The George Institute for Global Health

WHO Collaborating Centre for Injury Prevention and Trauma Care

UNSW SYDNEY

Synthesis of evidence to inform a technical package on falls prevention and management

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Synthesis Context and Purpose

Falls: a global problem

A fall is an event which results in a person coming to rest inadvertently on the ground, floor, or other lower level (World Health Organization 2018). Falls are the second leading cause of unintentional injury globally, with more than 646,000 individuals dying from falls each year (World Health Organization 2018). An estimated 172 million falls each year result in short- or long-term disability (Stanaway 2018).

Approximately 82% of fall-related deaths occur among people in low and middle income countries (LMICs) (World Health Organization 2018). Inequalities in standards of housing, workplace safety and access to safe products also contribute to elevated falls risk among those of lower socio-economic status (SES) in high income countries (HIC). Limited access to surgical care and rehabilitation services for people of low SES compound the burden of falls for the majority of the world's population. The challenge to redress these health inequities is further hampered by limited research for many types of falls and groups at risk, particularly in LMICs. As with many other public health issues, policy makers and practitioners in LMICs have few researchers, research institutions and health surveillance systems; subsequently there is a huge gap in evidence about the burden and risk factors for falls and the effectiveness of globally recognised falls prevention and management interventions (Norton, Hoe et al. 2017).

Globally, there was a 43% increase in the number of total deaths due to falls from 2000 to 2016, despite only a 0.9% increase in deaths due to all injuries combined during the same period (World Health Organization, 2018a).The financial burden of falls to individuals and nations are set to rise dramatically in the decades ahead if the problem is not comprehensively and strategically addressed. There are numerous drivers of the burden of falls at a global level. One key driver of this burgeoning public health problem is the aging population, as the highest rate of deaths due to falls is among people aged over 60 years (World Health Organization 2018). Another driving factor is the world's growing population, which means the proportion of people living in urban areas and in multi-storey buildings is increasing. As a result, there are many more people in the construction industry working at heights (Al-Thani, El-Menyar et al. 2015), and more people are living in high-rise apartments, which places young children at an elevated risk of serious falls (Spiegel and Lindaman 1977).

However, there is growing evidence and awareness that many falls are preventable (World Health Organization 2007, Gillespie, Robertson et al. 2012, Rimland, Abraha et al. 2016, Cameron, Dyer et al. 2018). Falls prevention efforts can be led and assisted by communities, individuals, employees, employers, institutions, governments, and international collaborations. These efforts are especially paramount given the increasing trend in fall risk and burden.

The genesis and purpose of this synthesis

This Evidence Synthesis was commissioned by the World Health Organization (WHO) to guide the development of a technical package for falls prevention and management. The technical package intends to provide an evidence informed guide on the prevention and management of falls, primarily for use by practitioners and program managers, along with policy makers and other decision makers involved in falls prevention and management or whose portfolios might affect fall outcomes. The concept, purpose and scope of the planned technical package were devised at a WHO Expert Consultation on Falls Prevention and Management in Geneva in June 2016.

The George Institute for Global Health, a designated WHO Collaborating Centre for Injury Prevention and Trauma Care, and the School of Population Health UNSW, Sydney, were commissioned to provide an overview of the available global literature from low, middle, and high-income countries. This report describes the available evidence on falls prevention and management in five requested population groups, each of which face unique fall risk factors and are the target of a variety of falls prevention approaches:

- children and adolescents
- people in occupational settings
- community dwelling older adults
- people living in residential care facilities
- people receiving care in hospitals

It also provides a quality assessment of included studies and rates the level of evidence underlying each intervention in order to inform decision making. A global survey of potential end-users of the package was also conducted, including 67 professionals who deal with falls prevention or management. The findings of this rapid evidence review, along with the end-user survey, informed the development of the final technical package.

Approach

A rapid evidence synthesis approach was taken to summarise the evidence for falls prevention and management strategies across five key population groups. The specific approach taken was guided by the current *state* of the evidence corresponding each for each population group (e.g., whether high-quality studies using the most robust designs were available); as well as about the *size* of the evidence corresponding to each group (e.g., relative abundance of research attention on falls in hospitals). The approach for each population group is summarised below:

1. **For children and adolescents**: an overview of findings from systematic reviews (of randomized controlled trials) and key randomized controlled trials identified by content experts
2. **For people in occupational settings**: an overview of findings from systematic reviews, randomized controlled trials, controlled before-after studies, interrupted time series, cohort studies, case-control studies, and crossover studies
3. **For community-dwelling older adults:** an overview of findings from systematic reviews (of randomized controlled trials), identified by the research team as the 'best available evidence', and key randomized controlled trials identified by content experts
4. **For older people living in residential care facilities**: an overview of findings from systematic reviews (of randomized controlled trials) and key randomized controlled trials identified by content experts
5. **For older people receiving care in hospitals**: an overview of findings from systematic reviews (of randomized controlled trials) and key randomized controlled trials identified by content experts

This approach enabled us to collate and synthesize a large amount of evidence within the pragmatic considerations of time and resources to inform the development of the technical package.

Eligibility criteria

Studies were included if they met pre-specified criteria, defined according to the population (P), intervention (I), comparator (C) and outcome (O).

Population:

- **For children and adolescents**, separate or exclusive reporting on those under the age of 20.
- **For individuals in occupational settings**, separate or exclusive reporting on interventions that occurred in any place of employment, fixed or mobile, regardless of geographic location or nature of work, but excluding transport to and from the workplace.
- **For community dwelling older adults**, separate or exclusive reporting on participants aged 60 years and over, or if the mean age of study participants were 60 years or over and living in their own homes or community environments.
- **For individuals living in residential facilities,** separate or exclusive reporting on those in long-term, out-of-home living arrangements (e.g., assisted living facilities, custodial care, retirement villages). Studies reporting on interventions that extended beyond the facility (e.g., after discharge, while individuals were in community environments) were excluded.

- **For individuals receiving care in hospitals**, separate or exclusive reporting on individuals during their stay in hospitals. Studies reporting on interventions that extended beyond the hospital (e.g., after discharge, while individuals were in community environments) were excluded.

Intervention:

- **For all groups,** any intervention that aimed to prevent or manage falls

Comparison:

- **For all groups,** any comparator. In many studies, the comparator was reported as "usual care" or as a "placebo" (no therapeutic effect).

Outcome:

- **For all groups,** any outcome relating to falls (e.g., falls rate, falls risk), injurious falls, or medically attended falls. For children and adolescents, injuries that were not specifically attributed to a fall but could result from a fall (e.g., injury from physical activity) were also reported.

Pragmatic limits were also placed on searches with regard to year of publication and study population size in studies of falls in: older people living at home; residential care facilities; and hospitals; only studies published after 2012 that contained a study population over 150 people were included.

Database search

Electronic databases were searched in September 2017 for identification of studies. Details about search strategies are presented in Appendix 1.

- Interventions for prevention of falls in children and adolescents – Appendix 1
- Interventions for prevention of falls in occupational settings – Appendix 2
- Intervention for prevention of falls in community dwelling older adults – Appendix 3
- Intervention for prevention of falls in residential facilities – Appendix 4
- Intervention for prevention of falls in hospitals – Appendix 5

In addition to these systematic searches, content expert reviewers were asked to nominate subsequently published systematic reviews and randomized trials published that contributed significant new evidence and these studies were manually added.

Screening for eligible studies

Titles and abstracts of articles were initially screened by a single reviewer. A subset of this was checked by another, independent reviewer. Records that remained after the title and abstract screen had their full text papers extracted for further review. At the full text review phase, two reviewers independently reviewed papers to determine final eligibility. Disagreements between two reviewers were referred to another reviewer for a decision.

Data extraction

For all study designs, the following data parameters were extracted, *where relevant*: first author name, year of publication, inclusion and exclusion criteria, participant characteristics, intervention, comparator, presence of co-interventions, outcome measures, findings, and funding source. In addition:

- the databases searched, the number of included studies, and the method(s) of synthesis were extracted for systematic reviews;
- pre- and post-intervention observations were extracted for interrupted time series designs;
- sample size and follow up time were extracted for cohort and crossover designs; and
- the country and setting in which the primary study took place were extracted for randomized controlled trials, cohort designs, crossover designs, and interrupted time series (i.e., all designs aside from systematic reviews).

In studies that reported on multiple outcomes, only data relevant to the outcomes of interest, as specified in the eligibility criteria, were extracted and included in this overview.

Odd ratios (OR), relative risks (RR) and rate ratios (RaR) were used to compare the impact of interventions on falls between intervention and control groups. Where possible pooled effect sizes from meta-analyses were extracted. Difference in means was used in studies conducted in LMICs, in which falls risk scores were reported as outcomes. 95% confidence intervals were reported for all effect estimates. Effect sizes (and accompanying p values and confidence intervals) were stated for change in prevention practices where available.

Quality assessment

The scientific quality of each study was assessed using the appropriate checklists for that study design, which included the AMSTAR rating tool for systematic reviews (Shea, Grimshaw et al. 2007), the Cochrane's Risk of Bias tool for randomized controlled trials (Higgins , Thomas et al. 2019), the CASP Cohort Study Checklist for cohort and crossover studies (Critical Appraisal Skills Programme 2018), and criteria suggested by the Cochrane EPOC Review Group for interrupted time series and controlled before-after studies (Cochrane Effective Practice and Organisation of Care (EPOC) 2017).

Synthesis of results

Evidence was synthesized using a narrative approach. The level of evidence for each intervention was rated according to the National Health and Medical Research Council of Australia (NHMRC) guidance on the Levels of Evidence (Coleman K, Norris S et al.), which determines the strength of evidence to support an intervention according to the amount of high quality studies conducted, the consistency of findings, extent of clinical impact, generalizability of the study population to the population of interest, and the applicability to both HIC and LMIC settings. Because few studies were based in LMIC settings, the rating for the applicability to LMIC settings was based on a judgement of resources (human, technology, skills etc.) required to implement the intervention. Findings are reported separately for each review, some of which reviewed the same primary studies, but this duplicate reporting of primary studies was considered in the evidence rating process. In sections concerning older people living in the community, residential care settings and hospitals, interventions have been classified according to the PROFANE taxonomy (Europe. 2011). The exception to this was one intervention concerning community-dwelling older people: "Medication— Psychotropic drugs reductions or withdrawal", to more accurately describe the interventions supported by evidence for this population group.

Results

Preventing falls among children and adolescents

Globally, falls are the 12th leading cause of death for children aged 5 to 9 years, and for adolescents aged 15 to 19 years (World Health Organization and United Nations International Children's Emergency Fund 2008). In 2016, falls were responsible for an estimated 48 574 deaths among children and adolescents aged below 15 years(World Health Organization 2018).The world's highest fatal child fall rates are estimated to occur in the LMIC countries of South-East Asia (2.4 per 100 000 deaths) and the Eastern Mediterranean (1.8 per 100 000 deaths) (Institute for Health Metrics and Evaluation 2017).

Characteristics of Included Studies

In this section, we provide an overview of interventions and evidence from six systematic reviews and three randomized controlled trials about falls prevention in children and adolescents. Many studies were excluded from this review because they did not report fall or injury outcomes, instead reporting more proximal injury prevention outcomes such as stair gate use. Appendices 1C & D describes the extracted data from the included studies.

Populations

Interventions targeted children (McClure, Nixon et al. 2005, Howard, Macarthur et al. 2009, Collard, Verhagen et al. 2010, Pearson, Hunt et al. 2012, Nauta, Knol et al. 2013), parents (Kendrick, Watson et al. 2008, Turner, Arthur et al. 2011, Young, Wynn et al. 2013), and the whole community (McClure, Nixon et al. 2005, Kendrick, Watson et al. 2008, Young, Wynn et al. 2013).

Interventions

Interventions included school-based physical skills training for children (Collard, Verhagen et al. 2010, Nauta J 2013), educational programs for children (Pearson 2012), playground-based interventions (McClure, Nixon et al. 2005, Howard, Macarthur et al. 2009), clinic-based safety education for parents (Kendrick, Watson et al. 2008, Young, Wynn et al. 2013), parental receipt of home safety information (Young, Wynn et al. 2013), home-focussed multicomponent interventions (Turner, Arthur et al. 2011), and community-based multicomponent interventions (McClure, Nixon et al. 2005, Kendrick, Watson et al. 2008, Young, Wynn et al. 2013).

Outcomes

Studies reported on either fall-specific outcomes or injury outcomes that could have resulted from falls, such as physical activity injuries.

Settings

Studies evaluated interventions that took place in various settings such as the school environment (Collard, Verhagen et al. 2010, Nauta, Knol et al. 2013), playground (McClure, Nixon et al. 2005, Howard, Macarthur et al. 2009), clinic (Kendrick, Watson et al. 2008, Young, Wynn et al. 2013), home (Turner, Arthur et al. 2011), and community environments (McClure, Nixon et al. 2005, Kendrick, Watson et al. 2008, Young, Wynn et al. 2013).

Quality of Included Studies

TABLE 1.1 QUALITY APPRAISAL OF THE INCLUDED SYSTEMATIC REVIEWS OF INTERVENTIONS FOR PREVENTING FALLS AMONG CHILDREN AND ADOLESCENTS

Author	Dowswell et al (1996)	Kendrick et al (2008)	McClure et al (2005)	Pearson et al (2012)	Turner et al (2011)	Young et al (2013)
1. Was an 'a priori' design provided?	No	No	No	Yes	No	No
2. Was there duplicate study selection and data extraction?	No	Yes	Yes	Yes	Yes	Yes
3. Was a comprehensive literature search performed?	No	Yes	Yes	Yes	Yes	Yes
4. Was the status of publication (i.e. grey literature) used as an inclusion criterion?	No	Yes	Yes	Yes	No	No
5. Was a list of studies (included and excluded) provided?	No	Yes	No	Yes	Yes	Yes
6. Were the characteristics of the included studies provided?	No	Yes	Yes	No	Yes	Yes
7. Was the scientific quality of the included studies assessed and documented?	No	Yes	No	Yes	Yes	Yes
8. Was the scientific quality of the included studies used appropriately in formulating conclusions?	No	Yes	Yes	Yes	Yes	Yes
9. Were the methods used to combine the findings of studies appropriate?	No	Yes	Yes	Yes	Yes	Yes
10. Was the likelihood of publication bias assessed?	No	Yes	No	No	Yes	Yes
11. Was the conflict of interest included?	No	No	No	Yes	No	No

*RESULTS FROM DOWSWELL REVIEW WERE NOT INCLUDED DUE TO POOR QUALITY

TABLE 1.2. QUALITY ASSESSMENT OF RANDOMISED CONTROLLED TRIALS INVESTIGATING FALLS PREVENTION INTERVENTIONS AMONG CHILDREN AND ADOLESCENTS (LEVEL OF BIAS)

Author	Collard et al (2010)	Howard et al (2009)	Nauta et al (2013)
Random sequence generation *(selection bias)*	Low	High	High
Allocation concealment *(selection bias)*	Unclear	High	High
Blinding of participants and personnel *(performance bias)*	Low	High	High
Blinding of outcome assessment *(detection bias)*	High	Low	High
Incomplete outcome data *(attrition bias)*	High	Low	High
Selective outcome reporting *(reporting bias)*	Unclear	Low	Low
Other bias	Unclear	Unclear	Unclear

Discussion of Evidence for Interventions

In this section, the evidence for each intervention type is summarised.

TABLE 1.3. SUMMARY OF APPRAISAL OF INTERVENTIONS FOR PREVENTION OF FALLS AMONG CHILDREN AND ADOLESCENTS.

Intervention	Evidence Statement Matrix						Grade of Recommendation
	Evidence base	Consistency	Clinical impact	Generalizability	Applicability		
					HIC	LMIC	
School-based physical skills training for children (RCT: Nauta et al. 2013, Collard et al. 2010)	A	A	D	B	B	C	C
Educational program for children (SR: Pearson 2012)	B	N/A	D	B	B	C	D
Playground-based interventions (SR: McClure et al. 2005; RCT: Howard et al. 2009)	B	B	D	A	B	C	C
Clinic-based safety education for parents (SR: Kendrick 2008; Young 2013)	C	N/A	D	B	A	C	D
Parental receipt of home safety information (SR: Young 2013)	B	N/A	B	B	A	B	B
Home-focused multicomponent interventions (SR: Turner 2011)	A	B	D	A	A	C	C
Community-based multicomponent interventions (SR: McClure et al 2005; Young 2013; Kendrick et al 2008)	B	C	D	A	C	C	D

School-based physical skills training for children

Overall, the level of evidence for school-based skills training as a single intervention was rated as a C, reflecting slight or restricted clinical impact and satisfactory generalizability and applicability. Two similar cluster randomised controlled trials were conducted in Dutch primary schools to examine the effectiveness of school-based interventions. One targeted children aged 7 to 12 years, over an 8 week period, and consisted of martial arts based falling skills training (Nauta, Knol et al. 2013), while the other targeted children aged 10 to 12 years of age, over an 8-month period, and focussed on strength and coordination exercises (Collard, Verhagen et al. 2010).

In the Nauta, Knol et al. (2013) study, the intervention was implemented every week for 1 hour and revolved around techniques that taught children to distribute the impact energy associated with a fall over a larger contact area and to convert the fall into a rolling motion. The effects of the intervention on the incidence of fall-injuries, in the 8 months following the start of the intervention, was calculated. Injuries were self-reported to teachers on a weekly basis and average weekly exposure to sports and leisure time physical activity was self-reported via a questionnaire at two time points. No statistically significant difference in injury incidence was observed between the intervention and control groups; however, when physical activity level was taken into account, the results suggested that the intervention was effective among the least active children. Similar conclusions were drawn from the other study.

In the Collard, Verhagen, et al. (2010) study the intervention was delivered via 5-minute exercises at the beginning and end of physical education classes, which took place for 45 minutes two times per week. These exercises were supplemented with monthly newsletters delivered to students and their parents respectively which focussed on improving knowledge, attitude, and self-efficacy for students, and knowledge and support strategies for parents. Students also had continued access to information on posters which were displayed in the school and a website. The effects of the intervention on physical activity injury incidence and severity were calculated, with outcome and exposure reporting occurring the same way as the former study. The authors observed a non-significant reduction in injury incidence and severity among the intervention group, and an effect modification effect for physical activity, whereby the intervention had a larger effect among the "low active" group. While neither study focussed specifically on falls (former: fall injuries; latter: physical activity injuries), they suggest that school-based injury prevention training may be effective particularly among the least active children. Educational program for children

Overall, the level of evidence for school-based information provision as a single intervention was rated as a D, reflecting slight or restricted clinical impact and fair ratings in all other domains. Evidence was derived from one systematic review (Pearson, Hunt et al. 2012), which described a before-after evaluation of a six-week head and spinal cord education program for children aged 6 to 9 years. The program introduced children to various injury topics including vehicular and pedestrian safety; bicycle safety; safety around weapons; playground, recreation, and sports safety; and water safety. Multiple teaching strategies were used including videos and role playing. The authors observed that a decline in the number and proportion of paediatric head and neck injuries in the subsequent two years; however, this was based on a trend over time and was not attributable to the intervention.

Playground-based interventions

Overall, the level of evidence for modification of the playground environment as a single intervention was rated as a C, reflecting slight or restricted clinical impact and reduced applicability. Evidence was derived from one systematic review (McClure, Nixon et al. 2005) and one randomised controlled trial (Howard, Macarthur et al. 2009).

The playground interventions in McClure's review (McClure, Nixon et al. 2005) were of low quality and/or insufficiently reported, precluding them for contributing much to the evidence base. One intervention was an unspecified "playground safety programme", which was evaluated using data on outdoor falls in children aged 5 to 16 years from an existing hospital-based surveillance system. Outcomes from the intervention area were compared to a nearby community, which served as a control. It appeared that the study did not adequately account for exposure and had potential risk of outcome misclassification. Therefore, no trustworthy conclusions could be drawn. The other intervention was of a "pilot playground injury prevention programme" that involved playground hazard audits as part of a state-wide campaign. A reduction in playground-related injuries was observed; however, the data were derived from one of three sites only.

In the Howard, MacArthur et al. (2009) trial, 37 primary schools in a Canadian city due for replacement of playground equipment and surfacing were cluster randomized to receive either Fibar wood chip surfacing or granite sand surfacing. Data were reliably collected over 2.5 years on arm fracture rates per 100,000 student months where the fracture was a result from a fall onto the playground surface during supervised hours of play during the school day (which was consistent across schools). The arm fracture rate among schools who were randomised to install Fibar, and who were compliant to the assignment was higher (9.4 per 100,000 student-months, 95% CI 3.7– 21.4) than that among schools randomised to and compliant with the assignment of granite (1.9 per 100,000 student-months, 95% CI 0.04–6.9). Results were borderline significant because overall arm fracture rates were substantially lower in both arms than baseline estimates. However, the results of this study suggest that granitic sand playground surfaces reduce the risk of arm fractures when compared with engineered wood fibre surfaces. Note that this study did not focus on all falls, but rather arm fractures resulting from falls.

