hazards and support for the use of hip protectors for those in residential care facilities.

Norway

A prospective 8-year intervention study compared a municipality that underwent a community-based intervention with a municipality that did not (128). The intervention included the removal of environmental hazards in homes and promotion of safe outdoor footwear in winter. Rates of fracture from falls did not decline in residential care settings but decreased 26% in the community. There was also a 16.7% reduction in hospital admission rates of fall-fracture patients from the community, indicating a substantial saving in short-term hospital costs.

Sweden

The WHO safe community-based injury prevention programme has been evaluated in terms of impact on injury severity, health care utilization, the lasting effect of the programme (sustainability), and multi-agency working (131). Although there was no change in risk of severe or fatal injuries, there was a reduction in moderately severe injuries in the intervention area compared to the control area that was deemed cost-effective (132).

Switzerland

The Swiss Federal Injury Prevention Agency started a national campaign to reduce fall-related injuries in 2000, beginning with an epidemiological survey. Thereafter, in 2002 and 2003, long-term care facilities were the main focus. From 2004 onwards, home-dwelling elderly will also be part of the target group. The campaign strongly supports the use of hip protectors, and also exercise and environmental adaptations as part of a multifactorial approach.

United Kingdom

A strategy with deadlines for implementation of fall injury reduction services has been presented as part of a framework of practice covering medical procedures for all older adults (133; www.doh.gov.uk/nsf/olderpeople.htm), the National Service Framework for Older People (Standard 6: Falls). There are supporting documents on implementation of a fall and fracture prevention strategy within a primary health care setting (www.ukc.ac.uk/CHSS/abstracts/falls.htm). There is currently fragmented service evaluation of the implementation of these guidelines and some services have shown reductions in risk factors in patients undergoing assessment and intervention (mostly uncontrolled trials). An interactive training programme exists for geriatricians and other medical staff assessing fallers ("Off His Legs" – www.medicaleducation.co.uk). Guidelines on implementing community based exercise and physical activity interventions to prevent falls amongst a wide population range (age and functional capacity) have also been published (134). A national qualification, for Physiotherapists and Advanced Exercise Instructors, exists to ensure safe but effective rehabilitation and community based fall prevention exercise groups (www.laterlifetraining.co.uk).

Recent guidelines and health service frameworks

United Kingdom and United States

Recently updated joint guidelines (135) by the American and British Geriatrics Societies (AGS, BGS) for fall prevention have been published (3), and include a review of current evidence. The central recommendations are:

- All older people under the care of a health professional should be asked about occurrence of falls at least once a year.
- All older people who report a single fall should be observed performing the “get up and go” test – any unsteadiness should lead to further fall risk assessment.
- All older people who report recurrent falls should be referred for a fall risk assessment performed by a clinician with appropriate skills and experience, which may necessitate referral to a geriatrician or other specialist.
- A falls evaluation / assessment should include:
 - a history of falls circumstances
 - clinical assessment and review (individual risk)
 - identification of acute or chronic medical conditions (including cardiovascular review) and medication review
 - physical conditioning and/or a history of rehabilitation or exercise programmes
 - education: health professional and patient/ resident
 - sensory evaluation (vision, neurological, lower limb sensation)
 - environmental assessment and modification
 - an assistive device/walking aid review
 - continence management.

Australia

Best practice guidelines, produced as part of Queensland Health’s Quality Improvement and Enhancement Program for Public Hospitals and Residential Care Settings are being successfully implemented through a comprehensive education programme for older people and all those working with older people who fall. There are risk assessment and patient education tools as well as specific strategies for identifying and working with older fallers with dementia. The internet, CDs, literature and leaflets are used (fallsprevention@health.qld.gov.au and www.safetyandquality.org). The Falls Risk Assessment and Management System (FRAMS) has been implemented via the internet. This prototype system attempts to help clinicians identify and prevent falls in patients at risk. The fall prevention information can also be accessed using a pre-defined application program interface specification over an internet connection. This provides software developers with an open platform to incorporate decision support for fall prevention within their clinical software (see <http://www.falls.unimelb.edu.au>).

Conditions to support successful strategies

The following section is intended to be a guide to fall intervention programme organizers, and is based on the opinions of the authors and supporting documentation (27,129,133).