Clinic-based safety education for parents

Overall, the level of evidence for clinic-based safety education for parents as a single intervention was rated as a D, reflecting slight or restricted clinical impact from a single primary study that had limited applicability to LMICs due to its specific context. Evidence was derived from two systematic reviews

(Kendrick, Watson et al. 2008, Young, Wynn et al. 2013), which drew on the same primary study of an intervention designed to reduce infant walker use. The Singapore-based intervention comprised of nurse counselling in a polyclinic setting. The authors observed no significant differences between the intervention and the control group in baby walker related falls, neither in regard to falls on flat ground nor in regard to falls down stairs or steps.

Parental receipt of home safety information

Overall, the level of evidence for home-based safety education for parents as a single intervention was rated as a B, reflecting good or excellent ratings across all categories. Evidence was derived from one systematic review (Young, Wynn et al. 2013) which reported on the effects of safety education for adolescent mothers in a U.S. city. In this observational study, a random sample of adolescent mothers were interviewed at 3 months post-partum to ascertain their receipt of home safety information by various sources, and at 15 months to collect self-reported data on the number of injuries incurred by their children that required medical attention. A correlation was observed whereby children of mothers who received home safety information from family and community-based sources by 3 months postpartum had significantly lower risk of injury during follow-up than children of mothers who had not received home safety information. From this study, Young, Wynn et al. (2013) write that "receipt of home safety information was associated with a reduction in injuries from falls" (pg. 167).

Home-focused multicomponent interventions

Overall, the level of evidence for home-based multicomponent interventions was rated as a C, reflecting slight or restricted clinical impact, some inconsistencies, and reduced applicability in LMIC contexts. Evidence was derived from one systematic review (Turner, Arthur et al. 2011) which identified five studies based around home modification, with four reporting no significant differences in injury occurrence among children between the intervention and the control groups.

No significant difference in injury rate was observed between intervention and control groups in a study that combined recommended home modification with free safety devices. Similarly, one study that combined free safety devices and safety counselling showed no significant difference in medically attended injuries.

Two studies focussed on interventions which combined direct or recommended home modification with an education strategy, one which reported no significant change in the frequency of at least one medically attended injury, emergency department presentation for injury, primary care presentation for injury, nor hospital admission for injury. In contrast, the other showed a significant reduction in injury visits per patient at 12 months, which diminished thereafter until 36 months. One additional study examined the effects of recommended modification, free safety device provision, and an education strategy. That study reported that primary care presentation for injury was significantly higher for the intervention group compared to the control group. Possible reasons for this apparent harmful effect were not discussed in Turner's review.

Community-based multicomponent interventions

Community-based interventions are those characterised by: a shared ownership of the injury problem and its solution by experts and community members, and joint responsibility for determining the priorities and interventions that are appropriate; an understanding that injury prevention acknowledges a complex causal web embedded in social and organization structures; a coordinated multi-strategy response; and an emphasis on optimizing community involvement (McClure, Nixon et al. 2005). Overall, the level of evidence for community-based multicomponent interventions was rated as a D, reflecting slight or moderate clinical impact, genuine uncertainty about the effectiveness, and reduced applicability. Evidence was derived from three systematic reviews (McClure, Nixon et al. 2005, Kendrick, Watson et al. 2008, Young, Wynn et al. 2013).

The earliest intervention summarised by McClure took place in New York City in 1972 (McClure, Nixon et al. 2005). Called "Children Can't Fly", it was developed by the New York City Department of Health to combat the high incidence of child mortality and morbidity due to falls from windows. It comprised a media campaign, community education (which included door-to-door hazard identification and counselling by outreach workers, and which rallied support from schools, tenant groups, clinics, churches, health care providers) and the provision of free, easily installed window guards to families with young children living in high-risk areas. Falls data were gathered from hospital and police reporting systems, as well as from death certificates. The authors observed a significant reduction in fall incidence and mortality over two years, and the success of the program led to new legislation requiring landlords to provide window guards in apartments where children ten years old and younger reside. While the results are encouraging, McClure notes that the authors did not discuss historical trends or imply any counterfactual contrast.

McClure also describes an intervention in which a coalition of health care providers, educators, retailers, and human service agencies embarked on a community-wide education initiative (McClure, Nixon et al. 2005). The initiative aimed to reduce the number of baby walker related injuries by educating the public on the dangers of baby walkers. While the authors observed a decrease in the proportion of children presenting at two paediatric emergency departments for walker-related falls in the post-intervention period, no firm conclusions can be drawn about the effectiveness of the intervention given the limited outcome reporting and lack of counterfactual control. In fact, national trends suggest that such decrease may have occurred anyway. Similar attribution problems characterise another study reported in McClure, Nixon et a. (2005), which evaluated the WHO Safe Community model on the incidence of falls for children under 15 years in Sweden. Post-programme reductions were observed for children of some age groups but not others; however, a national injury prevention programme occurred simultaneously to the intervention under study, undermining the ability to attribute reductions to the WHO Safe Community model (Lindqvist, Timpka et al. 2002).

The final intervention summarised by McClure and colleagues (2005) was also discussed in both the Young et al. (2013), and Kendrick et al. (2008) systematic reviews. The intervention was a state-wide childhood injury prevention program implemented in nine cities in the US state of Massachusetts between 1980 and 1982. The intervention involved injury counselling for parents of young children, household injury hazard identification, and other components that specifically targeted injury mechanisms other than falls (e.g., promotion of poison centres, burn prevention education). The intervention had no significant effect on reducing falls among children aged 0 to 5 years.

Preventing falls in occupational settings

Fall related injury is one of most common risks in occupational settings (Stanaway 2018). Falls can occur at the same level, due to a trip or slip on a slippery surface, or from height to a lower level (Bell, Collins et al. 2008).

An estimated 317 million people suffer work-related injuries globally each year (International Labour Organization 2014) and in 2017 alone, occupational injuries caused an estimated 304 000 deaths (Stanaway 2018). Falls are among the three most common causes of both fatal and non-fatal occupational injuries in many high-income countries (National Safety Council 2016, Australian Bureau of Statistics 2018, Health and Safety Executive 2018) In 2017 there were an estimated 36 000 deaths due to falls that occurred during work (Stanaway 2018).

It is estimated that, occupational slip, trip and fall (STF)-related injuries account for 20 to 40% of disabling occupational injuries (Courtney, Sorock et al. 2001). In the US alone, the total direct cost associated with fall-related occupational injuries was estimated at approximately US$6 billion per annum (Courtney, Sorock et al. 2001). Despite the significance of fall-related injuries in occupational settings, studies describing falls prevention interventions in occupational settings are scarce.

Characteristics of Included Studies

In this section, we provide an overview of interventions and evidence from one systematic review (van der Molen, Basnet et al. 2018), four quasi-experimental studies(Yassin and Martonik 2004, Bell, Collins et al. 2008, Menendez, Castillo et al. 2012, Rubio-Romero, Carrillo-Castrillo et al. 2015) and three cohort studies (Nelson, Kaufman et al. 1997, Verma, Chang et al. 2011, Verma 2014) that met inclusion criteria. Appendices 2C & D describes the extracted data from the included studies.

Populations

Studies were conducted with workers in the construction, hospital, and restaurant and catering industries.

Interventions

Studies examined a range of interventions targeted to different groups of participants, including the use of slip resistant shoes among restaurant employees (Verma, Chang et al. 2011, Verma 2014), increased floor cleaning frequency in a restaurant (Verma, Chang et al. 2011), increased roughness of floor surface (Verma, Chang et al. 2011), enforcement of more stringent safety standards among construction employers (Nelson, Kaufman et al. 1997, van der Molen, Basnet et al. 2018), higher scaffolding safety standard (including subsidy to use certified-scaffold) (Yassin and Martonik 2004, Rubio-Romero, Carrillo-Castrillo et al. 2015) and a multi-component falls prevention program in occupational settings (Bell, Collins et al. 2008, Menendez, Castillo et al. 2012).

Outcomes

The outcome measure(s) examined varied and included; slip rate (Verma, Chang et al. 2011, Verma 2014), workers compensation rate (Nelson, Kaufman et al. 1997, Bell, Collins et al. 2008), fall fatality rate (Yassin and Martonik 2004, Menendez, Castillo et al. 2012, van der Molen, Basnet et al. 2018), nonfatal injury rates (Yassin and Martonik 2004, van der Molen, Basnet et al. 2018), lost workdays per nonfatal injury cases and cost savings (Yassin and Martonik 2004). Outcomes were reported with the individual or the organization as the unit of analysis.

Settings

All studies were conducted in HICs, with one in Austria, Belgium, Germany (van der Molen, Basnet et al. 2018), one in Spain (Rubio-Romero, Carrillo-Castrillo et al. 2015) and the rest in the United States.

Quality of Included Studies

TABLE 2.1 QUALITY APPRAISAL OF THE INCLUDED SYSTEMATIC REVIEW OF INTERVENTIONS FOR PREVENTING FALLS IN OCCUPATIONAL SETTINGS

van der Molen et al. (2018)	
1) Was an 'a priori' design provided?	Yes
2) Was there duplicate study selection and data extraction?	Yes
3) Was a comprehensive literature search performed?	Yes
4) Was the status of publication (i.e. grey literature) used as an inclusion criterion?	Yes
5) Was a list of studies (included and excluded) provided?	Yes
6) Were the characteristics of the included studies provided?	Yes
7) Was the scientific quality of the included studies assessed and documented?	Yes
8) Was the scientific quality of the included studies used appropriately in formulating conclusions?	Yes
9) Were the methods used to combine the findings of studies appropriate?	Yes
10) Was the likelihood of publication bias assessed?	Yes
11) Was the conflict of interest included?	Yes

TABLE 2.2 QUALITY ASSESSMENT OF INCLUDED COHORT STUDIES OF INTERVENTIONS FOR PREVENTING FALLS IN OCCUPATIONAL SETTINGS

Author	Nelson et al (1997)	Verma et al (2011)	Verma et al (2014)
Cohort recruited in an acceptable way	No	Yes	Yes
Exposure accurately measured to minimise bias	Yes	No	No
Outcome accurately measured to minimise bias	Yes	No	No
All important confounding factors identified	Yes	Yes	Yes
All important confounding factors accounted for in the design and/or analysis	Yes	Yes	Yes
Follow up of subjects complete enough	Yes	Yes	Yes
Follow up of subjects long enough	Yes	Yes	Yes
Risk for other bias minimal	No	Yes	Yes

TABLE 2.3. QUALITY ASSESSMENT OF INCLUDED QUASI-EXPERIMENTAL STUDIES OF INTERVENTIONS FOR PREVENTING FALLS IN OCCUPATIONAL SETTING

Author and year	Bell et al. (2008)	Menendez et al. (2012)	Rubio-Rumero et. al. (2015)	Yassin et al. (2004)
Intervention independent of other changes	Unclear	Unclear	Unclear	Unclear
Intervention unlikely to affect data collection	Yes	Yes	Yes	Yes
Blinded assessment of primary outcome	Yes	Yes	No	Yes
Reliable primary outcome measure	Yes	Unclear	Yes	Unclear
Completeness of data set	Unclear	Yes	Yes	Yes
Shape of intervention effect pre-specified	Yes	Yes	Yes	Yes
Rationale for sample size	No	Yes	Yes	No
Data analysed appropriately	Yes	Yes	Yes	Yes
Risk for other bias minimal	Yes	No	No	No

Discussion of Evidence for Intervention

In this section, the evidence for each intervention type is summarised.

It should be noted that only a small number of low-quality studies of occupational falls were identified, each with a moderate to high risk of bias. One systematic review (van der Molen, Basnet et al. 2018) and five primary studies were conducted in the construction industry (Lingard and Rowlinson 1997, Nelson, Kaufman et al. 1997, Menendez, Castillo et al. 2012), which is perceived as having a higher risk for falls than other occupational settings, particularly for work that can occur at heights and/or involve the use of scaffolding such as carpentry, roofing, and high-rise construction (Nelson, Kaufman et al. 1997). Despite this, falls are also a concern in other workplace settings. Although some research in hospitals (Bell, Collins et al. 2008) and restaurants (Verma, Chang et al. 2011, Verma 2014) was identified, substantial research in other settings, such as factories, warehouses, agriculture, and window cleaning, is warranted.

TABLE 2.4. SUMMARY OF APPRAISAL OF INTERVENTIONS FOR PREVENTION OF FALLS IN OCCUPATIONAL SETTINGS

Intervention	Evidence Statement Matrix						Grade of Recommendation
	Evidence base	Consistency	Clinical impact	Generalizability	Applicability		
					HIC	LMIC	
Use of slip resistant shoes (CS: Verma 2011, Verma 2014)	C	A	C	C	A	C	C
creased floor cleaning frequency (CS: Verma 2011)	C	N/A	D	C	A	C	C
Increased roughness of floor surface (CS: Verma 2011)	C	N/A	D	C	A	C	C
Enforcement of more stringent safety standards among construction employers (CS: Nelson 1997; SR: van der Molen 2018)	D	N/A	C	B	A	C	C
Higher scaffold safety standards (QES: Yassin 2004; Rubio-Romero 2015; SR: van der Molen 2018)	C	N/A	D	C	A	C	D
ulti-component prevention program (QES: Bell 2008, Menendez 2012)	C	N/A	C	B	A	C	C

CS: COHORT STUDY, QES: QUASI-EXPERIMENTAL STUDY, SR: SYSTEMATIC REVIEW

Use of slip-resistant shoes

Overall, the level of evidence for using slip resistant shoes as a single intervention for preventing falls in occupational setting is C, reflecting the low quality of study designs, limited generalisability and applicability to LMIC settings, despite some significant clinical impacts and consistent findings from two cohort studies.

Slip resistance is a specific term given to footwear that reduces the risk of slipping. The footwear was specially designed and constructed to maximise contact between the sole and the walkway surface and therefore increase the friction. While we are not aware of any intervention study on the effect of the use of slip-resistant shoes, a prospective study on risk of slipping among restaurant workers in the US found that use of slip-resistant shoes was associated with 54% reduction in the reported rate of slipping (95%CI: 37% - 67%) (Verma, Chang et al. 2011). In another study, Verma et al. found that changing to a new pair of shoes among those wearing slip-resistant shoes at baseline was also associated with a 55% reduction in the rate of slipping (RR 0.45, 95% CI 0.23–0.89). Slip-resistant shoes have also been used as part of multicomponent interventions among hospital employees (see below) (Bell, Collins et al. 2008).

Increasing floor cleaning frequency

The level of evidence of increased floor cleaning frequency as a single intervention for falls prevention in occupational setting is C. This is a reflection of limited generalisability and applicability to LMIC settings. While there was some impact in reducing slipping rates, this was only from a single cohort study and only when considered in isolation but not after statistical adjustment for other factors.

Floor surfaces require sufficient grip to prevent slipping. The risk of slipping increases when the floor surface is wet or contaminated. A study of restaurant hazard identifies that common sources of slippery floors were wet and/or contaminated (Verma, Chang et al. 2011). Therefore, to reduce the risk of trip, slip and fall, regular and effective floor cleaning is commonly included in work safety guidelines. It is one of the strategies included in a comprehensive intervention to reduce slip, strip and fall among hospital employees (Bell, Collins et al. 2008).

Increased roughness of floor surface

Overall, the level of evidence for increased roughness of floor surface as a single intervention for preventing falls in occupational setting is C. The evidence is from only one cohort study, which showed inconsistent reduction in slipping. Increased in coefficient of friction was associated with decreased rate of slipping. Regarding floor surface roughness, the decrease in slipping rate was observed only when it was considered in isolation but not after statistical adjustment for other factors. It also has limited generalisability and applicability to LMIC settings.

Friction of floor surface is considered an important factor in the causation of STF. A slip is likely to occur when there is little friction at the floor surface/shoe sole interface to counteract shear forces generated by a foot during walking. Level of roughness of floor surface, in addition to shoe sole characteristics and contamination on the floor, can contribute to the risk of STF. In a study of STF hazards in restaurants in the US, Verma (2011) measured coefficient of friction and floor surface roughness, the two widely used measures of slip resistant property of a floor. It was found that the rate of slipping decreased by 21% (95% CI 5%- 34%) for each 0.1 increase in mean coefficient of friction. However, floor roughness parameters were not significantly associated with decreased slipping rate (Verma, Chang et al. 2011).

Enforcement of more stringent safety standards among construction employers

One cohort study and one systematic review, including nine interrupted time series studies, investigated the effect of enforcement of more stringent safety standards among construction employers on falls prevention. The overall level of evidence is C, reflecting the inconclusive effect of this intervention and limited generalisability and applicability in LMIC settings.

In the US, standards for fall protection in the construction industry include use of personal protective equipment, such as safety nets, safety belts, lifelines, and lanyards, and specifications regarding practices related to floor and wall openings and stairways. From 1991, the Fall Restraint and Fall Arrest Standard was consolidated in Washington State, which required construction companies to have a fall protection work plan which identifies employees at risk of a fall hazard of ten feet or more. Nelson et al. conducted a study on the effect of the increased regulation on fall injuries (Nelson, Kaufman et al. 1997).

It was found that fall injury rate among employees in companies that had been inspected (for new standard) decreased by 1.02 per 200,000 hours, compared to a decrease of 0.031 per 200,000 hours among employees in companies that had not been inspected. The intervention group was 2.3 times more likely to have reduction in injury claims than the control group (Nelson, Kaufman et al. 1997). In van der Molen et al.'s (systematic review of interventions to prevent injuries in construction workers, results from 9 interrupted time series studies found inconclusive effect of the regulatory interventions in both, fatal and non-fatal injuries.

Higher scaffolding safety standard

Overall, the level of evidence of higher scaffolding safety standard as a single intervention for preventing falls in occupational setting is C, reflecting the low quality of study designs, limited generalisability and applicability to HIC settings, despite some clinical impacts and consistent findings from three studies. Evidence were derived from one interrupted time series (Yassin and Martonik 2004), one quasi-experimental study (Rubio-Romero, Carrillo-Castrillo et al. 2015), and one systematic review (van der Molen, Basnet et al. 2018).

Scaffolds are one of the most common working environments related to fall to a lower level in construction industry. In the US, the revised scaffold safety standards requires that 1) each employee on a scaffold at a level higher than 10 feet above a lower level shall be protected from falling to that lower level; 2) employers provide fall protection for employees erecting or dismantling scaffolds; 3) personal fall arrest systems used on scaffold be attached by lanyard to a vertical lifeline, horizontal lifeline, or scaffold structure member; 4) the installation of guardrail systems before the scaffold is released for use by employees. Using data for the period before and after the effect of the revised scaffold safety standards, Yassin and Martonik estimated that the revised standards would prevent 4.6 fatalities, 404 non-fatal injuries and 2,896 lost workdays per year (Yassin and Martonik 2004). In Spain, Rubio-Romero evaluated the effect of a subsidy program for replacement of non-compliant scaffolds for construction companies in Andalusia (Spain) in the period 2009–2011. The incidence rate of fall in the intervention group decreased by 1172.5 per 100,000, whereas the rate in the control group increased by 95.5 per 100,000 (95% CI 258.1-2277.9) (Rubio-Romero, Carrillo-Castrillo et al. 2015).

Multi-component falls prevention intervention

Overall, the level of evidence of multi-component intervention for falls prevention in occupational setting was C. This is a reflection of the low quality of study designs, limited generalisability and applicability to HIC settings, despite some clinical impacts and consistent findings from three studies. Evidence were derived from two interrupted time series studies (Bell, Collins et al. 2008, Menendez, Castillo et al. 2012).

In a program of falls prevention for hospital employees in the US, a multi-component comprehensive strategy for slip, trips and falls prevention was implemented. The program include strategies to keep floors clean and dry, to prevent entry into areas that are contaminate, to use slip-resistant shoes, to keep walkways clear of objects and reduce clutter, to provide adequate lighting in all work areas including outdoor stairwells and parking garages, to secure loose cords, wires and tubing, to eliminate outdoor and indoor surface irregularities, check stairs, to prepare for ice and snow and to educate general awareness of falls prevention. Comparing the rate of workers' compensation claims during the period before (1996-1999) and after the intervention (2003-2005), there was a reduction of 58%, from 1.66 claims per 100 FTE to 0.76 claims per 100 FTE (Bell, Collins et al. 2008). Another was the FACE (NIOSH Fatality Assessment and Control Evaluation) program, a state-wide, publicly-funded quality improvement and safety program targeting all occupational settings in the US. The program involved delivery of delivery of FACE investigation reports to a wide range of stakeholders; and informing them regarding recommended occupational safety practices, policies and procedures, and interventions which may yield a sustained effect. In analysing 22 years of state fatality rates for occupational falls, Menendez et al. found a borderline significant reduction (aRR=0.92, 95% CI 0.84-1.00) (Menendez, Castillo et al. 2012).

Overall, findings were inconsistent for the impact of regulations and safety performance targets, while there was some evidence for the effectiveness of economic subsidies, slip-resistant shoes, and a multi-component intervention program, and no evidence supporting the effectiveness of performing safety investigations. However, the overall quality of the evidence was low. Additionally, it is apparent that the cost effectiveness of interventions will be an important consideration which has not yet been investigated. Further research with a robust study design, collecting consistent outcome measures, will better facilitate evaluating the effectiveness of falls prevention interventions for occupational settings.

Preventing falls among community-dwelling older adults

Our chances of being injured or dying as a result of a fall increase with age across the globe (Sattin 1992, World Health Organization 2007). Advancing age can impair balance, mobility, vision and cognition, each of which can increase the risk of falls (Campbell, Borrie et al. 1990). Globally, a third of people aged 65 years and older fall at least once per year, with 5% of these falls resulting in a fracture (Campbell, Borrie et al. 1990, Kannus, Parkkari et al. 1999). Other physical consequences of falls among older people include joint distortion and dislocation, soft-tissue damage, bruises and cuts (Jensen, Lundin-Olsson et al. 2002). Older people living independently in the community are most likely to fall in their own homes and yards, although falls also occur away from the home, including in public spaces, on public transport and when navigating the road system as pedestrians and cyclists (Kochera 2002, Mackenzie, Byes et al. 2002).

Characteristics of included studies

A total of eighteen systematic reviews and six randomized controlled trials were included in this evidence overview. Appendices 3C & D describes the extracted data from the included studies.

Population:

Community-dwelling people aged 60 years and older (age brackets varied between study).

Interventions:

Interventions included several types of exercise (Clemson, Fiatarone Singh et al. 2012, Gillespie, Robertson et al. 2012, Martin, Wolf et al. 2013, Burton, Cavalheri et al. 2015, Chan, Yeung et al. 2015, Hill, Hunter et al. 2015, Mansfield, Wong et al. 2015, Wang, Pi et al. 2015, Booth, Hood et al. 2016, Gawler, Skelton et al. 2016, Okubo, Schoene et al. 2016, Rimland, Abraha et al. 2016, Hill, Suttanon et al. 2018, Sherrington, Fairhall et al. 2019), environmental modifications (Gillespie, Robertson et al. 2012, Rimland, Abraha et al. 2016, Hill, Suttanon et al. 2018), hip protectors (Gillespie, Robertson et al. 2012, Santesso, Carrasco-Labra et al. 2014, Rimland, Abraha et al. 2016), education (Gillespie, Robertson et al. 2012, Rimland, Abraha et al. 2016, Hill, Suttanon et al. 2018), withdrawal of psychotropic drugs (Gillespie, Robertson et al. 2012, Hill and Wee 2012), vitamin D supplementation (Gillespie, Robertson et al. 2012, Hill, Suttanon et al. 2018), fluid and nutrition therapy (Gillespie, Robertson et al. 2012), surgery (cataract removal or pacemaker insertion) (Gillespie, Robertson et al. 2012, Rimland, Abraha et al. 2016), communication aids (Gillespie, Robertson et al. 2012, Rimland, Abraha et al. 2016), along with combinations of these and other interventions delivered as a multicomponent or multifactorial intervention (Gillespie, Robertson et al. 2012, Bunn, Dickinson et al. 2014, Goodwin, Abbott et al. 2014, Möller, Kristensson et al. 2014, Burton, Cavalheri et al. 2015, Cohen, Miller et al. 2015, Rimland, Abraha et al. 2016, Zozula, Carpenter et al. 2016, Chu, Fong et al. 2017, Cockayne, Adamson et al. 2017, Hill, Suttanon et al. 2018, Hopewell S 2018).

Outcomes

Studies examined the effects of the intervention on a fall or fall injury related outcomes, including fall rate (Clemson, Fiatarone Singh et al. 2012, Gillespie, Robertson et al. 2012, Hill and Wee 2012, Martin, Wolf et al. 2013, Booth, Hood et al. 2016, Bunn, Dickinson et al. 2014, Goodwin, Abbott et al. 2014, Möller, Kristensson et al. 2014, Burton, Cavalheri et al. 2015, Chan, Yeung et al. 2015, Cohen, Miller et al. 2015, Hill, McPhail et al. 2015, Mansfield, Wong et al. 2015, Wang, Pi et al. 2015, Gawler, Skelton et al. 2016, Okubo, Schoene et al. 2016, Rimland, Abraha et al. 2016, Zozula, Carpenter et al. 2016, Chu, Fong et al. 2017, Cockayne, Adamson et al. 2017, Huang, Feng et al. 2017, Hill, Suttanon et al. 2018, Sherrington, Fairhall et al. 2019), recurring fall risk, fracture risk and fracture rate (Santesso, Carrasco-Labra et al. 2014). Several non-fall specific outcomes were also examined, including acceptance and adherence (Santesso, Carrasco-Labra et al. 2014); complications or adverse effects (Santesso, Carrasco-Labra et al. 2014, Sherrington, Fairhall et al. 2019); balance, gait, and functional mobility (Martin, Wolf et al. 2013, Sherrington, Fairhall et al. 2019).

Settings

Studies took place mostly in high-income countries (Clemson, Fiatarone Singh et al. 2012, Gillespie, Robertson et al. 2012, Hill and Wee 2012, Bunn, Dickinson et al. 2014, Goodwin, Abbott et al. 2014, Möller, Kristensson et al. 2014, Santesso, Carrasco-Labra et al. 2014, Burton, Cavalheri et al. 2015, Cohen, Miller et al. 2015, Hill, McPhail et al. 2015, Booth, Hood et al. 2016, Gawler, Skelton et al. 2016, Zozula, Carpenter et al. 2016, Chu, Fong et al. 2017, Cockayne, Adamson et al. 2017, Huang, Feng et al. 2017, Hill, Suttanon et al. 2018, Sherrington, Fairhall et al. 2019), with fewer in middle-income countries (Gillespie, Robertson et al. 2012, Booth, Hood et al. 2016, Ang, Tuthill et al. 2018, Sherrington, Fairhall et al. 2019).

TABLE 3.1. QUALITY APPRAISAL OF SYSTEMATIC REVIEWS OF INTERVENTIONS FOR PREVENTING FALLS AMONG COMMUNITY-DWELLING OLDER ADULTS.

	Booth et al 2016	Bunn et al 2014	Burton et al 2015	Chan et al 2015	Gillespie et al 2012	Goodwin et al 2014	Hill et al 2012	Hill et al 2015	Hill et al 2018	Hopewell et al 2018	Huang et al 2017	Mansfield et al 2015	Martin et al 2013	Okubo et al 2016	Rimland et al 2016	Santesso et al 2014	Sherrington et al 2019	Wang et al 2015	Zozula et al, 2016
Was an 'a priori' design provided?	Yes	No	No	No	Yes	Yes	No	No	Yes	Yes	No	No	No	Yes	No	Yes	Yes	Yes	Yes
Was there duplicate study selection and data extraction?	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Was a comprehensive literature search performed?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Was the status of publication (i.e. grey literature) used as an inclusion criterion?	No	Yes	No	No	Yes	No	No	No	Yes	Yes	Yes	No	No	No	No	Yes	Yes	No	No
Was a list of studies (included and excluded) provided?	Yes	Yes	No	No	Yes	No	No	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes	No	No
Were the characteristics of the included studies provided?	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes
Was the scientific quality of the included studies assessed and documented?	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Was the scientific quality of the included studies used appropriately in formulating conclusions?	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Were the methods used to combine the findings of studies appropriate?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Was the likelihood of publication bias assessed?	Yes	Yes	Yes	No	Yes	Yes	No	No	No	Yes	Yes	Yes	No	Yes	No	No	Yes	Yes	No
Was the conflict of interest included?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	No

Domains for Risk of Bias (High/Low/Unclear)	Authors					
	Chu et al (2017)	**Clemson** et al. (2012)	**Cockayne** et al 2017)	**Cohen** et al (2015)	**Gawler** et al (2016)	**Möller** et al (2014)
Random sequence generation (selection bias)	Low	Low	Low	High	Low	Low
Allocation concealment (selection bias)	Low	Low	High	Unclear	Low	Unclear
Blinding of participants and personnel (performance bias)	Low	Low	Low	High	Low	Low
Blinding of outcome assessment (detection bias)	Unclear	Unclear	Unclear	High	Low	Low
Incomplete outcome data (attrition bias)	Low	Low	High	Unclear	High	Low
Selective outcome reporting? (Reporting bias)	Low	Unclear	High	High	Low	Unclear

TABLE 3.2 QUALITY ASSESSMENT OF RANDOMISED CONTROLLED OF INTERVENTIONS FOR PREVENTING FALLS AMONG COMMUNITY-DWELLING OLDER ADULTS (LEVEL OF BIAS)

Discussion of Evidence for Interventions

In this section, the evidence for each intervention type is summarised, starting with the findings for systematic reviews where relevant, before moving onto primary studies.

TABLE 3.3. SUMMARY OF APPRAISAL OF INTERVENTIONS FOR PREVENTION OF FALLS AMONG COMMUNITY-DWELLING OLDER PEOPLE.

Intervention	Evidence Statement Matrix						Grade of Recommendation
	Evidence base	Consistency	Clinical impact	Generalizability	Applicability		
					HIC	LMIC	
Exercise – Gait, balance, and functional training (RCT: Gawler 2016, Clemson 2012, SR: Sherrington 2019; Gillespie 2012; Rimland 2016; Okubo 2016; Mansfield 2015; Wang 2015; Booth 2016; Martin 2013; Chan 2015; Burton 2015; Hill 2015, Hill 2018)	A	A	B	B	B	C	A
Exercise – Strength/resistance training (SR: Sherrington 2019; Gillespie 2012, Hill 2018)	A	A	D	A	A	B	D
Exercise – 3D movement (Tai Chi) (SR: Huang 2017; Gillespie 2012; Sherrington 2019, Hill 2018)	A	A	B	A	A	A	A
Exercise – 3D movement (dance) (SR: Sherrington 2019)	C	NA	D	A	A	A	D
Exercise – General physical activity (walking or not specified) (SR: Sherrington 2019; Gillespie 2012)	B	A	D	A	A	A	D
Knowledge (SR: Rimland 2016, Gillespie 2012, Hill 2018)	B	A	D	A	A	B	D
Medication – Psychotropic drugs reductions or withdrawal (SR: Hill 2012, Gillespie 2012)	B	C	C	B	A	B	B
Medication – Vitamin D and analogues (SR: Gillespie 2012, Hill 2018)	B	B	C	B	A	C	C
Fluid or nutrition therapy-nutrition therapy (SR: Gillespie 2012)	C	A	D	A	B	C	D

Intervention	Evidence Statement Matrix						Grade of Recommendation
	Evidence base	Consistency	Clinical impact	Generalizability	Applicability		
					HIC	LMIC	
Surgery – Pacemaker insertion for fallers with cardio-inhibitory carotid sinus hypersensitivity (SR: Rimland 2016, Gillespie 2012**)**	B	B	B	A	B	C	C
Surgery – Cataract Removal (SR: Rimland 2016, Gillespie 2012)	B	C	C	B	B	C	C
Environment – furnishings adaptations (home) (SR: Rimland 2016, Gillespie 2012, Hill 2018)	A	B	B	A	B	C	A
Environment – Environment (Body worn aids for personal care and protection) (SR: Santesso et al., 2014; Gillespie 2012; Rimland 2016)	A	A	D	A	B	C	D
Environment – Communication aids (SR: Gillespie 2012; Rimland 2016)	A	B	D	A	B	C	D
Multiple interventions (SR: Rimland 2016, Gillespie 2012, Goodwin 2014, Hopewell, 2018, Hill 2018)	A	C	C	B	B	C	C
Multifactorial interventions (RCT: Cohen 2015, Cockayne 2017; Chu 2017; Moller 2014; SR: Burton 2015; Rimland 2016, Bunn 2014, Gillespie 2012, Zozula 2016, Hopewell, 2018, Hill 2018)	A	B	C	B	B	C	C

Exercise— Gait, balance, and functional training

Overall, the level of evidence for gait, balance, and functional training as a single intervention was rated as A, reflecting the large number of high-quality studies demonstrating substantial clinical impact and good applicability. Evidence was derived from 12 systematic reviews and 2 randomised controlled trials.

Balance and functional training

The Cochrane review by Sherrington, Fairhall et al. (2019) reviewed 48 RCTs, 6 of which were cRCTs, of the effect of balance and functional exercise programs (primarily gait, balance, coordination, or functional task training) on fall rate, risk of falling and number of people who experienced one or more fall-related fractures. Sherrington et al. reported findings by outcome type. Pooled analyses of 39 studies which reported fall rate, appraised as high certainty evidence, demonstrate a reduction in the rate of falls by 24% compared to controls (Sherrington, Fairhall et al. 2019). This effect did not vary according to participant fall risk at baseline, or program delivery via group or individual mode. However, interventions delivered by a health professional demonstrated a larger effect on rate of falls than programs not delivered by a health professional (Sherrington, Fairhall et al. 2019). Pooled results form 37 studies about the effect of balance and functional training on risk of falls with high certainty evidence and found the number of people experiencing one or more falls decreased by 13% (95%CI 0.82, 0.91) (Sherrington, Fairhall et al. 2019). This effect did not vary according to participant fall risk at baseline. For fall risk outcomes, little or no difference was found between programs delivered by health professionals and those that were not, nor between program delivery via group versus individual mode. Similarly, these interventions may reduce the number of people experiencing one or more fall-related fractures by 56% (95%CI 0.25-0.76) compared to control, however this was based on 7 trials appraised by Sherrington et al. as low certainly evidence.

The review by Gillespie et al. (2012) included pooled analyses for four trials of gait, balance and functional exercise programs. Group and home-based exercise programmes, usually containing some balance and strength training exercises. Group programs that included gait, balance and functional exercise resulted in a significant reduction in the rate of falls (4 trials) but not on the risk of falling (3 trials).

Rimland, Abraha et al (2016) reported on the results of systematic review by Thomas et al (Thomas, Mackintosh et al. 2010) of the Otago program at home, which pooled findings from 5 RCTS and one Controlled Clinical Trial (CCT) (Higgins, Thomas et al. 2019) and found a significant decline in fall rate (IRR 0.65).

Burton conducted a systematic review of exercise programs for older people with dementia (Burton, Cavalheri et al. 2015). Four studies were included, but only one examined the effect of exercise as a single intervention. This study included 3-arms: a group-based exercise program, a home-based exercise program, and usual care. The group exercise program consisted of pre-determined endurance, strength, and balance training. The home-based exercise program consisted of individually tailored training including balance and transfer training, walking, dual task training, and outdoor activities. Both were delivered by a physiotherapist. Compared to participants receiving usual care, those receiving home training had a significantly reduced fall rate. Those receiving group training also had a reduced fall rate compared with their usual care counterparts, although it was not statistically significant.

Gawler, Skelton et al. (2016) conducted a 3 arm RCT with community-dwelling adults aged 65+ recruited through GP practices in London and Nottingham. Those who fell more than 3 times in the past year were excluded. The study compared a home-based exercise program (based on Otago) vs community centred group exercise program (FAME) vs usual care. Otago participants were required to perform their 30-minute exercise 3 times per week. Volunteer peer mentors were recruited to provide home visit and telephone call support to Otago participants. FAME participants attended a once weekly, one hour supervised group exercise session which was supplemented with twice weekly 30-minute sessions of a home exercise program. Fall outcome data was based on self-report; during the 24-week intervention participants kept daily falls diaries and for 2 years thereafter, participants were asked about falls in the last 3 months. Adherence in both FAME and Otago was similar (40% in both conducted 75%

or more of program). The group exercise program (FAME) resulted in a significant reduction in injurious falls compared to the control group, an effect which continued for 12 months after program completion. The group program also significantly reduced all falls in the 12 months following program completion. The home-based program (Otago) did not have any significant intervention effect compared to usual care.

Hill, Sutton et al. (2018) conducted a systematic review of 26 RCTs of a range of falls prevention interventions among older people living in the community across Asia. Hill and colleagues identified three effective exercise programs that included balance training implemented through different modalities including: balance exercises in conjunction with strength exercises; Tai Chi; an obstacle course; and a combined group balance and strength training program. However, one of the ineffective exercise approaches included a group balance training program (Hirase, Inokuchi et al. 2015). Effective exercise programs were 24 to 52 weeks in duration and delivery varied from 1 to 8 times per week (Hill, Suttanon et al. 2018).

Home-based individual exercise

Hill, Hunter et al. (2015) conducted a systematic review of 12 trials of individualised home-based exercise programs, several of which targeted clinical groups (e.g. Parkinson's, Alzheimer's or hip fracture). Of these trials, one was a pragmatic trial and all were deemed high quality. While all studies included personalised, home-based exercise programs, the nature of the programs varied. Some studies were based on the Otago Exercise program (n=7, strength, balance, and walking, others were based on WEBB (n=1, Weight Bearing Exercise for Better Balance), LiFE (n=1, Lifestyle Integrated Functional Exercise approach), Exercise Plus (n=1) and some were unnamed (n=2). The programs ranged from being implemented over six weeks to two years and the frequency of exercise also ranged from three times a week to seven days a week. Pooled results from five studies found no significant effect of the intervention on the number of fallers. However, when a sensitivity analysis was performed with one study of participants recently discharged from hospital removed, the reduction in number of fallers in the intervention group was significant.

Clemson, Fiatarone, Singh and colleagues (2012) conducted a three arm RCT of home-based exercise programs with participants aged 70+ who had two or more falls or one injurious fall in the past twelve months, recruited from General Practice and Veteran's affairs databases. One group received the LiFE (Lifestyle Integrated Functional Exercise approach), which consist of strategies that are integrated into regular daily life activities, rather than being a prescribed set of exercises. Another group participated in a structured program for balance and lower limb strength while the control group participated in sham gentle home exercise program consisting of flexibility exercises, such as leg swings and hip rotations. Compared to the control group, LiFE participants had a statistically significant, 31% reduction in the rate of self-reported falls, but there was no difference between those who participated in the structured exercise and the control group.

Hill, Sutton and colleagues' (2018) systematic review found three ineffective programs conducted in Asia that used home based exercise programs, and one that combined group and home-based program. However, exercise programs that utilised a combination of both supervised and home-based sessions to delivery exercise programs were effective.

Dual task, perturbation and steps training

Dual task training, or cognitive motor interference (CMI) is a form of dual task training that involves carrying out two tasks simultaneously, a cognitive task and a motor task, e.g. walking while performing verbal fluency challenges. Wang, Pi et al. (2015) reviewed RCTs that compared CMI to no intervention or single task exercise with males and females aged 60 years and over with varying levels of cognition but excluding those with underlying pathology affecting balance such as Parkinson's disease. Findings from 27 of 30 examined studies were pooled. Those who participated in CMI had significantly lower fall rates than control groups. The follow up duration was less than one year and hence long-term effects are not known.

Booth et al. (2016) conducted a systematic review of combined cognitive and physical interventions among cognitively impaired people aged 65 years and over. They found 8 randomised studies, including studies of dual CMI training and studies of separate physical and cognitive components, as well as tailored training that included cognitive and physical components. Interventions were delivered via group settings, one-on one or with the assistance of technology, with intervention duration between 1-12 months. Control studies included standard care or single element comparator (either physical or cognitive training only). Four of these studies included fall outcomes. Findings were mixed; two trials found significant improvement in fall outcomes and two did not. Booth and colleagues found that although the effect of these interventions for older people with cognitive impairment was generally positive, evidence about their effectiveness was inconclusive.

Perturbation-based balance training incorporates exposure to repeated postural perturbations to evoke rapid balance reactions. Mansfield, Wong et al. (2015) conducted a metanalysis of perturbation-based balance training with older adults aged 60 years and over (healthy, frail and those with Parkinson's disease). The results from eight RCTS (404 participants) that examined perturbation-based balance training were pooled. Studies applied perturbations either manually or using equipment and included at least two training sessions. Pooled results revealed lower fall risk and rates among the intervention group compared to the control group. Despite promising results, the authors cautioned that the study quality was generally "low to fair".

Okubo et al. conducted a systematic review of 16 studies on interventions that trained "single or multiple volitional or reactive steps in an upright position in response to an environmental challenge (e.g., stepping on a target, avoiding an obstacle)". Only seven out of the 16 studies examined the impact of the intervention on falls. Pooled results from these studies revealed that step interventions significantly reduced the number of falls as well as the proportion of fallers among adults age 60 or older. Subgroup analyses reveal that both volitional and reactive interventions were individually effective and that neither living status (community vs. institution), risk-level, intervention duration, nor follow-up period influenced results.

In Hill, Sutton and colleagues' (2018) systematic review of 26 RCTs conducted in Asia they identified two studies that included a stepping program; one study which utilised a multi-target stepping program was found to be effective, but the other that implemented a square stepping program was ineffective.

Group- based strength and balance exercise programs of unspecified type

Martin (Martin, Wolf et al. 2013) conducted a systematic review to examine the effectiveness of group-based physiotherapist-led exercise among older adults 65 and older who either resided in the community or in institutional settings. Ten RCTs or controlled trials were included which either compared the intervention to a non-exercise control or to a home-based physiotherapist-led exercise program. While 10 studies were included, only 1 delivered group-based exercise as a single intervention and reported fall outcomes. This study by Means et a. (Means, Rodell et al. 2005)compared group-based exercise as single intervention to a no-exercise control group and found a small but significant reduction in fall rate and injury rate among the participants receiving the intervention.