It appears that for fall prevention strategies to be effective, injury prevention should not be undertaken in isolation, but in partnership with other interventions and integrated into major (generic) health promotion programmes aimed at older people. However, effective integration can only be achieved if the wider health impact of specific-injury prevention is recognized at the outset. Injury prevention needs to be developed alongside wider strategic plans, both as a subject in its own right and as an important component of public health programmes such as heart disease prevention, for example, through exercise programmes that can also prevent falls; as a reinforcement to smoking, alcohol and drug abuse programmes, insofar as those substances are contributory to accidents; or as adjunct to plans for the disabled, by showing how to prevent disability from the outset.

The diverse responsibilities of the professionals and agencies working with older people who have fallen need to be clearly defined (Table 2). The skills of geriatricians and physiotherapists with specialist interests in people with a history of falls are paramount to successful individualized fall-prevention programmes. Since exercise is a key part of a multifactorial fall intervention, seniors exercise instructors are crucial to the success of community intervention programmes and long-term prevention of falls. However, with the safety concerns facing practitioners working with fallers,

evidence-based specialized training is needed to ensure safe and effective practice. The following recommendations are based on the report of the United Kingdom Department of Health Accidental Injury Task Force's Working Group on older people (129).

Table 2. Roles and responsibilities of those working with people who have fallen (129)

Geriatricians (rheumatologists, orthopaedic surgeons, emergency department doctors)
<ul style="list-style-type: none">• individualize programmes in rehabilitation and outpatient packages• review ward (hospital) environment• identify reversible contributory factors and suggest evidence-based interventions• investigate risk of osteoporosis and treat as necessary• consider encouraging patients to use hip protectors.
Emergency department medical staff
<ul style="list-style-type: none">• assess main risk factors and implement appropriate referral and advice• arrange follow up of older patients seen because of fall and refer to a specialized outpatient hospital based falls service, if available.
Health authorities
<ul style="list-style-type: none">• implement fall-risk assessment for all older patients being admitted to hospital• devise a protocol for reviewing reversible risk factors for high-risk individuals• initiate prompt questions in any data collection practices• establish a specialized outpatient hospital-based fall service• support the role of the physiotherapy services rehabilitation of fallers• consider falls and fracture prevention as a joint strategy.
Primary health care teams
<ul style="list-style-type: none">• include individualized risk assessment in care package for frail older people• encourage patients to be physically active• review medications and physical activity of at risk residents of care facilities• investigate the risk of osteoporosis and treat as necessary.
Voluntary organizations (NGOs) providing services for older people
<ul style="list-style-type: none">• include Tai Chi in the activities offered• promote leisure activities involving movement.
Managers and staff of residential care facilities for older people
<ul style="list-style-type: none">• organize exercise sessions or physical activity options for residents• review the home environment for safety• assess residents after falls for reversible risk factors• encourage residents to use hip protectors.
Sports and physical activity departments /centres
<ul style="list-style-type: none">• make Tai Chi sessions and other appropriate activities available in community settings• train specialized exercise instructors in effective fall prevention exercise• promote leisure activities involving movement.
Central government
<ul style="list-style-type: none">• prioritize fall prevention in national targets for injury prevention• prioritize fall and fracture prevention in health provision for older people• prioritize health promotion information and policy on physical activity among older people• advocate the inclusion of injury-prevention issues in pre-retirement courses• support nationally recognized training in delivery of appropriate forms of physical activity.

Getting started

Aside from older people themselves and NGOs, all relevant health and social care professionals need to be educated and included, to ensure successful implementation of prevention programmes based around multi-agency, multiple risk-factor assessment and multifactorial intervention.

There needs to be continuing communication with each of the relevant groups and professionals, enhanced by multi-agency meetings and working groups. There is a need to develop local strategies based on current, ideally country-based, guidelines for fall prevention. Sufficient resources to implement sustainable cost-effective strategies are necessary.

Facilitating change

A professional facilitator can identify gaps in services as well as facilitate development to fill those gaps, and get agreement on roles, referral triggers, eligibility for referral and distribution of patient loads. Nurses, occupational therapists, physiotherapists and health promotion specialists are relevant professional backgrounds for the facilitating role, but training is needed to enhance effective practice.

Assessment and referral

In all settings, clear lines of responsibility, clear policies aimed at managing falls, procedures for all professional groups involved and a referral network need to be agreed with all relevant professionals. This will involve changes in behaviour of clinicians and social care staff.

In some settings (primary care, hospital clinics and wards), prompts for screening could be triggered by input of key information into computer systems to improve the screening rates of those most at risk; for example, typing "fall" as part of the reason for attendance at an emergency department would trigger a screening procedure. There will need to be a commitment from hospital and primary care management to support enhancement of geriatric services to cope with the increased referrals thus generated. Integrated care pathways may help breach the gap between organizations and professions dealing with older people at risk of falling and provide a standardized approach to care.

Conclusions

Falls and their subsequent outcomes are likely to remain a major health care cost for all European countries for the foreseeable future. Public and private health and social agencies need to work with non-governmental organizations and other community and statutory organizations to provide effective services if this major issue for older people is to be addressed.

There are still some gaps in knowledge and questions about generalizability of interventions across cultures, countries and settings. However, the central message from the papers considered in this review is that targeted multifactorial interventions are more effective than interventions aiming to change one risk factor alone. Strategies aiming to reduce overall population risk may be inexpensive, but targeting those at higher risk appears to be more effective; these approaches need to be developed in tandem. Known effective interventions include targeted balance and strength exercise, home hazard modification in those with a history of falling and evaluation of polypharmacy and psychotropic medications. Restraints are ineffective and can cause more serious injury. More work is needed to identify effective interventions in those with cognitive impairment.

In the United Kingdom, a framework for the prevention of falls and fractures in community health programmes has been published (16) as well as guidance on successful implementation of community-based physical activity interventions (134). Lord et al. (14) give good guidance on an integrated approach to preventing falls and injuries in hospitals and care facilities, and the American and British Geriatrics Societies guidelines for clinical practice (3,135) also give clear outlines of the assessment and management procedures. Health care providers can use the general principles and recommendations in these documents as a framework in their own health care settings, with their available resources.

References

1. Kellogg International Working Group. The prevention of falls in later life. *Danish medical bulletin*, 1987, 34,4:1-24.
2. Tinetti ME. Clinical practice. Preventing falls in elderly persons. *New England journal of medicine*, 2003, 348:42-49.
3. American Geriatrics Society, British Geriatrics Society and American Academy of Orthopaedic Surgeons Panel on Falls Prevention. Guidelines for the prevention of falls in older persons. *Journal of the American Geriatrics Society*, 2001, 49:664-672.
4. Grimley-Evans J, Seagroatt V, Goldacre MJ. Secular trends in proximal femoral fracture: Oxford record linkage study area and England 1968-1986. *Journal of epidemiology and community health*, 1997, 51:424-429.
5. Kannus P et al. Fall-induced injuries and deaths among older adults. *Journal of the American Medical Association*, 1999, 281 (20):1895-1899.
6. Graham HJ, Firth J. Home accidents in older people: role of primary health care team. *BMJ*, 1992, 305:30-32.
7. Oliver D, Hopper A, Seed P. Do hospital fall prevention programs work? A systematic review. *Journal of the American Geriatrics Society*, 1992, 48:1679-1689.
8. Shekelle P et al. Falls prevention interventions in the Medicare population. RAND evidence report and evidence based recommendations. Baltimore, United States Department of Health, 2003.
9. Gillespie LD et al. Interventions to reduce the incidence of falling in the elderly. Musculoskeletal injuries module of the Cochrane Database of Systematic Reviews. Issue 3, 2003.
10. Van Haastregt JCM et al. Effects of preventive home visits to elderly people living in the community: Systematic review. *BMJ*, 2000, 320:754-758.
11. Gardner MM, Robertson MC, Campbell AJ. Exercise in preventing falls and fall-related injuries in older people: a review of randomized controlled trials. *British journal of sports medicine*. 2000, 34:7-17.
12. Feder G et al. Guidelines for the prevention of falls in older people. *BMJ*, 2000, 321:1007-1011.
13. Gregg EW, Pereira MA, Caspersen CJ. Physical activity, falls and fractures among older adults: a review of the epidemiologic evidence. *Journal of the American Geriatrics Society*, 2000, 48:883-93.
14. Lord SR, Sherrington C, Menz HB. Falls in older people: risk factors and strategies for prevention. Cambridge University Press, 2000.
15. Cryer C, Patel S. A framework for a health improvement programme for the prevention of falls and osteoporotic fractures. A report to Proctor and Gamble. Kent, 2002.
16. Moreland J et al. Evidence-based guidelines for the secondary prevention of falls in older adults. *Gerontology*. 2003, 49(2):93-116.
17. Vetter NJ, Lewis PA, Ford D. Can health visitors prevent fractures in elderly people? *BMJ*, 2002, 304:888-890.
18. Kessler KM. The CONSORT statement: explanation and elaboration. Consolidated standards of reporting trials. *Annals of internal medicine*, 2002, 136:926-936.
19. Roy DK et al. Falls explain between-centre differences in the incidence of limb fracture across Europe. *Journal of bone and mineral research*, 2002, 31,6:712-717.
20. O'Loughlin J et al. Incidence of and risk factors for falls and injurious falls among the community-dwelling elderly. *American journal of epidemiology*, 1993, 137:342-54.
21. Halter M et al. Falls in the older population: a pilot study to assess those individuals who are attended to by the London Ambulance Service as a result of a fall but are not conveyed to an accident and emergency department. London Ambulance Service NHS Trust, 2000.
22. Tinetti ME, Speechley M. Prevention of falls among the elderly. *New England journal of medicine*, 1989, 320:1055-1059.
23. Freeman C et al. Quality improvement for people with hip fracture: experience from a multi-site audit. *Quality and safety in health care*, 2002, 11:239-245.