Chan et al. (Chan, Yeung et al. 2015) conducted a systematic review of group-based exercise for people with cognitive impairment who were either living in the community or in an institutional setting. These exercises included training in balance and strength, flexibility, walking, and coordination. Overall, the dose of interventions varied from 45 to 120 minutes per session, at least twice a week, for 3 to 12 months. After pooling data from seven RCTs, the authors found a significant reduction in the fall rate among participants receiving the intervention; however, there were no significant differences in the rate of fall-related fractures.

Exercise— Strength/ resistance training

Overall, the level of evidence for strength/resistance training as a single intervention was rated as a D, reflecting the restricted clinical impact. Evidence was derived from two systematic reviews: Gillespie (2012), which included 5 randomized controlled trials that tested the effects of resistance training against a control group and Sherrington (Sherrington, Fairhall et al. 2019) which included 7 randomized controlled trials, 3 of which were also reported in Gillespie (Gillespie, Robertson et al. 2012) (total of 9 RCTs). Sherrington ultimately concluded that due to the low-quality evidence, the effectiveness of strength exercise in reducing the rate of falls was uncertain (Sherrington, Fairhall et al. 2019). Sherrington et al. were also uncertain whether this type of exercise reduces the number of people experiencing one or more falls, the number of people experiencing medically-attended falls, nor the number of people experiencing one or more fall related fractures. Gillespie and colleagues (2012) also found no significant effect on the rate of frequency of falls, nor the number of people falling. Across the two systematic reviews, 2 trials reported that musculoskeletal complaints were higher in the intervention groups than in control groups (Latham, Anderson et al. 2003, Liu-Ambrose, Khan et al. 2004).

Exercise— 3D exercise (Tai Chi)

Overall, the level of evidence for Tai Chi exercise as a single intervention was rated as an 'A'. Evidence was derived from three systematic reviews, Huang (2017), Sherrington (2019) and Gillespie(2012), all of which examined the effect of Tai Chi for community-dwelling people aged 60 years and over. Huang included trials with participants that varied in their health and function, while Sherrington and Gillespie excluded trials that focused on specific clinical populations (e.g. post stroke and Parkinson's). Huang (2017) included 18 randomised controlled trials, including one that also recruited from hospital settings, Gillespie (2012) included 7 randomised and quasi-randomised trials, and Sherrington (2019) included 10 RCTs, 2 of which were cluster RCTs.

In Huang and colleagues' (2017) review, pooled results from 16 studies revealed that the risk of falling was significantly lower in the Tai Chi group, regardless of exercise frequency, exercise duration, baseline fall risk, and style of Tai Chi. Additionally, pooled results from 15 studies revealed that the rate of falling was significantly lower in the Tai Chi group (Huang, Feng et al. 2017). Results from the analyses of both outcomes also suggest a dose-response relationship between exercise frequency and effect (Huang, Feng et al. 2017). Results also suggest a superior effect among Yang style Tai Chi rather than Sun style Tai Chi (Huang, Feng et al. 2017). Similarly, Gillespie and colleagues' (2012)review also reported a reduction in both fall rate (5 trials) and risk (6 trials) among participants who received the Tai Chi intervention. The authors also concluded that Tai Chi appears to be more effective in people who are not at high risk of falling at baseline (Gillespie, Robertson et al. 2012).

Sherrington's (Sherrington, Fairhall et al. 2019) pooled analyses largely support that of Huang and Gillespie (Gillespie, Robertson et al. 2012), concluding that the number of people experiencing 1 or more falls was reduced by 20% (8 trials, high certainty evidence) and that the rate of falls decreased by 19% (7 trials, low certainty evidence) among those who received the Tai Chi intervention. Sherrington also noted evidence from one RCT suggesting that tai chi may reduce the rate of medically attended falls (Sherrington, Fairhall et al. 2019). There were no adverse events reported in the two trials that reported adverse event data (Sherrington, Fairhall et al. 2019).

In Hill, Sutton and colleagues' (2018) review, Tai chi was shown to reduce falls when used as a single intervention in three Asian studies and in one non-Asian country. Tai chi was also a component of two ineffective multi-intervention studies, however in both studies the Tai chi component did not incorporate the recommended 50 hours of exercise that is considered likely to achieve significant falls reductions (Sherrington, Tiedemann et al. 2011). Hill, and colleagues' (2018) conducted a subgroup meta-analysis for Tai chi exercise interventions. Results showed that Tai Chi interventions significantly reduced the number of falls (OR: 0.24 [0.13–0.47]) and number of fallers (OR: 0.46 [0.30–0.70]), but the authors advised that there was high heterogeneity for the number of fallers ($I^2 = 67\%$) and to interpret these results with caution.

Exercise— 3D exercise (Dance)

Overall, the level of evidence for dance exercise as a single intervention was rated as a D, reflecting restricted clinical impact from a single study of poor quality. Evidence was derived from one systematic review (Sherrington, Fairhall et al. 2019), which included only one cluster randomized controlled trial that tested the effects of dance training against a control. Sherrington concluded that, due to the low-quality evidence, the effectiveness of dance exercise in reducing the rate of falls was uncertain.

Exercise— General physical activity

Overall, the level of evidence for general physical activity as a single intervention was rated as a D, reflecting the restricted clinical impact. Evidence was derived from two systematic reviews (Gillespie, Robertson et al. 2012, Sherrington, Fairhall et al. 2019). Sherrington's review included three randomized controlled trials that tested the effects of walking programs against a control, the effects of which were uncertain due to low study quality. Gillespie's review included two randomized controlled trials that tested the effects of walking programs against a control, none of which observed an intervention effect (Gillespie, Robertson et al. 2012).

Exercise – Exercise programs delivered in the Asian Region

Hill, Sutton et al. (2018) conducted a systematic review of 26 RCTs that conducted a range of falls prevention interventions among older people living in the community across Asia. The author's meta-analysis of exercise interventions including studies that conducted exercise as a single intervention (n = 15) and as a multifactorial intervention (n=4). Results indicated that exercise achieved a significant reduction in the number of falls (OR: 0.35 [0.21–0.57]), number of fallers (OR: 0.43 [0.34–0.53]), and number of fallers injured (OR: 0.50 [0.35–0.71]).

Knowledge

Overall, the level of evidence for education as a single intervention was rated as a D, reflecting restricted clinical impact. Evidence was derived from two systematic reviews (Gillespie, Robertson et al. 2012, Rimland, Abraha et al. 2016) which referenced some of the same studies. The reviews found that increased knowledge about falls prevention falls prevention had no effect on the rate of falls (based on one trial) nor on the risk of falling (based on four trials).

Medication— Psychotropic drugs reductions or withdrawal

Overall, the level of evidence for psychotropic drugs reduction/ withdrawal as a single intervention was rated as a B, reflecting moderate clinical impact, some inconsistent findings, and limited applicability due to issues with post-intervention adherence. Evidence was derived from two systematic reviews (Gillespie, Robertson et al. 2012, Hill and Wee 2012). Hill and Wee (2012)identified four studies on interventions to reduce psychotropic drug-induced falls. These studies, however, were not limited to older adults in the community, but also included older adults in residential care and hospital settings. Two studies aimed to reduce the use of psychotropic medicines specifically while the other two aimed to reduce the use in inappropriate medication generally but reported outcomes for psychotropic medicines. Among the former two studies, contrasting results were reported. One study which utilised a standardised falls definition, monthly falls calendars, and phone call follow up achieved a significant reduction in the use of psychotropic medications at the end of the 12-month intervention, but the reduction was dramatically minimised within 1-month of ceasing the study. Regardless, a significant reduction in falls was observed among the intervention group.

The other study achieved a significant reduction in the number of patients taking four or more psychotropic medications in the intervention group but did not observe a significant reduction in falls compared to the control group. This study, however, did not use a standardized falls definition and recorded outcomes retrospectively, which may have affected study results. The latter two studies also had contrasting results, with one identifying a reduction in composite medication score without a corresponding reduction in falls and the other reporting no significant reduction in inappropriate medication use despite observing a difference in falls rate between the intervention and control groups. Overall, the studies in Hill and Wee's (2012) review demonstrated some success. In Gillespie's review, one trial tested the effectiveness of gradual withdrawal of psychotropic medication. The authors observed that the rate of falls was significantly reduced, but not the risk of falling.

Medication— Vitamin D and analogues

Overall, the level of evidence for vitamin D and equivalent supplements as single interventions was rated as C. There was restricted clinical impact of Vitamin D overall, but significant clinical impact in those with low levels of Vitamin D. Vitamin D analogues had a significant clinical effect but were associated with adverse effects.

Evidence was derived from one systematic review (Gillespie, Robertson et al. 2012). Fourteen trials in this review evaluated the efficacy of Vitamin D either alone or with calcium supplementation (Gillespie, Robertson et al. 2012). Pooled results did not show a statistically significant effect on rate of falls, risk of falling or risk of fracture in study participants overall, regardless of fall risk status at baseline. However, in studies of people with low levels of Vitamin D at baseline, Vitamin D supplementation resulted in a significant reduction in both the rate of falls (2 trials) and risk of falling (4 trials). This suggests that targeted use of Vitamin D in people with low levels of Vitamin D may be effective.

In studies of Vitamin D analogues, one trial tested the effect of Calcitriol alone and reported a significantly reduced rate of falls and risk of falling, but not risk of fracture (Gallagher, Fowler et al. 2001). In another trial, Alfacalcidol did not result in a significant reduction in risk of falling (Dukas, Bischoff et al. 2004). Gillespie also noted that there was a statistically significant increase in hypercalcaemia in those receiving Vitamin D analogues (2 trials) (Gillespie, Robertson et al. 2012).

In Hill, Sutton and colleagues' (2018) systematic review there was one Asian study that investigated the effect of Vitamin D2 supplementation for two years, in combination with Vitamin K2 and Calcium, in older women with probable Alzheimer's disease. No effect on falls outcomes was found, but there was a signification reduction in fractures in the group receiving the medication.

Fluid or nutrition therapy

The level of evidence for fluid or nutrition therapy as a single intervention was rated as D, reflecting restricted clinical impact. Evidence was derived from one systematic review, which included three trials (Gillespie, Robertson et al. 2012). Pooled results from these trials revealed that older people receiving oral nutritional supplementation did not have a reduced risk of falling (Gillespie, Robertson et al. 2012).

Surgery— Pacemaker insertion for fallers with cardio-inhibitory carotid sinus hypersensitivity

Overall, the level of evidence for cardiac pacemaker insertion as a single intervention was rated as a C, reflecting variation in impact on different fall outcomes, the limited applicability of findings to the general population and potential barriers to accessibility in some health care settings. Evidence was derived from two systematic reviews (Gillespie, Robertson et al. 2012, Rimland, Abraha et al. 2016), with both reporting on the same five trials of fallers with cardio-inhibitory carotid sinus hypersensitivity. Cardiac pacing was associated with a reduced fall rate, but not fall risk or fracture risk, among fallers with cardio-inhibitory carotid sinus hypersensitivity. There is no evidence to support cardiac pacemaker insertion to reduce falls in the general population.

Surgery— Cataract removal

Overall, the level of evidence for cataract surgery as a single intervention to reduce falls in older people with cataracts was rated as a C, reflecting inconsistent findings, moderate clinical impact, study of specific populations and potential barriers to access.

Evidence was derived from two systematic reviews (Gillespie, Robertson et al. 2012, Rimland, Abraha et al. 2016), which both reported the same two trials. Both reviews reported on Harwood, Foss and colleagues' (2005) randomised control trial that found that cataract removal in one eye (expedited first eye cataract surgery) reduced fall rates among older women but not in risk of falling or fracture. However, there was no effect on the rate of falls when cataract surgery was performed on the second eye (Harwood, Foss et al. 2005, Gillespie, Robertson et al. 2012).

Rimland and colleagues' identified three additional systematic reviews of RCTS with older people of both genders of: cataract surgery (no decrease in the number of fallers); expedited cataract surgery (no reduction in fall rate compared to routine surgery) (Desapriya, Subzwari et al. 2010); and second eye cataract surgery (insufficient evidence to draw a conclusion) (Ishikawa, Desapriya et al. 2013).

Environment – Furnishings/ adaptations (home)

Overall, the level of evidence for environment and home modifications as a single intervention was rated as a A, reflecting a high-quality evidence base, consistent findings, substantial clinical impact, and good applicability. Evidence was derived from two systematic reviews (Gillespie, Robertson et al. 2012, Rimland, Abraha et al. 2016), with the results of Gillespie included in Rimland. In Gillespie and colleagues' (2012) review, it was found that home safety modifications were associated with a reduction in the rate and risk of falls. However, when subgroup analyses were conducted, this effect only persisted among individuals with a greater risk of falling and when the intervention was administered by an occupational therapist. Likewise, another review included in Rimland and colleagues' (2016) review, which mapped the evidence of occupational therapy for the elderly, reported that the one-year fall rate of older people living at home decreased following environmental modification by occupational therapists. Two other reviews were reported in Rimland and colleagues' review, one which reported a reduction in falls, and the other which did not observe a reduction in the number of fallers.

In the Hill, Sutton and colleagues' (2018) systematic review, two studies investigated home assessment and adaptation in Asia. One Japanese study compared the implementation of a home hazard checklist and training program on home hazards plus a multifactorial assessment and intervention program, to a control group that only received the multifactorial assessment and intervention program. The multifactorial assessment and intervention program included falls risk factor equation, exercise, blood pressure review and physical and cognitive assessments. The study showed a significant increase in falls prevention awareness and the implementation of home modifications, but no significant reductions in falls. Lin et al. (2007) conducted a randomised trial in Taiwan comparing home assessment and medication to an exercise intervention. Lin and colleagues (2007) reported no significant reduction in the rate of falls in the home safety intervention group, but the Cochrane review by Gillespie and colleagues (2012) reported a significant reduction.

Environment – body worn aids for personal care and protection

Overall, the level of evidence for environment and home modifications as a single intervention was rated as a D, reflecting restricted clinical impact. Evidence was derived from three systematic reviews (Santesso, Carrasco-Labra et al. 2014, Rimland, Abraha et al. 2016). Two systematic reviews reported on the effects of footwear modification, with Gillespie's findings on two RCTs contained within the Rimland and colleagues' (2016) review. In Gillespie, Robertson and colleagues' (2012) review, one RCT tested the effects of a non-slip shoe device, finding that it achieved a statistically significant reduction in the rate of outdoor falls during hazardous winter conditions. The other RCT tested the effect of balance-enhancing insoles, which did not result in a significant reduction in risk of falling when compared with 'normal' insoles. Two systematic reviews reported on the effects of hip protector provision on fall rate and fall-related fracture, with Santesso and colleagues' (2014) findings from five studies contained within Rimland's (Rimland, Abraha et al. 2016). Santesso and colleagues' (2014) conducted pooled analyses of five randomized trials, finding no significant effect between the intervention and control groups for all outcomes among community-dwelling older people.

Environment – communication aids

Overall, the level of evidence for communication aids as a single intervention was rated as a D, reflecting inconsistent findings, restricted clinical impact with the risk of harm from some interventions, and potential barriers to applicability in resource-poor settings. Evidence was derived from two systematic reviews (Gillespie, Robertson et al. 2012, Rimland, Abraha et al. 2016). Gillespie's review included three studies, the results of which were not pooled. In one study, the intervention included vision assessment and eye examination followed by the provision of spectacles or canes and the referral for expedited ophthalmology treatment, or mobility training, where relevant. This intervention significantly increased both the rate of falls (RaR 1.57, 95% CI 1.19- 2.06) and the number of participants falling (RR 1.54, 95% CI 1.24- 1.91). An increased risk of fracture was also observed, although this was not significant. In another study, single lens distance glasses were provided to regular wearers of multifocal glasses for indoor and outdoor walking and standing activities. Compared to continued to use multifocal glasses, this intervention produced a non-significant reduction in fall rate and risk, and a non-significant increase in fracture risk. However, the results differed when participants were split according to activity level. Among those more active participants, the intervention resulted in a significant decrease in all falls (inside plus outside) and outside falls, whereas among less active participants, the intervention resulted in a significant increase in outdoor falls. In the third study included in Gillespie's review, there was no significant reduction in fall rate among participants who received a visual acuity assessment and referral compared to those that did not. In addition to these three studies reported in Gillespie, Rimland reported an additional systematic review containing two RCTs, both of which found that vision correction did not influence number of fallers of community-living older people. Rimland notes that older people appear to be at increased risk during the period following changes to their prescription and while adjusting to new glasses and/or multifocal glasses.

Multi-component interventions

Multi-component interventions are those that comprise two or more fixed combinations of falls prevention interventions that are not individually tailored following a risk assessment (Goodwin, Abbott et al. 2014). Overall, the level of evidence for multiple component interventions was rated as C, mostly reflecting the inconsistency of findings and the moderate clinical impact. Evidence was derived from 4 systematic reviews (Gillespie, Robertson et al. 2012, Goodwin, Abbott et al. 2014, Rimland, Abraha et al. 2016, Hopewell S 2018). Rimland's review re-articulated the results of Gillespie's review, which was of trials published up to 2012. Gillespie found 19 individual trials that investigated different types of multiple interventions on the rate of falls (Gillespie, Robertson et al. 2012). Eight out of the 19 were able to reduce fall rate. Gillespie also found 18 trials that investigated multiple interventions on the risk of falling, with 5 out of them leading to fewer older people falling at home. Gillespie noted that the majority of the multiple intervention combinations included an exercise component. Because the results of individual trials could not be pooled, Gillespie summarised each individually, and ultimately concluded that few multiple interventions were effective. They further noted that exercise was included in all but one of the multiple interventions that were effective.

Hopewell and colleagues' (2018) review found 18 trials that assessed the effects of multiple component interventions for preventing falls. Multiple component interventions were compared to usual care or attention control in 17 trials, and to exercise in 5 trials[1]. 17 trials included exercise as an intervention in addition to: education, home safety, nutrition, psychological intervention, home safety and nutrition, home safety and vision assessment, or nutrition and psychological intervention. One trial assessed a nutrition and psychological intervention. Pooled results found that when compared to usual care there was moderate-quality evidence that multiple interventions probably reduce the rate of falls (RaR 0.74 (0.60, 0.91); 6 trials; 1085 participants) and risk of falls (RR 0.82 (CI 0.74, 0.90); 11 trials; 1980 participants). They also found there was low-quality evidence that multiple interventions may reduce the risk of recurrent falls, but that multiple interventions may have little or no effect on the risk of requiring medical attention for a fall. Conversely, they may slightly improve health-related quality of life. When compared to exercise there was low-quality evidence of little or no difference between the two interventions in rate of falls and risk of falling and very low-quality evidence, meaning we are uncertain of the effects on hospital admission (1 trial).

Goodwin and colleagues' (2014) review had a broader scope than that of Gillespie, but ultimately included ten of the same studies as Gillespie. Goodwin included trials that took place in any setting and that targeted specific clinical populations such as visual impairment, osteoporosis/osteopenia, and malnourishment. Goodwin's search resulted in 18 trials, 10 of which were delivered in community settings. When results of individual trials were pooled, Goodwin found that, compared to no intervention,

[1] Note that the numbers do not add up to 18 as some studies had multiple arms

placebo, or usual care, multi-component interventions significantly reduced both the fall rate (RR 0.80 (0.73 to 0.88)) and fall risk (RR 0.85 (0.80 to 0.91)) among older people. They performed a sensitivity analysis, removing two studies that took place in residential care settings (but retaining those that took place in other non-community settings such as outpatient clinics and hospitals), but found that this did not make a difference. In contrast to Gillespie, Goodwin ultimately concluded that multi-component interventions were effective at preventing falls.

In Hill, Sutton and colleagues' (2018) systematic review, five RCTS were identified that evaluated the effect of multiple interventions to reduce falls in Asia. Only one of the trials was effective, which including the provision of education and free access to a geriatric clinic. The four ineffective trials included a combined Tai chi exercise and education program, a combined Tai Chi and Cognitive Behavioural Therapy, an intervention that combined strength, balance and fitness exercise, health education, home assessment and modification, medication review, and ophthalmology and other specialty consultations, and a factorial design where participants received one or more of nutrition, exercise and cognitive training interventions.

Multifactorial interventions

Overall, the level of evidence for multifactorial component interventions was rated as C, reflecting moderate clinical impact, satisfactory evidence base, some inconsistency, and limited applicability to LMICs. Evidence was derived from 6 systematic reviews (Gillespie, Robertson et al. 2012, Bunn, Dickinson et al. 2014, Burton, Cavalheri et al. 2015, Rimland, Abraha et al. 2016, Zozula, Carpenter et al. 2016) and 4 randomized controlled trials (Möller, Kristensson et al. 2014, Cohen, Miller et al. 2015, Chu, Fong et al. 2017, Cockayne, Adamson et al. 2017). Cohen, Miller and Colleagues' (2015) trial was on the LIFT (Living Independently and Falls-free Together) Wellness Program, which recruited adults aged 75 and older who were not already receiving claims from the databases of long-term care insurers. Those consenting to participate were then randomly assigned to the intervention group, the active control group, or the administrative control group. Participants in the intervention group received a comprehensive, in-home clinical assessment conducted by a registered nurse, the results of which informed a personalised action plan that was then delivered to participants. The plan documented specific fall risk factors and provided recommendations for minimizing fall risk. Within 2 weeks of the delivery of the action plan, a nurse conducted a follow-up coaching call with the participant. Additionally, a newsletter was also mailed quarterly. Outcome data were collected from those in the intervention and active control groups, via interview, every three months over the course of the one-year intervention. Participants had been provided with a fall diary to aid their recall about falls. In the first year following the intervention, participants in the intervention group had an 11 percent reduction in risk of falling and an 18 percent reduction in risk of injurious falls, compared to participants in the active control group.