24. Berg WP et al. Circumstances and consequences of falls in independent community-dwelling older adults. *Age and ageing*, 1997, 26:261-268.
25. Tinetti M, Speechley M, Ginter S. Risk factors for falls among elderly persons living in the community. *New England journal of medicine*, 1988, 319:1701-1707.
26. Lord SR, McLean D, Strathers G. Physiological factors associated with injurious falls in older people living in the community. *Gerontology*, 1992, 38:338-346.
27. Cryer C. Reducing unintentional injuries in older people in England: goals and objectives for the period 1998-2010. Report to the Department of Health: London, 1998.
28. World Health Organization. *Assessment of fracture risk and its application to screening for postmenopausal osteoporosis*. Technical report series 843. Geneva, 1994.
29. Rubenstein LZ, Josephson KR, Robbins AS. Falls in the nursing home. *Annals of internal medicine*, 1994, 121:442-451.
30. Salkeld G et al. Quality of life related to fear of falling and hip fracture in older women: a time trade off study. *BMJ*, 2000, 320:341-346.
31. Thapa PB et al. Psychotropic drugs and risk of recurrent falls in ambulatory nursing home residents. *American journal of epidemiology*, 1995, 142:202-211.
32. Friedman SM et al. Increased fall rates in nursing home residents after relocation to a new facility. *Journal of the American Geriatrics Society*, 1995, 43:1237-1242.
33. Tinetti ME. Factors associated with serious injury during falls by ambulatory nursing home residents. *Journal of the American Geriatrics Society*, 1987, 35:644-648.
34. Nevitt M et al. Risk factors for recurrent non syncopal falls. *Journal of the American Medical Association*, 1989, 261:2663-2668.
35. Cali CM, Kiel DP. An epidemiologic study of fall-related fractures among institutionalized older people. *Journal of the American Geriatrics Society*, 1995, 43:1336-1340.
36. Butler M et al. The risks of hip fracture in older people from private homes and institutions. *Age and ageing*, 1996, 25:381-385.
37. Age Concern. Looking for a fall. A report on falls incidence in the UK. London, 1997.
38. Tinetti M et al. Fear of falling and fall-related efficacy in relationship to functioning among community-living elders. *Journal of gerontology*, 1994, 49:M140-M147.
39. Campbell AJ, Spears GF, Borrie MJ. Examination by logistic regression modelling of the variables which increase the relative risk of elderly women falling compared to elderly men. *Journal of clinical epidemiology*, 1990, 43:1415-1420.
40. Robbins AS et al. Predictors of falls among elderly people. Results of two population-based studies. *Archives of internal medicine*, 1989, 149:1628-1633.
41. Wickham C et al. Muscle strength, activity, housing and the risk of falls in elderly people. *Age and ageing*, 1989, 18:47-51.
42. Friedman SM et al. Falls and fear of falling: which comes first? A longitudinal prediction model suggests strategies for primary and secondary prevention. *Journal of the American Geriatrics Society*, 2002, 50, 8:1329-1335.
43. Ray W, Thapa P, Gideon P. Benzodiazepines and the risk of falls in nursing home residents. *Journal of the American Geriatrics Society*, 2000, 48:682-685.
44. Leipzig RM, Cumming RG, Tinetti ME. Drugs and falls in older people: a systematic review and meta-analysis: I. Psychotropic drugs. *Journal of the American Geriatrics Society*, 1999, 47:30-39.
45. Campbell A, Borrie M, Spears G. Risk factors for falls in a community-based prospective study of people 70 years and older. *Journal of gerontology*, 1989, 44:M112-117.
46. Lawlor DA, Patel R, Ebrahim S. Association between falls in elderly women and chronic diseases and drug use: cross-sectional study. *BMJ*. 2003, 327:712-717.
47. Koski K et al. Physiological factors and medications as predictors of injurious falls by elderly people: a prospective population-based study. *Age and ageing*, 1996, 25:29-38.
48. Koski K et al. Risk factors for major injurious falls among the home-dwelling elderly by functional abilities. *Gerontology*, 1998, 44:232-238.
49. Tinetti M et al. Risk factors for serious injury during falls by older persons in the community. *Journal of the American Geriatrics Society*, 1996, 43:1214-1221.

50. Luukinen H et al. Predictors for recurrent falls among the home-dwelling elderly. *Scandinavian journal of primary health care*, 1995, 13:294-299.
51. Skelton DA. Effects of physical activity on postural stability. *Age and ageing*, 2001, 30, S4:33-39.
52. Whipple RH, Wolfson LI, Amerman PM. The relationship of knee and ankle weakness to falls in nursing home residents: an isokinetic study. *Journal of the American Geriatrics Society*, 1987, 35:13-20.
53. Skelton DA, Kennedy J, Rutherford OM. Lower limb muscle strength and power in community dwelling female fallers and non-fallers aged over 65. *Journal of physiology*, 2001, 531:48.
54. Graafmans W et al. Falls in the elderly: a prospective study of risk factors and risk profiles. *American journal of epidemiology*, 2001, 143:1129-1136.
55. Arfken CL et al. The prevalence and correlates of fear of falling in elderly persons living in the community. *American journal of public health*, 1994, 84:565-556.
56. Maki BE, Holliday PJ, Topper AK. Fear of falling and postural performance in the elderly. *Journal of gerontology*, 1991, 46:M123-131.
57. Maki B. Gait changes in older adults: predictors of falls or indicators of fear? *Journal of the American Geriatrics Society*, 1997,45:313-320.
58. Larsson F. Effect of dietary supplementation on nutritional status and clinical outcome in 501 geriatric patients: a randomized study. *Clinical nutrition*, 1990, 9:179-184.
59. Meunier P. Prevention of hip fractures by correcting calcium and vitamin D insufficiencies in elderly people. *Scandinavian journal of rheumatology*, 1996, 25:75-78.
60. Folstein MF, Folstein SE, McHugh PR. "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. *Journal of psychiatric research*, 1975 12:189-198.
61. Van Schoor NM et al. Different cognitive functions in relation to falls among older persons. Immediate memory as an independent risk factor for falls. *Journal of clinical epidemiology*, 2002, 55:855-862.
62. Van Doorn C et al. Dementia as a risk factor for falls and injuries among nursing home residents. *Journal of the American Geriatrics Society*, 2003, 51, 9:1213-1218.
63. Jack CI et al. Prevalence of low vision in elderly patients admitted to an acute geriatric unit in Liverpool: elderly people who fall are more likely to have low vision. *Gerontology*, 1995, 41:280-285.
64. Ivers RQ et al. Visual impairment and falls in older adults: the Blue Mountains Eye Study. *Journal of the American Geriatrics Society*, 1998, 46:58-64.
65. Lord SR, Dayhew J, Howland A. Multifocal glasses impair edge-contrast sensitivity and depth perception and increase the risk of falls in older people. *Journal of the American Geriatrics Society*, 2002, 50, 11:1760-1766.
66. Lord SR, Bashford GM. Shoe characteristics and balance in older women. *Journal of the American Geriatrics Society*, 1996, 44:429-433.
67. Dean E, Ross J. Relationships among cane fitting, function, and falls. *Physical therapy*, 1993, 73:494-504.
68. Graafmans WC et al. Daily physical activity and the use of a walking aid in relation to falls in elderly people in a residential care setting. *Zeitschrift fur gerontology*, 1993, 36, 1:23-28.
69. Ebrahim S et al. Randomized placebo-controlled trial of brisk walking in the prevention of post-menopausal osteoporosis. *Age and ageing*, 1997, 26:253-260.
70. Tinetti M. Performance-orientated assessment of mobility problems in elderly patients. *Journal of the American Geriatrics Society*, 1986, 34:119-126.
71. Lord SR et al. Differing risk factors for falls in nursing home and intermediate-care residents who can and cannot stand unaided. *Journal of the American Geriatrics Society*, 2003, 51, 11:1645-1650.
72. Oliver D et al. Development and evaluation of evidence based risk assessment tool (STRATIFY) to predict which elderly inpatients will fall: case-control and cohort studies. *BMJ*, 1997, 315:1049-1053.
73. Close JCT et al. Predictors of falls in a high risk population - Results from the prevention of falls in the elderly trial (PROFET). *Emergency medicine journal*, 2003, 20,5:421-425.