Cockayne, Adamson and colleagues' (2017) trial was of a multi-faceted podiatry intervention delivered in England and Ireland to adults aged 65 and older who had attended podiatry clinics for routine services in the previous 6 months and who had fallen within the last 12 months or experienced an injurious fall within the last 24 months. The intervention supplemented routine podiatry care with a falls prevention leaflet, foot and ankle exercises, foot orthoses, and, if required, new footwear. The number of self-reported falls at 12 months experienced by those randomized to the intervention were compared to that of their counterparts in the control group, who received usual podiatry treatment and the falls prevention leaflet. Outcome data were collected via self-reported monthly falls calendars. The authors observed a small, non-significant reduction in the incidence of falls and the proportion of participants experiencing falls in the intervention group. They also observed a significantly lower proportion of participants experiencing multiple falls in the intervention group. However, the intervention group reported more foot pain.

Chu, Fong and colleagues' (2017) trial was of an occupational therapy fall reduction home visit program. Participants were adults aged 65 and older, living in Hong Kong, who were admitted to the emergency department for a fall and who were then discharged to the home. Participants randomized to the intervention group received a single home visit from an occupational therapist within 2 weeks of discharge. The home visit lasted 1.5 hours and included an environmental hazards evaluation, a daily life routine assessment, a fall risk behavioural identification, recommendations for environmental recommendations, provision of a customised fall reduction care plan, and provision of on-site skills training. Referrals for community services and prescriptions of assistance devices were made where appropriate. Participants randomized to the control group received a well-wishing visit from a research assistant not trained in falls prevention. Primary outcome data were collected via telephone calls made every 2 weeks for 12 months. A fall diary was not provided to participants to aid recall. Analyses revealed that the intervention was effective in the short term, as demonstrated by a significant reduction in the number of fallers and number of falls at 6 months. However, there was no difference between the two groups at 9 nor 12 months.

Möller, Kristensson and Colleagues' (2014) trial was of a home-based case management intervention delivered in a Swedish municipality over one year. Participants were 65 years or older, needed help with at least two activities of daily living, and were admitted to the hospital at least twice or have had at least four outpatient contacts during the previous 12 months. Fall risk was not an inclusion criterion. The intervention comprised of monthly home visits by nurses and physiotherapists employing a multifactorial preventive approach. This approach included case management tasks, the provision of general information, the provision of specific information, and the availability of ongoing support via phone contact during office hours. Self-reported falls and self-reported injurious falls were elicited via structured interviews by research staff and collected at baseline and at 3, 6, 9, and 12 months. No significant differences were found between groups in falls, injurious falls, and medically attended falls.

Gillespie and colleagues' (2012) review included 40 trials, 16 of which had participants receiving an assessment and an active intervention rather than a referral and the remaining trials contained an intervention that consisted predominantly of assessment and referral or the provision of information. Pooled results from 19 trials revealed that multifactorial interventions were associated with a decline in fall rate (RaR 0.76, 95% CI 0.67–0.86). Pooled results from 34 trials revealed that they did not affect the risk of falling (RR 0.93, 95% CI 0.86–1.02). Pooled results from 11 trials did not show a significant reduction in the risk of fracture (RR 0.84, 95% CI 0.67-1.05). Two additional trials could not be included in the meta-analysis but neither concluded an intervention effect of the multifactorial intervention on falls. Overall, it appears that multifactorial interventions reduced the rate of falls but not the risk of falling. Rimland's review reported on the results of Gillespie's review and supplemented it with the results of three other meta-analyses and one randomized controlled trial. These studies found that multifactorial interventions did not reduce the number of fallers among older people at high risk of falling, the number of fallers among older people overall, the incidence of falls, nor falls experienced by older people with cognitive impairment respectively.

Hopewell's review found 43 trials comparing multifactorial interventions with usual care or attention control intervention. After assessment of each participant's risk profile the commonly applied or recommended interventions applied included exercise, environment or assistive technologies, medication review and psychological interventions. Pooled results found low quality evidence that multifactorial interventions may reduce the rate of falls compared with control (RaR 0.77, 95%CI 0.67, 0.87); 19 trials; 5853 participants. Hopewell et al. reported low-quality evidence of little or no difference in the risks of falling (RR 0.96, 95%CI 0.90, 1.03); 29 trials; 9637 participants); recurrent falls (RR 0.87 95%CI 0.74,1.03); 12 trials; 3368 participants); fall-related hospital admission (RR 1.00 95%CI 0.92, 1.07); 15 trials; 5227 participants); requiring medical attention (RR 0.91 95%CI 0.75, 1.10; 8 trials; 3078 participants). They reported low-quality evidence that multifactorial interventions may reduce the risk of fall-related fractures (RR 0.73 95%CI 0.53, 1.01); 9 trials; 2850 participants) and may slightly improve health-related quality of life but not noticeably (SMD 0.19 95%CI 0.03 to 0.35); 9 trials; 2373 participants). Three trials reported on adverse events; one found none, and two reported 12 participants with self-limiting musculoskeletal symptoms in total. One trial compared multifactorial interventions to exercise but was too small (n= 51) for conclusions to be made about the effect of multifactorial interventions on the rate of falls when compared to exercise.

Zozula, Caprenter and colleagues' (2016) review took a different focus. It specifically examined prehospital emergency services screening and referral and included 6 studies. However, only 2 of these studies examined falls outcomes. One study failed to demonstrate any reduction in the risk of falling within 30 days; however, it was not adequately powered. The other study cited a high effect size, indicative of an intervention effect, however it was judged by Zozula and colleagues that this effect size is likely overestimated due to a high risk of bias. Overall Zozula and colleagues concluded that they found no high-quality minimally biased evidence to suggest that prehospital emergency services screening and referral significantly reduce falls in community-dwelling older adults (Zozula, Carpenter et al. 2016).

Burton and colleagues' (2015) review investigated exercise-based falls prevention interventions for older adults with dementia. Two of their four included studies were delivered as a multifactorial intervention. One study delivered an intervention that featured individualised falls and injury management plans with a range of exercises, medication management, vision assessment, and footwear. This study was designed as a single-group pre and post study and experienced high attrition, with only 32 of the 64 participants completing a post-test. From baseline to post-test six months later, there was no significant differences in the number of falls. The second study delivered strength and balance training alongside a home hazard reduction program, which included 6 occupational therapy home visits, 5 physiotherapist home visits, and 3 phone calls. This study was designed as a randomized controlled trial. Compared to the control group, which received usual care, participants in the intervention group had a lower risk of falling at 3 months. However, this was not statistically significant.

Bunn, Dickson and colleagues' (2014) review investigated falls prevention interventions for older adults with mental health problems. Their review included four studies of multifactorial interventions that took place in the community, with only one finding a significant reduction in the incidence of falls in people with depressive symptoms. One other study, which was a pilot trial, found a non-significant reduction in fallers and incidence of falls in older people receiving a home hazard reduction and exercise program. Another study which took place in a geriatric outpatient clinic reported a non-significant increase in fallers and falls.

Hill, Sutton and colleagues' (2018) systematic review, four RCTS conducted in Asia were identified that implemented a multifactorial falls prevention intervention. Only one of the trials was effective in reducing falls in the intervention group, which incorporated an interdisciplinary care model pre- and post-surgery, improved discharge planning and post discharge follow up, including home visits, for patients discharged post hip fracture surgery (Shyu, Liang et al. 2010). One other study investigated improved discharge planning and follow up for patients post hip fracture surgery but was ineffective at reducing falls outcomes. The remaining two trials were ineffective and included the implementation of three monthly home visit health screening by a non-health professional with subsequent referral to a nurse or geriatrician, and a targeted falls risk brochure, followed up with targeted risk factor management support, focused on medication and home safety, by a visiting nurse.

Preventing falls in residential care facilities

Residential care facilities are domestic settings where long-term care is provided for people who are not able to care for themselves independently, for example due to age, disability or impairment, or substance dependence. Falls are common among people living in residential care facilities, largely due to the fact than many people requiring residential care are at risk of falls due to impaired mobility, function or cognition. The vast majority of research into preventing falls in residential care facilities is conducted with older residents.

In this section, we provide an overview of interventions and evidence from six systematic reviews and four randomized controlled trials that were included in this evidence synthesis.

Characteristics of included studies

Appendices 4C & D describes the extracted data from the included studies.

Populations

Older people living in residential aged care facilities requiring low to high levels of care.

Interventions

Four trials were included in this evidence overview. One tested the effectiveness of exercise as a single intervention (Sitja-Rabert, Martinez-Zapata et al. 2015), one the effectiveness of a nursing education program which trained participants to recognize harmful medications and adverse drug effects (Juola, Bjorkman et al. 2015), and the remaining examined a multifactorial intervention (Whitney, Jackson et al. 2017, Hewitt, Goodall et al. 2018) of which exercise was a component.

By virtue of their design, the six systematic reviews, together, encompassed a broader range of interventions. These included exercise (Stubbs, Denkinger et al. 2015, Rimland, Abraha et al. 2016, Lee and Kim 2017, Cameron, Dyer et al. 2018), staff training (Vlaeyen, Coussement et al. 2015, Rimland, Abraha et al. 2016), hip protectors (Santesso, Carrasco-Labra et al. 2014, Rimland, Abraha et al. 2016), environmental modifications (Rimland, Abraha et al. 2016), patient education (Vlaeyen, Coussement et al. 2015, Rimland, Abraha et al. 2016), vitamin D supplementation (Stubbs, Denkinger et al. 2015, Vlaeyen, Coussement et al. 2015, Cameron, Dyer et al. 2018), management of urinary incontinence (Vlaeyen, Coussement et al. 2015, Rimland, Abraha et al. 2016), lavender patches (Rimland, Abraha et al. 2016), sunlight exposure (Rimland, Abraha et al. 2016), along with combinations of these and other interventions delivered as a multicomponent or multifactorial intervention (Stubbs, Denkinger et al. 2015, Vlaeyen, Coussement et al. 2015, Rimland, Abraha et al. 2016, Lee and Kim 2017, Cameron, Dyer et al. 2018).

Outcomes

Studies examined the effects of the intervention on a fall or fall injury related outcomes, including fall rate (Santesso, Carrasco-Labra et al. 2014, Juola, Bjorkman et al. 2015, Sitja-Rabert, Martinez-Zapata et al. 2015, Vlaeyen, Coussement et al. 2015, Whitney, Jackson et al. 2017), fall risk (Vlaeyen, Coussement et al. 2015, Rimland, Abraha et al. 2016, Whitney, Jackson et al. 2017), recurring fall risk (Vlaeyen, Coussement et al. 2015), fracture risk and fracture rate (Santesso, Carrasco-Labra et al. 2014). Several non-fall specific outcomes were also examined, including acceptance and adherence (Santesso, Carrasco-Labra et al. 2014); complications or adverse effects (Santesso, Carrasco-Labra et al. 2014, Sitja-Rabert, Martinez-Zapata et al. 2015); prevalence of harmful medication use (Juola, Bjorkman et al. 2015); number of psychotropic medications (Juola, Bjorkman et al. 2015); balance, gait, and functional mobility (Sitja-Rabert, Martinez-Zapata et al. 2015, Whitney, Jackson et al. 2017); and economic outcomes(Santesso, Carrasco-Labra et al. 2014).

Settings

All studies took place in high income countries.

Quality of included studies

TABLE 4.1. QUALITY APPRAISAL OF THE INCLUDED SYSTEMATIC REVIEWS OF INTERVENTIONS FOR PREVENTING FALLS IN RESIDENTIAL CARE FACILITIES.

Authors	Cameron et al. (2018)	Lee et al. (2017)	Rimland et al. (2016)	Santesso et al. (2014)	Stubbs et al. (2015)	Vlaeyen et al. 2015)
1) Was an 'a priori' design provided?	Yes	No	No	Yes	Yes	Yes
2) Was there duplicate study selection and data extraction?	Yes	Yes	Yes	Yes	Yes	Yes
3) Was a comprehensive literature search performed?	Yes	Yes	Yes	Yes	Yes	Yes
4) Was the status of publication (i.e. grey literature) used as an inclusion criterion?	No	No	Yes	No	No	No
5) Was a list of studies (included and excluded) provided?	Yes	No	No	Yes	Yes	Yes
6) Were the characteristics of the included studies provided?	Yes	No	No	Yes	Yes	Yes
7) Was the scientific quality of the included studies assessed and documented?	Yes	Yes	Yes	Yes	Yes	Yes
8) Was the scientific quality of the included studies used appropriately in formulating conclusions?	Yes	Yes	Yes	Yes	Yes	Yes
9) Were the methods used to combine the findings of studies appropriate?	Yes	Yes	Yes	Yes	Yes	Yes
10) Was the likelihood of publication bias assessed?	Yes	No	No	No	Yes	No
11) Was the conflict of interest included?	Yes	No	Yes	Yes	Yes	Yes

TABLE 4.2. QUALITY ASSESSMENT OF RANDOMISED CONTROLLED TRIALS INVESTIGATING FALLS PREVENTION INTERVENTIONS IMPLEMENTED IN RESIDENTIAL CARE FACILITIES (LEVEL OF BIAS)

Authors	Hewitt et al (2018) (cluster RCT)	Juola et al. (2015) (cluster RCT)	Sitjà-Rabert et al. (2015) (cluster RCT)	Whitney et al. (2017) (clusterRCT)
Random sequence generation (selection bias)	Low	Low	Low	Low
Allocation concealment (selection bias)	Low	Unclear	Unclear	Low
Blinding of participants and personnel (performance bias)	High	High	High	High
Blinding of outcome assessment (detection bias)	Low	High	Low	Low
Incomplete outcome data (attrition bias)	Low	Low	Low1	Low2
Selective outcome reporting (reporting bias)	Low	Unclear3	Low	Low
Other bias	Low	Low	Low	Low

All outcomes listed in the Protocol paper of the cRTC were reported in the current paper
[2] A separate protocol paper was not listed; outcomes were well matched with study objectives
[3] The current paper reported 5/13 outcomes listed in the Protocol paper of the cRTC. However, it would not be practical to report all outcomes in one paper.

Discussion for Evidence of Interventions

In what follows, the evidence on each intervention type is summarised, starting with the findings for systematic reviews (where relevant) before moving onto primary studies. The summary for each intervention type should be considered in a manner that is relevant to the quality of the evidence. Quality of evidence is ranked in Table 4.3.

TABLE 4.3. SUMMARY OF APPRAISAL OF INTERVENTIONS FOR PREVENTION OF FALLS IN RESIDENTIAL CARE FACILITIES.

Intervention	Evidence Statement Matrix						Grade of Recommendation
	Evidence base	Consistency	Clinical impact	Generalizability	Applicability		
					HIC	LMIC	
Exercise (SR: Cameron 2018, Lee 2017, Rimland 2016, Stubbs 2015; RCT: Sitjà-Rabert 2015)	A	C	C	A	A	B	C
Environmental – Social Environment (SR: Rimland 2016, Vlaeyen 2015; Cameron 2018; RCT: Juola 2015)	A	C	C	A	A	C	C
Environment – Body worn protective aids (SR: Rimland 2016, Santesso 2014)	A	B	C	A	A	C	C
Environment – Furnishings and adaptations (SR: Rimland 2016)	A	B	D	A	B	C	D
Knowledge (resident)(SR: Rimland 2016)	B	B	C	A	A	C	C
Medication - Vitamin D and analogues (SR: Cameron 2018, Vlaeyen 2015, Stubbs 2015)	A	B	C	A	A	B	B
Medication Review (SR: Cameron 2018)	A	B	D	A	B	C	D
Other - Lavender Patches (SR: Rimland 2016; Cameron 2018)	C	C	D	A	A	B	D
Other - Increased Sunlight Exposure (SR: Rimland 2016; Cameron 2018)	C	C	D	A	B	B	D
Multicomponent Interventions (SR: Vlaeyen 2015; Cameron 2018)	C	C	D	A	A	B	C
Multifactorial Interventions (SR: Cameron 2018, Rimland 2016, Vlaeyen 2015, Stubbs 2015; Lee 2017; RCT: Whitney 2017; Hewitt 2018)	A	B	B	A	A	C	A

Exercise

Overall, the level of evidence of exercise as a single intervention for preventing falls in residential care facilities is C, mostly reflecting the quality of study designs, moderate clinical impact, some inconsistent findings, and potential barriers to applicability in LMIC settings. Four systematic reviews and one randomized controlled trial investigated the effectiveness of exercise in preventing falls.

Lee and Kim (2017) pooled the results of 18 trials and found a significantly lower rate of falls among those in the intervention group compared to the control group, but no difference in the number of fallers. However, when they estimated the effects of trials where exercise was delivered as a single intervention and removed from their analyses trials in which exercise was delivered as a multifactorial intervention, they found that no significant differences between the intervention and the control group in the rate of falls nor in the number of fallers. Like Lee and Kim's review, Rimland's (Rimland, Abraha et al. 2016) review also included studies of exercise across multiple modes of delivery. In Rimland's review, there were three such studies which took place in care facilities. Two studies pooled the results of trials in which exercise was delivered as a single intervention and found no significant effect. The remaining study of exercise interventions included in Rimland's review pooled trials of exercise delivered both individually and as part of a multifactorial intervention. Those results will not be discussed here as the evidence it provides is aggregated at a level that is incompatible with the established intervention categories in this synthesis.

Cameron and colleagues (2018) pooled the results of ten trials that compared exercise as a single intervention with usual care. They ultimately concluded that they were uncertain of the effectiveness of exercise in reducing the rate of falls, as the quality of the evidence was assessed as very low. However, they also noted the variation in study outcomes between studies and attributed this to differences in the level of care provided to participants. This implies that exercise effectiveness might vary depending on participants' functional capacity and/or other characteristics such that it may be effective in some population subgroups but not others. Cameron and colleagues further noted that exercise "may make little or no difference to the risk of falling" but acknowledged that, in one of their included studies, the primary authors found differences between frail and non-frail participants whereby frail participants may have had an increased risk of falling as a result of the exercise intervention. This may be a result of the exercise intervention being at a level (e.g., intensity) that is beyond the adaptive capacities of those specific participants. The mixed nature of the evidence was also echoed by Stubbs and colleagues (2015), who cited "inconsistent evidence" across four meta-analyses.

Sitja-Rabert and colleagues (2015) examined the effectiveness of a progressive strength and balance training program in preventing falls when performed on Whole Body Vibration platform over 6 weeks. They found that exercise on the platform had no effect on the number of falls when compared to exercise without the platform. However, the number of falls was not their primary outcome and therefore not the basis of sample size calculations. Therefore, it is possible that the lack of effect of the vibration platform may be due to insufficient power.

Environmental – Social Environment

The social environment includes staff training and service model changes (Europe. 2011). Overall, the level of evidence about the effect of changes to the social environment as a single intervention for preventing falls in residential care facilities is C, reflecting some inconsistent findings, moderate clinical impact, and potential barriers to applicability in LMIC settings. Three systematic reviews (Vlaeyen, Coussement et al. 2015, Rimland, Abraha et al. 2016, Cameron, Dyer et al. 2018) and one randomized controlled trial (Juola, Bjorkman et al. 2015) investigated the effectiveness of staff training in preventing falls.

In the most recent review, Rimland and colleagues (2016) commented on four trials which tested the effects of unspecified staff training. While the results from these trials were not pooled, the authors indicated that no effect on the rate of falls nor on the number of fallers was observed. Vlaeyen and colleagues (2015) reviewed four studies of staff training interventions delivered in nursing homes, which they described as providing around-the-clock personal care but limited clinical care. Two of these studies focussed on dissemination of information on falls prevention, as well as fall risk assessment and potential modification of risk factors. One also included education on post falls management review. Results of these two studies were pooled and the pooled estimates revealed that the intervention group had significantly more falls than the control group, despite staff training, indicating a harmful intervention effect.

The other two relevant studies in Vlayen and colleagues' review evaluated medication-related service model changes, one of which used medication records to identify patients for observation by nurse assistants and the other of which trained pharmacists who reviewed clinical and prescribing information and then consulted with general practitioners to improve prescribing behaviour. The two studies were pooled; the pooled effect estimate indicated a nonsignificant intervention effect.

In Cameron and colleagues' (2018) review, three intervention studies were identified, one a half-day education programme about fall and fracture prevention for managers, nurses, and health care assistants, another an intervention for an unspecified target group to learn how to implement a patient-safety programme, and the last a program to improve staff connections, communication, and problem-solving. For all three studies, the authors cited uncertainty of evidence as the equality of the evidence was very low.

Despite the findings reported in the reviews, a randomized controlled trial conducted in Finland found staff training to be an effective intervention for falls prevention (Juola, Bjorkman et al. 2015). In that study, staff training consisted of two four-hour interactive training sessions designed to train nurses to recognise potentially harmful medications. Despite the trial presumably not being powered to detect falls outcomes, as falls were a secondary outcome, and the possibility that nurses in the control facilities could undertake training relating to medication use, the authors reported that the trial was effective at reducing the incidence of falls over 12 months. Specifically, the intervention group had an adjusted fall rate that was significantly lower than that of the control group. However, the intervention appeared to make no difference among participants with a MMSE score that was below 10.

The promising findings from Juola and colleagues' trial (2015), which contrasted with the negative results from these other reviews, may be explained by differences in the nature of the training intervention and in the care setting. Regarding the former, Juola and colleagues' trial tested an intervention which had a very targeted and specific goal (to reduce harmful medication) while the studies included in Vlaeyen and colleagues' (2015) review consisted of less focussed training. Unfortunately, the nature of the training programs contained in Rimland et al.'s (2016) review was not specified. Regarding the latter, trial took place in Finland where nursing staff are highly qualified; their high level of competence may be associated with increased ability to implement the lessons from their training to improve patient safety (Juola, Bjorkman et al. 2015).

Environmental – Body-worn protective aids

Hip protectors are plastic shields or foam pads, usually fitted in pockets in specially designed underwear (Santesso, Carrasco-Labra et al. 2014). Overall, the level of evidence of hip protectors as a single intervention for preventing falls in residential care settings is C, reflecting the few inconsistent findings, moderate clinical impact, and potential barriers to applicability in LMIC settings. This may be partially explained by compliance, which is generally low (Santesso, Carrasco-Labra et al. 2014). Two systematic reviews (Santesso, Carrasco-Labra et al. 2014, Rimland, Abraha et al. 2016) investigated the effectiveness of hip protectors in preventing fall-related injuries, specifically hip fractures.

Santesso and colleagues (2014) conducted a review and meta-analysis solely focussed on evaluating the effectiveness of hip protectors. Fourteen trials were conducted in institutional settings, and when pooled, their results indicate a small reduction in hip fractures with the provision of hip protectors. This effect was borderline statistically significant when all trials were included and not significant after the removal of four trials deemed to be at high risk of bias. Overall, the authors concluded that these trials were of moderate quality and were in favour of a small reduction in hip fractures. When the effect of hip protectors on pelvic fractures, other fractures, and falls were analysed, the authors found no significant intervention effect. They further noted that there may be a slight increase in pelvic fractures, but that that estimate is imprecise and based on a mixed residential and community setting. Rimland and colleagues' (2016) review identified a prior review of 4 trials, the results of which were not pooled. While the evidence across those 4 trials were inconclusive, the authors ultimately recommended hip protectors.

Environment – Furnishings and adaptations

Overall, the level of evidence for modification of the environmental through furnishings and adaptations as a single intervention for preventing falls in residential care settings is D, reflecting restricted clinical impact and potential barriers to applicability in LMIC settings. One systematic review included studies that examined the effectiveness of environmental modification in falls prevention (Rimland, Abraha et al. 2016). Of the five such studies, three were relevant to residential care facilities, while the other two focussed specifically on hospital settings. However, all three studies, which were reviews themselves, focused on a mixed hospital and residential care setting and included environmental interventions delivered both as a sole intervention and as part of a multifactorial strategy. In those studies, environmental modification encompassed bed modifications such as low height beds and bed exit alarms, wireless position-monitoring device, carpeted floors, and identification bracelets. No study observed a reduction in falls.

Knowledge

Overall, the level of evidence of increasing residential care recipients' knowledge as a single intervention for preventing falls in residential care settings is C, reflecting moderate clinical impact and potential barriers to applicability in LMIC settings despite good study designs and minimal inconsistencies between studies. One systematic review included studies that examined the effectiveness resident education in falls prevention (Rimland, Abraha et al. 2016). In that review, the results of two randomized controlled trials were described, which diverged in their conclusions. One study observed a decline in fall rate associated with the intervention which targeted individual fall risk factors among patients with a high risk of falling. However, the other study observed no effect on either fall rate or the number of fallers. The nature of the training program in the latter study was not detailed in Rimland's review.

Medication - Vitamin D and analogues

Overall, the level of evidence of vitamin D supplementation as a single intervention for preventing falls in residential care settings is B, reflecting moderate clinical impact despite good to excellent ratings across other domains. Across the three systematic reviews that investigated the role of Vitamin D supplementation in preventing falls, mixed results emerged. In the most recent review, Cameron and colleagues (Cameron, Dyer et al. 2018) concluded that, based on moderate quality evidence, "Vitamin D supplementation probably reduces the rate of falls but that it probably makes little or no difference to the risk of falling". The two other reviews either found no significant reduction in the number of falls or fallers (Vlaeyen, Coussement et al. 2015) or found mixed results across a small set of studies, ultimately concluding that the current evidence does not support Vitamin D supplementation to reduce falls in this setting (Stubbs, Denkinger et al. 2015).

Medication Review

Overall, the level of evidence to support medication review as a single intervention for preventing falls in residential care settings is D, reflecting restricted clinical impact in included studies and potential barriers to applicability. Evidence was derived from one systematic review (Cameron, Dyer et al. 2018), which identified twelve studies on the effect of medication review interventions in care facilities on falls. Pooled results from six clinically similar trials on general medication review revealed no significant effect on the rate nor risk of falls. An additional cluster RCT was conducted to educate physicians on drug use in older people and included a medication review with feedback in 10% of patients. The authors of that study did not observe a significant intervention effect in the three months following the intervention.

Other - Lavender Patches

Overall, the level of evidence to support the use of lavender patches as a single intervention for preventing falls in residential care settings is D, reflecting lower ratings for quality of study design, consistency, and clinical impact. Evidence were derived from two systematic reviews (Cameron, Dyer et al. 2018). Cameron's review identified one individually randomised trial which examined the effect of lavender olfactory stimulation over one year. The intervention consisted of applying lavender patches or placebo patches to clothing near the neck daily. The authors observed no significant effect on the rate nor the risk of falls and the quality of the study was rated by Cameron et al. (2018) to be very low. This conclusion was echoed by Rimland in the second review.

Other - Increase Sunlight Exposure

Overall, the level of evidence of increase sunlight exposure as a single intervention for preventing falls in residential care settings is D, reflecting lower ratings for quality of study design, consistency, and clinical impact despite good to excellent ratings for applicability and generalisability. Evidence were derived from two systematic reviews (Rimland, Abraha et al. 2016, Cameron, Dyer et al. 2018). Cameron's review identified one cluster-randomised trial of sunlight exposure. The authors observed low adherence to the intervention and no effect on falls. Cameron concluded the quality of the evidence to be very low. This conclusion was echoed by Rimland in the second review.

Multicomponent Interventions

Multicomponent interventions are those where the same combination of single categories of intervention was delivered to all participants in the group (Cameron, Dyer et al. 2018). Overall, the level of evidence of multicomponent interventions for preventing falls in residential care settings is C, reflecting fewer high-quality studies, some inconsistent findings, and restricted clinical impact. Two reviews included multicomponent interventions (Vlaeyen, Coussement et al. 2015, Cameron, Dyer et al. 2018). Within Vlaeyen and colleague's review, only one study was cited. In that study, the multicomponent intervention consisted of incontinence care and a low-intensity functionally oriented exercise program. The authors did not observe an effect of the intervention on the number of falls or fallers. Within Cameron's review, three trials were cited. One comprised of supervised exercises, fluids, and regular toileting, which did not result in any effect on the rate nor the risk of falls and which was described by Cameron as low-quality evidence. Another trial comprised of increase sunlight exposure plus calcium supplementation, which also did not result in any intervention effect and which was also described as low-quality evidence. The last trial in Cameron's review combined cognitive behavioural therapy to address fear of falling with an exercise program over eight weeks. Because of the low-quality evidence, Cameron concluded that the effects of this intervention remain uncertain.

Multifactorial Interventions

Multifactorial interventions are defined as interventions where there are multiple intervention components and where the delivery and/or selection of the interventions are linked to an individual's risk profile, which is determined via an individual risk assessment (Cameron, Dyer et al. 2018). Overall, the level of evidence of multifactorial interventions for preventing falls in residential care settings is A, reflecting good to excellent rating across most domains despite potential barriers to applicability in LMIC settings. Some mixed results were reported across and within the studies, and this is likely due to differences in the number and nature of intervention components and the manner in which individual risk was assessed and the basis by which the it provided information for individual tailoring. Five systematic reviews (Stubbs, Denkinger et al. 2015, Vlaeyen, Coussement et al. 2015, Rimland, Abraha et al. 2016, Lee and Kim 2017, Cameron, Dyer et al. 2018) and two randomized controlled trials (Whitney, Jackson et al. 2017, Hewitt, Goodall et al. 2018) examined the role of multifactorial interventions on falls prevention.

Cameron and colleagues (Cameron, Dyer et al. 2018) found no statistically significant effect on the rate of falls when the results of ten trials were pooled nor on the risk of falling when the results of nine trials were pooled. In subgroup analyses, Cameron and colleagues (Cameron, Dyer et al. 2018) found that decreases in both fall rate and risk occurred among participants in care facilities that provide either high or intermediate levels of care, while the lack of intervention effect persisted when analyses were stratified by the cognitive status of participants.

In the review conducted by Rimland and colleagues (Rimland, Abraha et al. 2016), five out of the seven relevant studies reported quantitative, inferential results. Of these five primary studies, two studies (which pooled the results of nine trials and six studies respectively) reported a decline in falls or fall rate associated with the multifactorial intervention; two studies (which pooled the results of seven trials and 59 studies respectively) cited no intervention effect; and the remaining reported mixed results, which varied by outcome measure (e.g., risk vs. rate vs. recurrent fallers).

Vlaeyen and colleagues (Vlaeyen, Coussement et al. 2015) made similar observations- that, pooled estimates of the included multifactorial interventions differed in the direction and magnitude of effect depending on the outcome measure. Specifically, they found that multifactorial interventions had a significant beneficial effect for the number of falls and recurrent fallers but not for the number of fallers.

In contrast to Cameron, Rimland, and Vlaeyen's reviews, Stubbs and colleagues (Stubbs, Denkinger et al. 2015) concluded that "multifactorial interventions are effective in reducing falls in long-term care facilities". Their conclusion was based on the results of two meta-analyses, both of which were deemed to be high quality.

Specific to exercise when delivered as a multifactorial intervention, Vlaeyen and colleagues (Vlaeyen, Coussement et al. 2015) found exercise to have a significant beneficial effect on the number of falls but not for the number of fallers. In contrast, Lee and Kim (2017) pooled the results of a subset of 18 exercise trials in which the mode of delivery was through a multifactorial intervention and found that the rate of falls and the number of fallers were significantly lower among the intervention group.

Two trials examined multifactorial interventions with exercise components(Whitney, Jackson et al. 2017, Hewitt, Goodall et al. 2018). Hewitt (Hewitt, Goodall et al. 2018) reported the results of a multi-factorial exercise intervention where the progressive resistant training component was individually tailored and performed in addition to a non-tailored progressive balance exercise. They found a significant reduction in the rate of falls among the intervention group during the 12-month program. Whitney (Whitney, Jackson et al. 2017) also examined exercise in the context of a multi-factorial intervention. In this study, the exercise component consisted of a twice weekly balance training session. The authors found that, after 6 months, no differences were evident in the risk or rate of falls between the group exposed to the multifactorial intervention and the group who received usual care. However, sample size calculations were not based on fall related outcomes, suggesting that detection of effect may be inadequate, and not all participants receiving the intervention participated in or completed the exercise component, suggesting implementation may be inadequate.

Preventing falls in hospitals

Hospitals treat a wide variety of people, including patients of all ages admitted for many reasons, and while they aim to alleviate illness and injury, they are complex places where adverse events can result in harm to individuals. Most of research on falls prevention in hospitals has been conducted with older adults (DiBardino, Cohen et al. 2012, Hempel, Newberry et al. 2013, Miake-Lye, Hempel et al. 2013, Lee, Pritchard et al. 2014, Stubbs, Denkinger et al. 2015, Rimland, Abraha et al. 2016, Marques 2017, Cameron, Dyer et al. 2018). In this section, we provide an overview of interventions and evidence from seven systematic reviews.

Characteristics of included studies

Appendices 5C & D describes the extracted data from the included studies.

Populations

Older people aged 60 years and over in hospital

Interventions

The interventions included in the systematic reviews were exercise (Rimland, Abraha et al. 2016, Cameron, Dyer et al. 2018), environmental modification (Marques 2017, Cameron, Dyer et al. 2018), changes to the social environment (Rimland, Abraha et al. 2016, Cameron, Dyer et al. 2018), patient education (Rimland, Abraha et al. 2016, Cameron, Dyer et al. 2018), medication review (Cameron, Dyer et al. 2018), vitamin D supplementation (Cameron, Dyer et al. 2018), along with combinations of these and other interventions delivered as a multicomponent (Miake-Lye, Hempel et al. 2013) or multifactorial intervention (Stubbs, Denkinger et al. 2015, Rimland, Abraha et al. 2016, Cameron, Dyer et al. 2018).

Outcomes

Studies examined the effects of the intervention on falls or fall-related injury outcomes, including fall rate (Hempel, Newberry et al. 2013, Lee, Pritchard et al. 2014, Hill, McPhail et al. 2015, Hill, Hunter et al. 2015, Stubbs, Denkinger et al. 2015, Cameron, Dyer et al. 2018), injurious fall rate (Lee, Pritchard et al. 2014, Barker, Morello et al. 2016), fall risk (Lee, Pritchard et al. 2014, Stubbs, Denkinger et al. 2015, Rimland, Abraha et al. 2016, Cameron, Dyer et al. 2018), injurious fall risk (Lee, Pritchard et al. 2014), and the number of falls (Miake-Lye, Hempel et al. 2013). Results from Hempel were not used, as the authors pooled the effects of studies which contained a mix of single and multi-component interventions. As such, the evidence it provides is aggregated at a level that is incompatible with the established intervention categories in this synthesis.

Settings

All include reviews that reported study locations took place in high income countries.

Quality of included studies

TABLE 5.1. QUALITY APPRAISAL OF THE INCLUDED SYSTEMATIC REVIEWS OF INTERVENTIONS FOR PREVENTING FALLS IN HOSPITALS.

Authors	Cameron et al. 2018	Hempel et al. 2013	Lee et al. 2014	Marques et al. 2017	Miake-Lye et al 2013	Rimland et al. 2016	Stubbs et al. 2015
1) Was an 'a priori' design provided?	Yes	Yes	No	Yes	No	No	Yes
2) Was there duplicate study selection and data extraction?	Yes	No	No	N/A	No	Yes	Yes
3) Was a comprehensive literature search performed?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
4) Was the status of publication (i.e. grey literature) used as an inclusion criterion?	No	Yes	No	Yes	No	Yes	No
5) Was a list of studies (included and excluded) provided?	Yes	No	No	Yes	No	No	Yes
6) Were the characteristics of the included studies provided?	Yes	Yes	No	N/A	Yes	No	Yes
7) Was the scientific quality of the included studies assessed and documented?	Yes	No	No	N/A	Yes	Yes	Yes
8) Was the scientific quality of the included studies used appropriately in formulating conclusions?	Yes	No	No	N/A	No	Yes	Yes
9) Were the methods used to combine the findings of studies appropriate?	Yes	Yes	Yes	N/A	No	Yes	Yes
10) Was the likelihood of publication bias assessed?	Yes	Yes	No	N/A	No	No	Yes
11) Was the conflict of interest included?	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Discussion for Evidence of Interventions

Below is a summary of the evidence for each intervention type.

TABLE 5.2. SUMMARY OF EVIDENCE APPRAISAL OF INTERVENTIONS FOR PREVENTION OF FALLS IN HOSPITALS.

Intervention	Evidence Statement Matrix						Grade of Recommendation
	Evidence base	Consistency	Clinical impact	Generalizability	Applicability		
					HIC	LMIC	
Exercise (SR: Cameron 2018, Rimland 2016)	A	C	C	A	A	B	C
Environmental – Furnishings and adaptations (SR: Cameron 2018, Marques 2017, Rimland 2016)	A	B	D	A	A	C	D
Environmental – Social Environment (SR: Rimland 2016; Cameron 2018)	A	B	C	A	A	C	D
Knowledge (patient) (SR: Rimland 2016, Lee 2014; Cameron 2018)	A	B	B	A	A	C	C
Medication Review (SR: Cameron 2018)	D	D	D	D	A	B	D
Medication - Vitamin D & analogues (SR: Cameron 2018)	D	D	D	D	A	C	D
Multicomponent Interventions (SR: Miake-Lye 2013)	A	B	B	A	A	C	B
Multifactorial Interventions (SR: Cameron 2018, Rimland 2016, Stubbs 2015, Lee 2014)	A	C	B	A	A	C	C

Exercise

Overall, the level of evidence for exercise as a single intervention for preventing falls in hospitals was rated as a C, reflecting the quality of study designs and strong generalisability and applicability, but low clinical impact. Two systematic reviews investigated the independent effects of exercise as a single intervention in preventing falls in hospitals (Rimland JM 2016, Cameron, Dyer et al. 2018). Both reviews were of high quality, reported results are consistent between studies and exercise interventions were mostly generalisable. However, across both reviews, the magnitude and direction of effect depended on the outcome measure used and, when there was a significant effect, effect sizes were small. Specifically, Cameron (Cameron, Dyer et al. 2018) pooled the results of 3 trials that tested exercise in rehabilitation wards of hospitals. They rated the overall quality of the evidence as very low, finding evidence of a reduction in fall risk but no evidence for a reduction in falls rate. In Rimland's review (Rimland, Abraha et al. 2016), only one previous review examined exercise as a single intervention in hospitals (Rimland, Abraha et al. 2016). That review found that supervised exercise in subacute wards did not decrease the fall rate, although it led to a decrease in fall risk.

Environmental – Furnishings and adaptations

Overall, the level of evidence for environmental modification through furnishings and adaptations as single interventions for preventing falls in hospitals was rated as poor (D), mostly reflecting the restricted clinical impact and the potential barriers to applicability in LMIC settings. Three systematic reviews investigated the effects of modification to physical hospital environments in preventing falls(Rimland, Abraha et al. 2016, Marques 2017, Cameron, Dyer et al. 2018). For the most part, only studies which examined hospital environment modifications independently were included in the evidence base; however, some studies did not distinguish whether the intervention was delivered alone or as part of a multifactorial strategy. Likewise, few studies did not distinguish between hospital and residential care settings.

The Marques review (Marques 2017) focussed exclusively on bedrails in non-ICU settings; however, they found no studies that met inclusion criteria and therefore did not have findings to report. Bed modification was also examined in Rimland's review (Rimland, Abraha et al. 2016), via two separate reviews. Neither of these reported an intervention effect for bed modification, with one which examined low bed heights and bed alarms citing no effect and the other which examined bed alarms citing inconclusive evidence. However, the results of these cannot be attributed solely to bed interventions in hospital settings, as one review was of a mixed hospital-residential setting and the other did not distinguish whether intervention was delivered alone or as part of a multifactorial strategy. The results of Cameron's review (Cameron, Dyer et al. 2018) echoed that of Rimland, whereby the effects of low bed heights and bed alarms were rated as inconclusive due to the low-quality evidence.

Aside from bed modifications, the evidence claimed no effect of chair modifications (Rimland, Abraha et al. 2016), identification bracelets (Rimland, Abraha et al. 2016, Cameron, Dyer et al. 2018), nor various other environmental modification interventions (Rimland, Abraha et al. 2016). However, some of these studies were conducted in mixed hospital-residential care settings. Both Rimland and Cameron's review (Rimland, Abraha et al. 2016, Cameron, Dyer et al. 2018) reported that floor carpeting led to increased fall rates.

Environmental – Social Environment

The social environment includes staff training and service model changes (Europe. 2011). Overall, the level of evidence to support changes to health service delivery as a single intervention for preventing falls in hospitals was rated as poor (D), mostly reflecting the moderate clinical impact and issues with applicability, particularly in LMIC settings. Two systematic reviews investigated the effects if social environment changes in preventing falls (Rimland, Abraha et al. 2016, Cameron, Dyer et al. 2018). Some studies included in these reviews did not distinguish between hospital and residential care settings.

In Rimland's review (Rimland, Abraha et al. 2016), staff training and service model changes in hospitals and residential settings were analysed together with estimates indicating no influence of the interventions on falls. Cameron's review examined service model changes more closely, referring to the implementation of clinical guidelines (no effect; low quality evidence), the use of a computer-based falls prevention tool kit (no effect; low quality evidence), a behavioural advisory service for people with confusion (no effect), and a change in the ward within a hospital. Regarding the latter, two studies provide contrasting results. In one study, the intervention was the provision of care in an acute ward for the elderly, which found no strong evidence of an intervention effect. However, the other RCT compared post-operative care in a ward providing a comprehensive ortho-geriatric service to usual care on an orthopaedic ward among patients following surgery for hip fracture. This study found that the intervention group had a substantially and significantly lower rate of both falls and a risk of falling at discharge (Stenvall, Olofsson et al. 2007).