74. Nandy S et al. Development and preliminary examination of the predictive validity of the Falls Risk Assessment Tool (FRAT) for use in primary care. *Journal of public health and medicine*, forthcoming.
75. Tromp AM et al. Fall-risk screening test: a prospective study on predictors for falls in community dwelling elderly. *Journal of clinical epidemiology*, 2001, 54:837-844.
76. Raiche M et al. Screening older adults at risk of falling with the Tinetti balance scale. *Lancet*, 2001, 356:1001-1002.
77. Berg KO, Wood-Dauphinee SL, Williams JL. Measuring balance in the elderly: validation of an instrument. *Canadian journal of public health*, 1992, 83, supplement 2:S7-11.
78. Podsiadlo DA, Richardson S. The timed up and go: a test of basic functional mobility for frail elder persons. *Journal of the American Geriatrics Society*, 1991, 39:142-148.
79. Lundin-Olsson L, Nyberg L, Gustafson Y. The mobility interaction fall chart. *Physiotherapy research international*, 2000, 5:190-201.
80. Lundin-Olsson L et al. Predicting falls in residential care by a risk assessment tool, staff judgement, and history of falls. *Aging clinical and experimental research*, 2003, 15:51-59.
81. Stel VS et al. A classification tree for predicting recurrent falling in community-dwelling older persons. *Journal of the American Geriatrics Society*, 2003, 51, 10:1356-1364.
82. Centre for Clinical Effectiveness. Effectiveness of fall prevention strategies for older patients in institutionalized settings, Southern Health Care Network/Monash Institute of Public Health & Health Services Research, Clayton, 2000. www.med.monash.edu.au/publichealth/cce.
83. Campbell AJ et al. Psychotropic medication withdrawal and a home-based exercise program to prevent falls: a randomized controlled trial. *Journal of the American Geriatrics Society*, 1999, 47:850-853.
84. Close J et al. Prevention of falls in the elderly trial (PROFET): a randomized controlled trial. *Lancet*, 1999, 353:93-97.
85. Coleman EA et al. Chronic care clinics: a randomized controlled trial of a new model of primary care for frail older adults. *Journal of the American Geriatrics Society*, 1999, 47:775-783.
86. Kenny RA et al. Carotid sinus syndrome: a modifiable risk factor for non-accidental falls in older adults (SAFE PACE). *Journal of the American College of Cardiology*, 1999, 38, 5:1491-1496.
87. Day L et al. Randomized factorial trial of falls prevention among older people living in their own homes. *BMJ*, 2002, 325:128-132.
88. Nikolaus T, Bach M. Preventing falls in community-dwelling frail older people using a home intervention team (HIT): results from the randomized falls-HIT trial. *Journal of the American Geriatrics Society*, 2003, 51, 3:300-305.
89. Province MA. et al. The effects of exercise on falls in elderly patients. A preplanned meta-analysis of the FICSIT Trials. *Journal of the American Medical Association*, 1995, 273:1341-1347.
90. Wolf SL et al. Reducing frailty and falls in older persons: an investigation of Tai Chi and computerized balance training. Atlanta FICSIT Group. *Journal of the American Geriatrics Society*, 1996, 44:489-497.
91. Wolf SL et al. Intense Tai Chi exercise training and fall occurrences in older, transitionally frail adults: a randomized, controlled trial. *Journal of the American Geriatrics Society*, 2003, 51,12:1693-1701.
92. Lord SR et al. The effect of group exercise on physical functioning and falls in frail older people living in retirement villages: a randomized, controlled trial. *Journal of the American Geriatrics Society*, 2003, 51,12:1685-92.
93. Barnett A et al. Community-based group exercise improves balance and reduces falls in at-risk older people: a randomized controlled trial. *Age and ageing*, 2003, 32:407-414.
94. Skelton DA, Dinan SM. Exercise for falls management: rationale for an exercise programme aimed at reducing postural instability. *Physiological theory and practice*, 1999, 15,2:105-120.
95. Skelton DA et al. FaME (Falls Management Exercise): an RCT on the effects of a nine month group exercise programme in frequently falling community dwelling women aged 65 and over. Abstract presented to EU Working Party on Effective Falls Prevention. Brussels, 2003.

96. Robertson MC et al. Effectiveness and economic evaluation of a nurse delivered home exercise programme to prevent falls. 1: Randomized controlled trial. *BMJ*, 2001, 322:697-701.
97. Robertson MC et al. Effectiveness and economic evaluation of a nurse delivered home exercise programme to prevent falls. 2: Controlled trial in multiple centres. *BMJ*, 2001, 322:701-704.
98. Becker C et al. Effectiveness of a multifaceted intervention on falls in nursing home residents. *Journal of the American Geriatrics Society*, 2003, 51,3:306-313.
99. Bischoff HA et al. Effects of vitamin D and calcium supplementation on falls: a randomized controlled trial. *Journal of bone and mineral research*. 2003, 18:343-351.
100. Parry SW et al. Diagnosis of carotid sinus hypersensitivity in older adults: carotid sinus massage in the upright position is essential. *Heart*, 2000, 83:22-23.
101. Shaw FE et al. Multifactorial intervention after a fall in older people with cognitive impairment and dementia presenting to the accident and emergency department: randomized controlled trial. *BMJ*, 2002, 326:73.
102. Ray WA et al. A randomized trial of a consultation service to reduce falls in nursing homes. *Journal of the American Medical Association*, 1997, 278:557-562.
103. Baraff LJ et al. Effect of a practice guideline for emergency department care of falls in elder patients on subsequent falls and hospitalizations for injuries. *Academic emergency medicine*, 1999, 6:1224-1231.
104. Tideiksaar R, Feiner CF, Maby J. Falls prevention: the efficacy of a bed alarm system in an acute care setting. *Mount Sinai journal of medicine*, 1993, 60:522-527.
105. Mayo NE, Gloutney L, Levy AR. A randomized trial of identification bracelets to prevent falls among patients in a rehabilitation hospital. *Archives of physical medicine and rehabilitation*, 1994, 74:1302-1308.
106. Rubenstein LZ et al. The value of assessing falls in an elderly population. *Annals of internal medicine*, 1990, 113:308-316.
107. Hauer K et al. Exercise training for rehabilitation and secondary prevention of falls in geriatric patients with a history of injurious falls. *Journal of the American Geriatrics Society*, 2001, 49:10-20.
108. Jensen J et al. Fall and injury prevention in older people living in residential care facilities. A cluster randomized trial. *Annals of internal medicine*, 2002, 136:733-741.
109. Jensen J et al. Fall and injury prevention in residential care; effects in residents with higher and lower levels of cognition. *Journal of the American Geriatrics Society*, 2003, 51:627-635.
110. Meyer G et al. Effect on hip fractures of increased use of hip protectors in nursing homes: cluster randomized controlled trial. *BMJ*, 2003, 326:76.
111. Cumming RG et al. Home visits by an occupational therapist for assessment and modification of environmental hazards: a randomized trial of falls prevention. *Journal of the American Geriatrics Society*, 1999, 47:1397-1402.
112. Tracey M. Will elderly rest home residents wear hip protectors? *Age and ageing*, 1998, 27:195-198.
113. Van Haastregt JCM et al. Effects of a programme of multifactorial home visits on falls and mobility impairments in elderly people at risk: randomized controlled trial. *BMJ*, 2000, 321:994-998.
114. Brandis S. A collaborative occupational therapy and nursing approach to falls prevention in hospital in-patients. *Journal of quality in clinical practice*, 1999, 19:215-220.
115. Kannus P et al. Prevention of hip fracture in elderly people with use of a hip protector. *New England journal of medicine*, 2000, 343:1506-1513.
116. Parker MJ, Gillespie LD, Gillespie WJ. Hip protectors for preventing hip fractures in the elderly. *The Cochrane Library*, Issue 4. Oxford: Update Software, 2000.
117. Parkkari J, Heikkilä J, Kannus P. Acceptability and compliance with wearing energy-shunting hip protectors. *Age and ageing*, 1998, 27:225-229.
118. Birks YF et al. Randomized controlled trial of hip protectors for the prevention of second hip fractures. *Age and ageing*, 2003, 32:442-444.
119. Jantti P et al. Hip protectors and hip fractures. Letters to the Editor. *Age and ageing*, 2000, 29:758-759.