Knowledge (patient)

Overall, the level of evidence to support improving patient knowledge as a single intervention for preventing falls in hospitals was rated as satisfactory (C), mostly reflecting the moderate clinical impact in included studied. Three systematic reviews investigated the independent effects of patient education in preventing falls in hospitals (Lee, Pritchard et al. 2014, Rimland, Abraha et al. 2016, Cameron, Dyer et al. 2018).

In Rimland's review (Rimland, Abraha et al. 2016), the results of two randomized controlled trials in a mixed hospital and residential care setting were described, which diverged in their conclusions. One study concluded a decline in fall rate associated with the intervention and the other study concluded no effect on either fall rate or the number of fallers. While differences in the nature of the intervention and/or its delivery and in the characteristics of the patients could explain the divergent findings, no information in this regard was provided.

In Lee's review (Lee, Pritchard et al. 2014), five studies were included that focused solely on hospitalised older adults in receipt of patient education delivered as a single intervention. While information was provided about the characteristics of education as a single intervention (e.g., three intensive patient education programs and two brief education programs), their effects on falls were pooled with findings from studies about education delivered as part of a multifactorial intervention and/or with people after discharge from hospital.

Cameron et al (Cameron, Dyer et al. 2018) reported a number of results which were derived from pooling the estimates of multiple studies according to combinations of settings (hospital vs. post-hospital), mode of delivery (individual vs. multifactorial), outcome measure (fall risk, fall rate, injurious fall risk, injurious fall rate), and patient cognitive status with most analysis broader in scope than that on which we focus. The analysis that was closest in scope to our focus reported only hospital-based studies, but which may have included patient education in a multifactorial format. That analysis found a statistically significant reduction in the proportion of patients who became fallers.

Cameron's review included two trials: one was of an education session provided by a trained research nurse and targeted individual risk factors among patients at a high risk of falling and which, although low quality, found a reduction in fall risk. The other compared two forms of education to each other and to usual care. Compared to usual care, neither resulted in an intervention effect; however, the authors suggested that cognitively intact participants of the more intensive intervention (written and video materials along with one-on-one bedside follow up from a physiotherapist) had less frequent falls. Ultimately, Cameron expressed low confidence in these results but suggest that providing educational materials only may make little or no difference to falls.

Medication Review

Overall, the level of evidence of medication review as a single intervention for preventing falls in hospitals is poor (D). One systematic review investigated the independent effects of medication review in preventing falls in hospitals (Cameron, Dyer et al. 2018). Cameron's review only referenced one quasi clustered randomised trial, which compared medication review for aged patients against usual care. No evidence in the reduction of fall rate nor risk was reported.

Medication - Vitamin D and analogues

Overall, the level of evidence to support the use of Vitamin D supplementation as a single intervention for preventing falls in hospital is poor (D). One systematic review investigated the independent effects of vitamin D supplementation in preventing falls in hospitals (Cameron, Dyer et al. 2018). Cameron's review only referenced one trial which was individually randomised and compared vitamin D supplementation in addition to calcium supplementation against calcium supplementation only. No evidence about effect on fall risk was reported.

Multicomponent Interventions

Multicomponent interventions are those where the same combination of single categories of intervention was delivered to all participants in the group (Cameron, Dyer et al. 2018). Overall, the evidence to support multicomponent interventions for preventing falls in hospital is B. Only one review included multicomponent interventions (Miake-Lye, Hempel et al. 2013). In this review, the results of 21 studies were summarised, which together included patient education, bedside risk signs, staff education, alert wristband, footwear, review after fall, toileting schedules, medication review, environmental modification, movement alarms, bedrail review, exercise, hip protectors, urine screening, and vest, belt, or cuff restraint. While the results were not pooled, the authors concluded that, overall, across all studies, inpatient multicomponent programs appear to be effective at reducing falls. They, however, could not indicate which components are most important for success.

Multifactorial Interventions

Multifactorial interventions are interventions with multiple intervention components where the delivery and/or selection of the interventions are linked to an individual's risk profile, which is determined via an individual risk assessment (Cameron, Dyer et al. 2018). Overall, the evidence to support multifactorial interventions for preventing falls in hospitals is C. Four systematic reviews (Lee, Pritchard et al. 2014, Stubbs, Denkinger et al. 2015, Rimland, Abraha et al. 2016, Cameron, Dyer et al. 2018) examined the role of multifactorial interventions on falls prevention.

The results reported in the reviews by Cameron (Cameron, Dyer et al. 2018) and Rimland (Rimland, Abraha et al. 2016) were of a mixed nature. Rimland (Rimland, Abraha et al. 2016) review contained five other reviews on multifactorial interventions in hospitals that, while were not pooled, demonstrated mixed results. Cameron (Cameron, Dyer et al. 2018) pooled the results from up to five trials (depending on the outcome measure) and found borderline significant reduction in the rate of falls but no significant reduction in the risk of falling among studies that they rated as low quality. When they performed subgroup analysis by the type of care, Cameron observed that fall rates were reduced in subacute settings, but not in acute nor in mixed care settings.

Two trials within Cameron et al (2018) found promising results. Barker and colleagues (Barker, Morello et al. 2016) compared a nurse-led multifactorial program to usual care among patients admitted to acute hospital wards. The multifactorial program consisted of a fall risk tool and individualised use of one or more of six interventions: signage to denote fall risk, patient supervision in bathrooms, ensuring walking aids are within reach, a toileting regime, use of low height bed, and use of a bed or chair alarm. While the intervention resulted in positive changes in falls prevention practice, it did not have an effect on falls or fall injuries when compare to usual care. Hill, McPhail and colleagues (2015) also tested the effects of a multifactorial intervention against usual care but centred the intervention around patient education. Their intervention consisted of physiotherapist-delivered individualised falls prevention education program that aimed at facilitating health behaviour change among patients aged 60 and over who were staying in hospital-based rehabilitation units. The educational content was based on personal fall risk, falls epidemiology, and falls prevention strategies and the educational format included pedagogical techniques such as written action plans and personal goal setting. The intervention was designed to be delivered in 30 minutes across two to four sessions, and the physiotherapist-educator communicated information on patient progress to all multidisciplinary staff who were then equipped with the knowledge to support patients if the opportunity allows it. The authors found that patients had a lower fall rate, injurious fall rate, and fall risk during the intervention period than in the control period. While the intervention was effective at reducing falls among the whole group of patients, the authors noted that the intervention had the largest impact among patients with better cognition.

In Lee and colleagues' review (2014), eight studies were included that focused on hospitalised older adults in receipt of patient education delivered as a multifactorial intervention. While some information on the characteristics of these interventions were provided (e.g., three intensive programs and five brief programs), their effects on falls were not differentiated from one another. Nor were their effects isolated from *post*-hospitalised older adults in receipt of patient education delivered as a *sole* intervention. In other words, the authors reported a number of results which were derived from pooling the estimates of multiple studies according to combinations of settings (hospital vs. post-hospital), mode of delivery (individual vs. multifactorial), outcome measure (fall risk, fall rate, injurious fall risk, injurious fall rate), and patient cognitive status with most analysis broader in scope than that on which we focus. For example, the authors reported on the effects of patient education delivered as both a sole intervention and as a multifactorial strategy in hospital-based studies (reduction in the proportion of patients who became fallers); or on the effects of multifactorial patient education programs across both hospital-based and post-hospital studies (no effect on the proportion of patients who became fallers). The only analysis that matched our exact scope- that is, is specific to multifactorial patient education in hospitals-saw no significant reduction in the proportion of fallers with injury. While their findings varied according to the type of analysis conducted, overall, the authors concluded that patient education should be recommended for older adults while in hospital. Stubbs and colleagues' (2015) also suggest that multifactorial interventions are promising for hospital-based falls prevention, as their review noted reductions in both fall rate and fall risk from two moderate-to-high quality meta-analyses.

Appendices, Search Strategies and Results

Appendix 1A. Search strategy: Interventions for prevention of falls in children and adolescents

Pubmed

1. infant* OR newborn* OR neonate* OR baby OR babies OR child OR children OR adolescent* OR teen* OR pediatric* OR paediatric* OR kid OR kids OR toddler*
2. Accidental Falls [MeSH] OR Fall* [tw]
3. systematic review[tiab] OR meta-analysis[ptyp] OR meta-analysis[tiab] OR systematic literature review[ti] OR this systematic review[tw]OR meta synthesis[ti] OR meta-analy*[ti] OR integrative review[tw] OR integrative research review[tw] OR rapid review[tw] OR umbrella review [tw]
4. (randomized controlled trial[pt] OR controlled clinical trial[pt] OR randomized[tiab] OR placebo[tiab] OR clinical trials as topic[mesh:noexp] OR randomly[tiab] OR trial[ti] NOT (animals[mh] NOT humans [mh]))
5. 3 OR 4
6. 1 AND 2 AND 5

Embase via OvidSP (1947-present)

1. infant* OR newborn* OR neonate* OR baby OR babies OR child OR children OR adolescent* OR teen* OR pediatric* OR paediatric* OR kid OR kids OR toddler*
2. Falling/
3. (falls or fallers).tw
4. 2 OR 3
5. exp Randomized Controlled Trial/ or exp Controlled clinical trial/ or (random* or RCT or placebo or allocat*).ti,ab
6. (exp Animal/ or Nonhuman/) not (exp Human)
7. 5 NOT 6
8. exp Systematic Review/ or Systematic literature review/ or Meta synthesis/ or Meta-analy*/
9. 7 OR 8
10. 1 AND 4 AND 9
11. Limit 10 to exclude medline journals

Cochrane Library

1. infant* OR newborn* OR neonate* OR baby OR babies OR child OR children OR adolescent* OR teen* OR pediatric* OR paediatric* OR kid OR kids OR toddler*
2. MeSH descriptor Accidental Falls

3. falls or faller*
4. 2 OR 3
5. 1 AND 4 (Use the study design filters of trials and systematic reviews (Cochrane and others in the database)

Cinahl via Ebsco (1982-present)

1. (MH “Accidental Falls”)
2. (T1 (falls or faller*) OR AB (falls or faller*)
3. 1 OR 2 (Limiters – Age 0 to18 years)
4. PT (randomized controlled trial or controlled clinical trial)
5. TI random* OR AB random*
6. 4 OR 5 (Limiters – Human)
7. PT (systematic review)
8. 6 OR 7
9. 3 AND 8

Scopus

Filters: Article title, abstract, keywords

1. infant* OR newborn* OR neonate* OR baby OR babies OR child OR children OR adolescent* OR teen* OR pediatric* OR paediatric* OR kid OR kids OR toddler*
2. 1 AND Fall*
3. 1 AND 2 AND (systematic review OR systematic literature review OR meta synthesis OR meta-analy* OR integrative review OR integrative research review OR rapid review OR umbrella review random* OR placebo OR trial OR randomized AND controlled AND trial)
4. limited to English language

Appendix 1B. PRISMA diagram: Interventions for prevention of falls in children and adolescents

Figure 1 shows the process of identification, screening and selection using the PRISMA flowchart. There were 6,067 records identified from database searching and 21 records identified from other sources. After removing duplicates, 2,682 records were left. A further 2,615 records were excluded after title and abstract screening. Full text articles were retrieved for the remaining 68 records to assess their eligibility. Of these records, 59 records were removed as either they were not RCTs or systematic reviews (20 records), full text papers were not obtainable (2 records), they did not report fall-related outcomes, but instead reported proximal outcomes such as stair gate use (16 records), or they had already been included in other systematic reviews (21). Overall, a total of 3 RCTs and 6 systematic reviews were included.

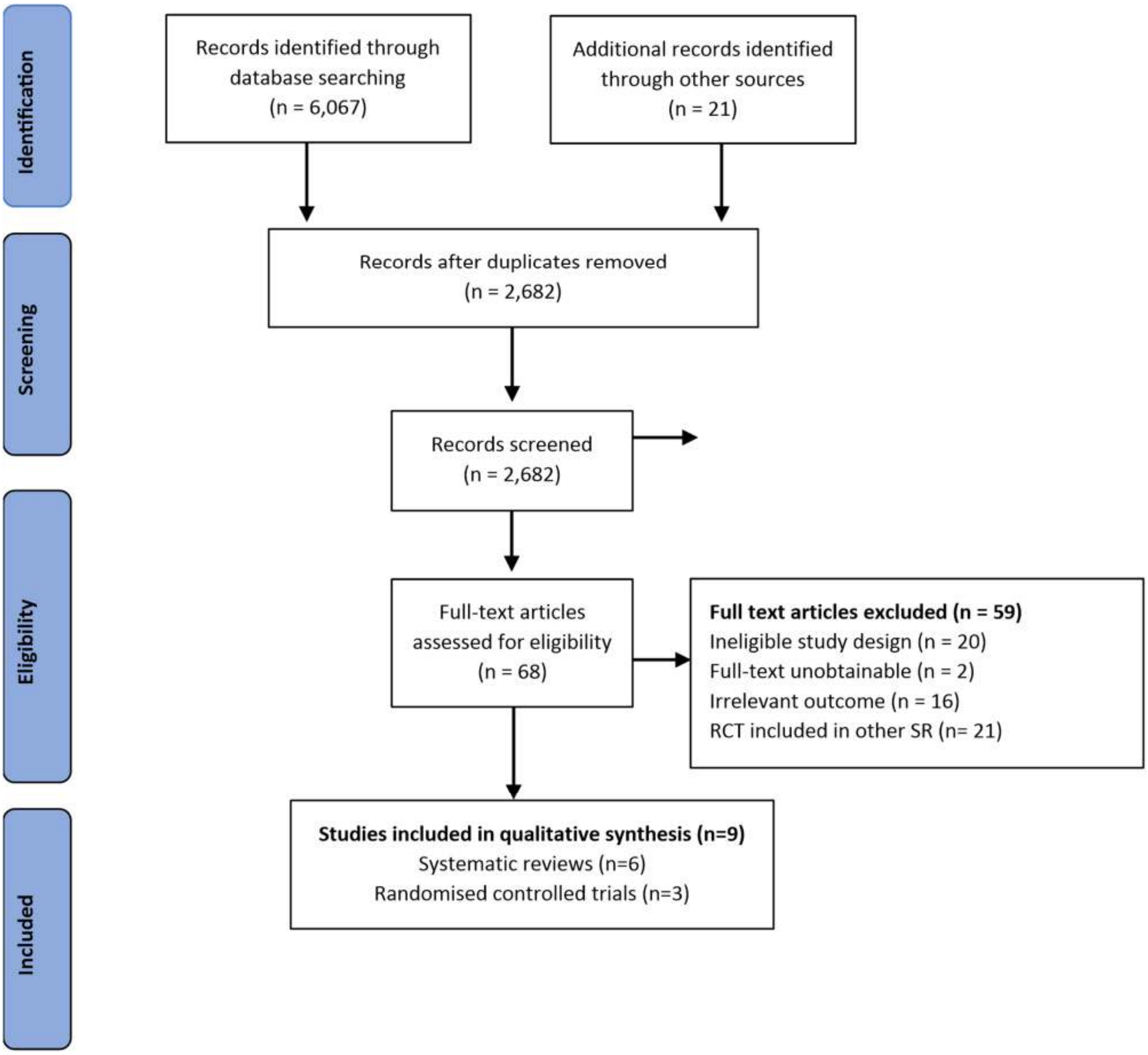

Figure 1. PRISMA Flowchart of search methodology for interventions for prevention of falls in children and adolescents

Appendix 1C. Data extraction of systematic reviews investigating falls prevention interventions for children and adolescents

Authors, year, name of study	Participant characteristics	Country	Intervention	Comparator	Outcome measures	Funding	Databases searched	Included studies	Methods of syntheses	Findings and conclusions
Dowswell et al. (1996) Preventing childhood unintentional injuries – what works? A literature review.	Children aged 0-14 years and their families. Age:0-14 Mean: NR Female: NR	UK Denmark Germany the Netherlands Canada USA Norway North America Australia New Zealand.	Safe home-design, product design, safety device, parent and child home safety education, playground falls prevention interventions were discussed.	Not reported.	Increase in knowledge, change in behaviours, fall-related injuries and fatalities.	Not reported.	BIDS, MEDLINE, EXCERPTA, MEDICA, the DHSS database, SSRI	Not reported.	Narrative.	Safety education on prevention of falls from windows with provision of free window guards resulted in a 35% reduction in mortality from falls. Campaigns which provided, installed and maintained free/low-cost home safety equipment were more likely to achieve positive outcomes than those where participants had to buy, install and maintain these devices themselves. Legislation in addition to education may increase the number of homes protected by safety devices
Kendrick et al. (2008) Preventing childhood falls at home: Meta-Analysis and Meta-Regression**.**	Children aged 0-19 years and their families Age:0-19 Mean: NR Female: NR	UK USA France Singapore Greece Hong Kong Australia Italy New Zealand	Home safety education (with or without free, low-cost, or discounted safety equipment); and that reported fall-prevention practices and/or self-reported or medically attended falls	Control groups did not receive the mentioned interventions .	Adoption of fall-prevention practices and/or self-reported or medically attended falls.	Department of Health (UK)	MEDLINE, EMBRASE, CINAHL, ASSIA, PsycINFO, Web of Science.	21 studies, of which 13 included in meta-analysis (10 RCTs, 2 Non-RCTs, 1 CBA) Quality assessment of the included individual studies included.	Meta-analysis and meta-regression.	Stair gate use increased significantly post intervention (OR 1.26, 95% CI 1.05-1.51). Some evidence of decreased baby-walker use post intervention (OR 0.66, 95% CI 0.43-1.00). Little evidence of increased possession of window locks, screens, or windows with limited opening (OR 1.16, 95% CI 0.84-1.59). Little evidence of increased possession of nonslip bath mats or decals (OR 1.15, 95% CI 0.51-2.62). Home-safety education and the provision of free or low-cost safety device improved some fall-prevention practices, but the impact on fall injury incidence is unclear. There was some evidence that the impact of these interventions varied depending on social groups.

Authors, year, name of study	Participant characteristics	Country	Intervention	Comparator	Outcome measures	Funding	Databases searched	Included studies	Methods of syntheses	Findings and conclusions
McClure **et al. (2005)** Community based programmes to prevent falls in children.	Children aged 0-16 years and their families. Age: 0-16 Mean: NR Female: NR	USA Sweden,	Community based intervention study: operationally defined as an intervention that applies more than one single strategy and is targeted towards a whole community.	Community controls: the intervention community as a historical control in a before-after design.	Fall-related injury rates.	The National Health and Medical Research Council (Australia).	MEDLINE, CINAHL, PsycINFO.	6 community based intervention studies.	Narrative. Meta-analysis impossible due to heterogeneity.	Putting bars on windows, enhacing playground safety and removing baby walkers are effective in reducting fall injuries in children aged 0-4 years. Fall reduction could be achieved in the 7– 16 year age group by means of the WHO safe community model of intervention. Specific falls-targeted programs were more effective than those focusing on reducing multiple injury outcomes.
Pearson **et al. 2012)** Preventing unintentional injuries to children under 15 years in the outdoors: a SR of the effectiveness of educational programs.	Children under 15 years of age and their families. Age:0-15 Mean: NR Female: NR	UK Canada USA New Zealand, Greece	Interventions involved the provision of information, advice and education on: -Safety and risk (including risk assessment) -Safety clothing and protective equipment. Information could be delivered via one-to-one or group-based verbal information, print media (eg, leaflets, posters), new media (eg, internet-based social networking sites), email and text	Control groups did not receive the mentioned interventions.	Injury outcomes, behaviour, attitude and knowledge outcomes, use of protective equipment outcomes.	The Centre for Public Health Excellence, National Institute for Health and Clinical Excellence (UK).	MEDLINE, PsycINFO, SSCI, SCI-EXPANDED, HMIC, CINAHL, ASSIA, The Cochrane database of SR, EconLit, EMBRASE, EPPIC-Centre, ERIC, TRoPHI, DoPHER, Bibliomap, CRDD, DARE, NHSEED, HTA, SPORTDiscuss.	23 studies included (2 RCTs, 3 cluster RCTs, 7 CBAs, 11 BAs).	Narrative. ORs, mean differences and effect sizes (with 95% CIs), comparing intervention and control groups taken directly from the individual studies or calculated by the review team.	Results were not discussed specifically for falls, but unintentional injuries in general. The 20 studies that measured behaviour, attitude or knowledge change outcomes reported highly mixed results. The cluster RCT which evaluated the "Risk Watch" injury prevention program targeting both in the home and outdoors found no evidence of improvement in children's (aged 7-10 years) knowledge about preventing falls outdoors. The 5 studies that measured the use of protective equipment reported mixed results, although some evidence suggests that more extensive educational programs (such as health fairs and media campaigns) increase their use.