120. Van Schoor NM et al. The Amsterdam hip protector study: compliance and determinants of compliance. *Osteoporos international*, 2003, 14:353-359.
121. Lauritzen JB, Petersen MM, Lund B. Effect of external hip protectors on hip fractures. *Lancet*, 1993, 341:11-13.
122. Poulstrup A, Jeune B. Prevention of fall injuries requiring hospital treatment among community-dwelling elderly. *European journal of public health*, 2000, 10:45-50.
123. Steinberg M et al. a sustainable programme to prevent falls and near falls in community dwelling older people: results of a randomized trial. *Journal of epidemiology and community health*, 2000, 54:227-232.
124. Tennstedt S et al. A randomized, controlled trial of a group intervention to reduce fear of falling and associated activity restriction in older adults. *Journals of gerontology. Series B, psychological sciences and social sciences*, 53B:P384-P392.
125. Scuffham P, Chaplin S, Legood R. Incidence and costs of unintentional falls in older people in the United Kingdom. *Journal of epidemiology and community health*, 2003, 57:740-744
126. Salkeld G et al. The cost effectiveness of a home hazard reduction program to reduce falls among older persons. *Australian and New Zealand journal of public health*, 2000, 24:265-271.
127. Smith RD, Fordham RJ. Economics of fall prevention programs: evidence and research priorities. *Pharmacoeconomics and outcomes research*, 2001, 1:59-67.
128. Ytterstad B. The Harstad injury prevention study: community based prevention of fall-fractures in the elderly evaluated by means of a hospital based injury recording system in Norway. *Journal of epidemiology and community health*, 50:112.
129. Cryer C. Accidental Injury Task Force's working group on older people (UK): priorities for prevention. London, 2001. (www.doh.gov.uk/accidents/pdfs/olderpeople.pdf).
130. Kempton A et al. Older people can stay on their feet: final results of a community-based falls prevention programme. *Health promotion international*, 2000, 15:27-33.
131. Lindqvist K, Timpka T, Schelp I. Evaluation of an inter-organizational prevention program against injuries among the elderly in a WHO safe community. *Public health*, 2001, 115:308-316.
132. Lindqvist K, Lindholm L. A cost-benefit analysis of the community-based injury prevention programme in Motala, Sweden, a WHO safe community. *Public health*, 2001, 115:317-322.
133. Department of Health. National service framework for older people: modern standards and service models. London, Her Majesty's Stationary Office, 2001.
134. Simey P, Pennington B. Physical activity in the prevention of hand fractures. London, Health Education Authority, 1999.
135. Rubenstein LZ et al. Preventing falls in older people: new advances and the development of clinical practice guidelines. *Journal of the Royal College of Physicians of Edinburgh*, 2003, 33:262-272.

Acknowledgements

The authors wish to thank Dr Colin Cryer for his help and permission to reproduce aspects of his work. We also wish to thank our partners in ProFaNE – www.profane.eu.org - Dr Jacqueline Close, Dr Clemens Becker, Prof Sallie Lamb, Dr Wiebren Zijlstra, Prof Lucy Yardley as well as Dr Ruud Kemper for their comments on an earlier draft of this synthesis.

Glossary

community dwelling older people – older people living independently in their own homes or in a communal setting without health care facilities

emergency department - casualty department or accident and emergency department, emergency room– the first point of entry into the hospital after a fall

geriatrician – a doctor specializing in medicine for older people

multifactorial - strategies using several interventions together

primary care physician – a family doctor (general practitioner) based in a community primary health care setting

proprioception – the ability to sense the position and location and orientation and movement of the body and its parts

residential care setting – an institutional dwelling where older people have specialist health care professionals available at all times