Authors, year, name of study	Participant characteristics	Country	Intervention	Comparator	Outcome measures	Funding	Databases searched	Included studies	Methods of syntheses	Findings and conclusions
			messaging or mass-media campaigns.							
Turner et al. (2011) Modification of the home environment for the reduction of injuries (Cochrane review).	People of all age groups (including separate data extraction for children). Age:0-8 Mean: NR Female: NR	USA UK Germany,	Environmental modification to the domestic environment +/- home visit and assessment +/-free safety devices, educational strategies and multifactorial programs.	Control groups did not receive the mentioned interventions.	Change in injury rate or risk, change in prevalence of safety features, change in prevalence of hazards.	Not reported.	MEDLINE, MEDLINE In-Process, ASSIA, BNI, CINAHL, Cochrane Library, EMBRASE, ICONDA, Planex, RIBA, SafetyLit, Web of Science, OpenSIGLE, Urbadisc,	28 completed RCTs and 1 unpublished study, of which 9 studies involved children.	Mostly narrative due to heterogeneity. Meta-analysis was conducted with 2 studies that were sufficiently similar to allow pooling of data	No included studies examined falls or fall-related injury as an outcome measure in children There was some evidence that home visits and education may change parent behaviour with regard to home hazard reduction There was some evidence of reduced self-reported injuries in intervention groups Single home visits may be insufficient to encourage a continuing adoption of home safety measures.
Young et al. (2013) Preventing child falls within the home: Overview of systematic reviews and a systematic review of primary studies.	Children aged 0-19 years. Age: 0-19 Mean: NR Female:NR	Hong Kong USA	Non-legislative interventions aimed at primary and secondary prevention of falls.	Control groups did not receive the mentioned interventions.	Reported medically or non-medically attended falls, possession or use of home safety equipment to prevent falls, or other falls prevention interventions.	The National Institute for Health Research	MEDLINE, EMBRASE, CINAHL, ASSIA, PsycINFO, Web of Science.	13 reviews were found, containing 24 primary studies (20 RCTs, 5 NRCTs, 3 CBAs and 1 Observational design)	Not reported.	1 of 3 primary studies that reported fall or fall injury outcomes found a reduction in falls in the intervention arm. There was some evidence of improvements in possession and use of safety equipment, which were more common in studies providing or fitting low-cost/free equipment. Interventions were effective in promoting the use of safety gates and furniture corner covers. There was some evidence that interventions focusing solely on decreasing baby walker use may be effective. The effectiveness of interventions to increase use of window safety devices, non-slip bath mats/decals and the reduction of tripping hazards was mixed. Evidence for the effectiveness of restricting access to roofs, avoiding staggering furniture layout and improving lighting in corridors was limited.

NR: Not reported

Appendix 1D Data extraction of randomised controlled trials investigating falls prevention interventions for children and adolescents

Authors (year) Name of Study	Setting Country	Inclusion	Exclusion	Intervention	Comparator	Other therapies	Outcomes	Funding
Collard et al. (2010) Effectiveness of a school-based physical activity (PA) injury prevention program.	40 primary schools. Netherlands (HIC)	Children aged 10-12 years in participating schools (n=2210).	Not reported.	Received 8-month iPLAY intervention program that targeted physical activity injuries including falls. 5-minute exercises were given at the beginning and end of each PE class to improve strength, speed, flexibility and overall coordination. Each month students and their parents received a newsletter, aimed at improving knowledge, attitude and self-efficacy toward the prevention of PA injuries. Posters were displayed in classrooms. The iPlay websites contained interactive information for students, parents and PE teachers. (n=1015)	Received the regular curriculum. (n=996)	Baseline demographic characteristics were reported .	The intervention 'exerted a larger effect' of reducing physical activity injury incidence in the low active group. A small nonsignificant intervention effect on total (HR,0.81; 95% confidence interval [CI], 0.41-1.59), sports club (0.69; 0.28-1.68), and leisure time injuries (0.75; 0.36-1.55). However, physical activity appeared to be an effect modifier.In those who were less physically active, the intervention had a larger effect. The intervention reduced the total and leisure time injury incidence (HR,0.47; 95% CI, 0.21- 1.06; and 0.43; 0.16-1.14; respectively). Sports club injury incidence was significantly reduced (HR,0.23; 95% CI, 0.07-0.75). No specific data on fall injuries was reported.	The Netherlands Organization of Health Research and Development.
Nauta et al. (2013) Prevention of fall-related injuries in 7-year-old to 12-year-old children.	33 primary schools Netherlands (HIC)	Children aged 7-12 years in the participating schools (n=3317).	Not reported.	'Falling is a sport', an 8-week educational programme (weekly 1 hour lesson of increasing difficulty) of martial arts techniques to improve falling skills during physical education classes. The most important aspect of the lessons was to avoid blocking a fall with extended elbows to reduce forearm impact forces. Children were taught to keep their head from touching the ground and to slap the ground hard with hand to stop the rolling motion. (17 schools, n=1397)	Regular physical education classes. (16 schools, n=1920)	Baseline demographic characteristics were reported.	Lower fall-related injuries were reported in the intervention group: I vs. C: 36 injuries (an IID of 0.14 fall-related injuries per 1000h of physical activity, 95% CI 0.09-0.18) vs. 96 injuries (an IID of 0.26, 95% CI 0.21-0.32). However, intracluster correlation was high (ICC=0.46), making differences in injury incidence not statistically significant. When activity level was taken into account, a trend was shown suggesting that the 'falling is a sport' programme was effective in decreasing falling related injury risk in the least active children. *IID: Injury Incidence Densitu *ICC: Intracluster Correlation	Dutch Ministry of Health, Welfare and Sports.
Howard et al. (2009) School playground surfacing and arm fractures in children: A RCT comparing sand to wood chip surfaces.	37 elementary schools Toronto, Canada (HIC)	Students in participating schools (n=15,074)	Injuries and fractures occurring in playgrounds after supervised school hours, or on weekends.	Schools received qualified funding for installation of new playground equipment and surfacing of granitic sand. (18 schools, average school size 407)	Schools received qualified funding for installation of new playground equipment and surfacing of engineered wood fibre (Fibar) (19 schools, average school size 397)	Baseline information on playground equipment and surfacing was collected for both groups.	Sand surfacing was associated with a significantly lower arm fracture rate. An arm fracture rate of 1.9 (95%CI 0.04–6.9) per 100,000 student-months was observed for falls into sand, compared with an arm fracture rate of 9.4 (95%CI 3.7–21.4) for falls onto Fibar surfaces. This difference in fracture rates is significant (p<=0.049). No serious head injuries and no fatalities were observed in either group.	Not reported.

Appendix 2A. Search strategy: Interventions for prevention of falls in occupational settings

Search strategy:

Ovid MEDLINE

1. Accidental Falls/ or fall*.tw.
2. (work-related or workplace* or occupation* or worke* or worksite* or job* or industry or construction* or building* or factory or laborer* or labourer* or "machine operator" or "brick mason" or "tower crane" or scaffolder* or bricklayer* or plasterer* or plasterpainter* or roofer* or glazier* or screeder* or electrician* or painter* or roofing).tw.
3. 1 and 2
4. limit 3 to english language

Appendix 2B. PRISMA diagram: Interventions for prevention of falls in occupational settings

Figure 2 shows the process of article identification, screening and selection using the PRISMA flowchart. A total of 59,976 records were identified from database searching and 16 records were identified from other sources. After removing duplicates, 36,679 records remained. At the screening phase, 36,650 records were excluded following review of title and screening of abstract. Full text articles were retrieved for the remaining 29 records to assess their eligibility. Of these records, 14 were removed because of ineligible study design, 4 reported an ineligible outcome measure, and 1 had a sample size of just two participants. One additional study published after the search date was recommended by an occupational falls expert and so was added manually. A further 3 studies were included in a systematic review (van der Molen, Basnet et al. 2018) so were also removed. Overall, 1 systematic review, 3 cohort studies, and 4 quasi-experimental studies were included.

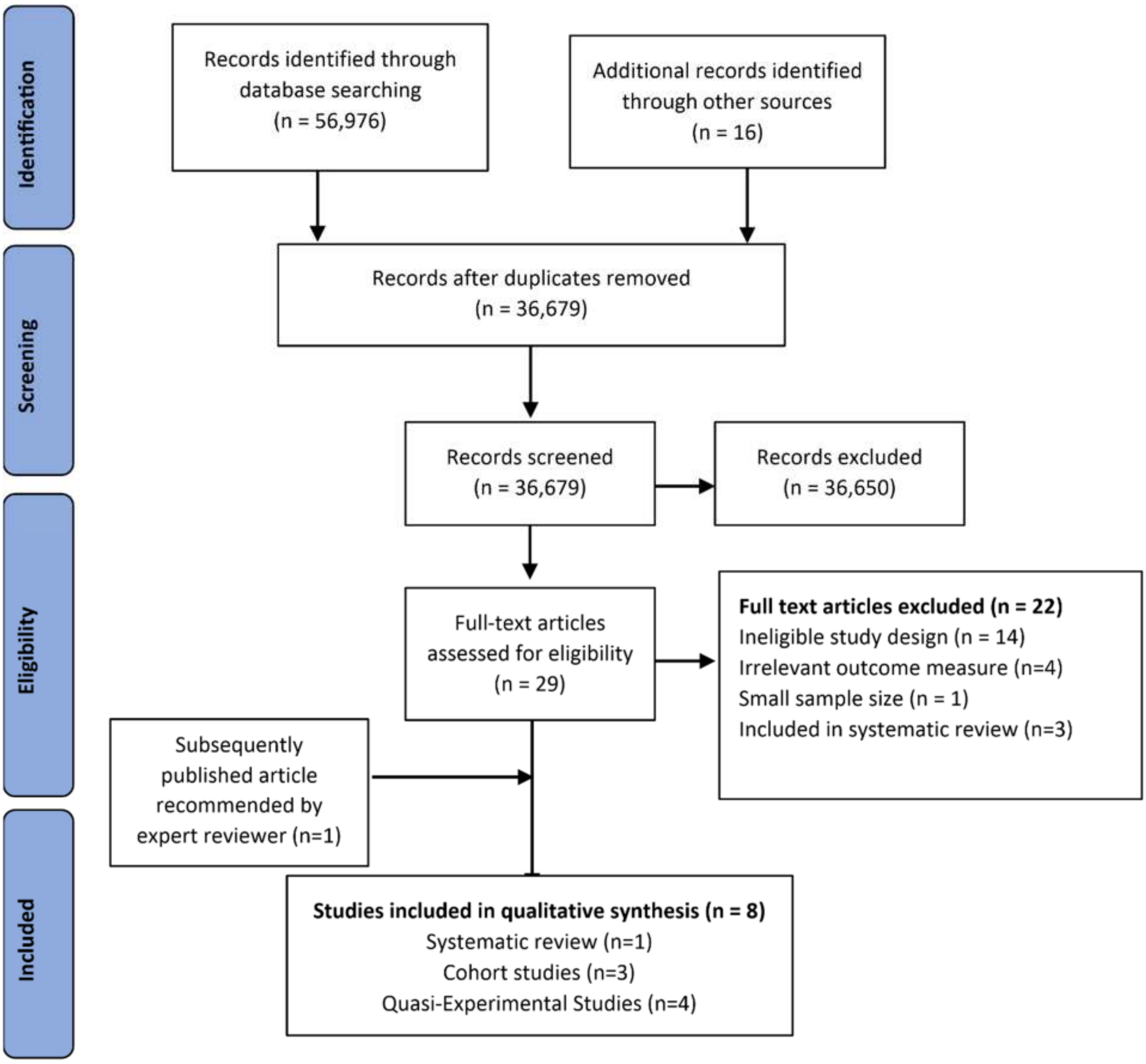

FIGURE 2. PRISMA FLOWCHART OF SEARCH METHODOLOGY FOR INTERVENTIONS FOR PREVENTION OF FALLS IN OCCUPATIONAL SETTINGS

Appendix 2C. Data extraction of systematic reviews investigating falls prevention interventions for children and adolescents

Author, Year Name of SR	Participant characteristics	Country	Intervention	Comparator	Outcome measures	Funding	Databases searched	Included studies	Methods of syntheses	Findings and conclusions
van der Molen et. al. (2018) Interventions to prevent injuries in construction workers (Review)	Workers at construction sites. Age:NR Mean:NR Female: NR	USA UK Italy Denmark Finland Austria Belgium Germany Spain	Enforcement of more stringent safety standards among construction employers	Interrupted time series	Fatal and non-fatal occupational injuries.	Not reported.	CENTRAL, MEDLINE, Embase, PsyscINFO.	17 studies 14 interrupted time-series, and 3 controlled before-after studies. 9 of the ITS included fall-related injuries.	Narrative	Regulatory interventions at national or branch level may or may not have an initial effect (effect size (ES) of −0.33; 95% confidence interval (CI) −2.08 to 1.41) and may or may not have a sustained effect (ES −0.03; 95% CI −0.30 to 0.24) on fatal and non-fatal injuries (9 ITS studies) due to highly inconsistent results (I^2 = 98%). The vast majority of interventions to adopt safety measures recommended by standard texts on safety, consultants and safety courses have not been adequately evaluated. There is very low-quality evidence that introducing regulations as such may or may not result in a decrease in fatal and non-fatal injuries.

Appendix 2D. Data extraction from cohort studies of falls prevention interventions in occupational settings

Authors, year, name of study	Country	Participants and setting	Sample size	Time of follow-up	Exposure	Outcomes	Funding
Regulations							
Nelson (1997) Falls in Construction: Injury Rates for OSHA-Inspected Employers Before and After Citation for Violating the Washington State Fall Protection Standard	USA	State Fund construction employers who were aware of the standard and penalties for noncompliance in Washington's construction industry	state fund construction companies: n=28613 Case – employers cited: n=784 Controls – employers not cited: n=8301	24 months (1 year period prior to the first inspection in 1991–92 where the standard was violated, and the one-year period following this inspection)	Insured for workers' compensation by Washington's State Fund and were inspected by state safety inspectors 3and cited for violating the falls in construction standard in 1991–1992	Cited employers' (n=784) claim rate for compensable fall injuries decreased from 1.78 to 1.39 per 200,000 hours worked for the one-year periods before and after inspection. For the control group (n=8,301), the claim rate decreased from 1.04 to 0.95 per 200,000 hours. Cited companies 2.3 times more likely to have a fall injury claim rate reduction compared to controls (p<0.0001), adjusted for industry type and size.	Not reported
Yassin & Martonik (2004) The effectiveness of the revised scaffold safety standard in the construction industry	USA	Construction industry nationwide. The construction industry was organized using two-digit standard industrial classification codes system(SIC): SIC 15, building construction—general contractors and operative builders; SIC 16, construction other than building construction— general contractors; and SIC 17, construction—special trades contractors	?	5 year pre-period (1992-1996) compared to 5 year post period (1997-2001)	Introduction of the the Occupational Safety and Health Administration's (OSHA)'s 1996 revised scaffold safety standard, which regulates the design, construction, and use of scaffolds. The standard addresses hazards such as falls, falling objects, structural instability, electrocution, and overloading.	The effectiveness of revised scaffold safety standard was evident in the post-standard period. Statistically significant differences were noted between pre and post-implementation period. Within 5 years of the promulgation of OSHA's 1996 revised scaffold safety standard, fatal and nonfatal injury rates declined by 38.8%, that is more than the targeted 20% reduction. The findings indicated that in the post-standard period fatal injuries rates declined by 5.8%, nonfatal injury rates involving lost workdays declined by 33.0%, and nonfatal injury rates with 31 or more lost workdays declined by 29.3%. An increase of 56.3% in the number of cited violations of scaffold safety in the post-standard period was observed and this increase could be translated as an increase of penalty for firms not in compliance with the OSHA standards.	

Authors, year, name of study	Country	Participants and setting	Sample size	Time of follow-up	Exposure	Outcomes	Funding
Slip-resistant shoes and floor cleaning							
Verma (2011) A prospective study of floor surface, shoes, floor cleaning and slipping in US limited-service restaurant workers	USA	Workers from 36 limited-service restaurants of 3 major chains in 6 states	Recruited: n=475 Loss to follow-up: n=53 Analysed: n=422	12 weeks	Usage of slip-resistant shoes Frequency of floor cleaning Floor surface characteristics	Mean individual slipping rate was 0.02 to 2.49 slips per 40 work hours. Use of slip-resistant shoes was associated with a 54% reduction in the reported rate of slipping (95% CI 37% to 64%), and the rate of slipping decreased by 21% (95% CI 5% to 34%) for each 0.1 increase in mean coefficient of fricition (COF). Slip-resistant shoes was associated with a 40% reduction in the reported rate of major slipping (rate ratio (RR).0.60, 95% CI 0.24 to 1.48) Rate of major slipping decreased by 54% (RR.0.46, 95% CI 0.31 to 0.66) for each 0.1 increase in the mean COF Floor cleaning frequency: slip rate RR=0.88 (95% CI 0.79 to 0.99) in univariate model; no significant effect in multivariable model.	Not reported
Verma (2014) Duration of slip-resistant shoe usage and the rate of slipping in limited-service restaurants: results from a prospective and crossover study	USA	Workers from 36 limited-service restaurants of 3 major chains in 6 states	Recruited: n=475, loss to follow-up: n=13 Shoe usage □6 months: n=279 Shoe usage >6 months: n=183 Exclusions: 2 participants changed shoes within first week; 1 participant with very high slip rate (278 slips per 2000 hours)	12 weeks	Duration of shoe usage, change to new shoes, usage of slip-resistant shoes	Association with rate of slipping Slip-resistant shoes used □6 months: RR=0.42 (95% CI 0.28 to 0.64) Slip-resistant shoes used >6 months: RR=0.55 (95% CI 0.29 to 1.02) RR for the rate of slipping before and after shoe change New slip-resistant shoes RR=0.44 (95% CI 0.27 to 0.73) New non-slip-resistant shoes RR=0.61 (95% CI 0.34 to 1.11)	Not reported

Appendix 2E. Data extraction from quasi-experimental studies investigating falls prevention interventions in occupational settings

Authors, year, name of study	Country	Participants and setting	Pre-intervention observation	Post-intervention observation	Intervention	Outcomes	Funding
Multifaceted prevention program							
Bell (2008) Evaluation of a comprehensive slip, trip and falls prevention programme for hospital employees	USA	Employees at 3 non-profit hospitals (n=835±11,n=2803±70, and n=3045±98 employees each year at each hospital)	4 years, annual data	3 years, annual data	3-year comprehensive falls prevention program informed by on-site needs assessment, consisting of 11 strategies addressing issues that included floor cleanliness, slip-resistant shoe usage, and walking hazard elimination	STF workers' compensation claim rates declined from 1.66 to 0.76 per 100 FTE (RR_{adj}=0.42, 95% CI 0.33 to 0.54) Study hospital STF rates had greater decline compared to national lost work day STF incidence rates (RR=0.55, 95% CI: 0.43 to 0.69, p<0.01)	Not reported
Investigations							
Menendez (2012) Evaluation of a nationally funded state-based programme to reduce fatal occupational injuries	USA	Persons aged 16 or older with a a falls-related occupational injury deaths (n= 12 781 fall-related deaths) States participating in the FACE programme	10 years, annual data	12 years, annual data	FACE programme: • delivery of FACE investigation reports to safety professionals, industry leaders, union representatives and other target audiences aiming to enhance their safety knowledge and attitudes, • dissemination of FACE investigation findings to the public through electronic and printed media • informing stakeholders regarding recommended occupational safety practices, policies and procedures, and interventions	Association between state program participation and fall fatality rates RR_{adj}=0.92 (95% CI: 0.84-1.00) at 1-year lag, RR_{adj}=0.96 (95% CI: 0.89-1.05) at 2-year lag, RR_{adj}=0.98 (95% CI: 0.89-1.08) at 3-year lag, and RR_{adj}=1.01 (95% CI: 0.94-1.09) at 5-year lag	Not reported
Rubio-Rumero (2015) Prevention of falls to a lower level: evaluation of an occupational health and safety intervention via subsidies for the replacement of scaffolding	Spain	Construction companies in Andalusia (Spain) (n=6201 companies)	2009, annual data	Data from 2010 and 2011, annual data	• Subsidy policy for construction companies to replace non-compliant scaffolds with standardised and certified scaffolds compliant with EU norm. • Subsidies were granted through • a public competitive call. Companies in the control group were selected from the social security census of companies in order to avoid selection bias	Incidence rate of accidents to a lower level. The subsidy policy led to 71% decrease in the rate of accidents involving falls to a lower level in the companies which received grants in the period 2009-2011. The confidence interval for the comparison for the before-after difference in rates between the intervention group and the control group was significant (95% CI: 258.1; 2,277.9).	Not reported

Appendix 3A. Search strategy: Interventions for prevention of falls in community-dwelling older adults

MEDLINE (via OVID)

1. Accidental falls/
2. (falls or faller$1).tw
3. 1 or 2
4. ((randomized controlled trial or controlled clinical trial).pt or randomized.mp. or placebo.mp or clinical trials as topic/ or randomly.mp. or trial.ti) not (exp Animals/ not Humans/)
5. systematic review.mp or meta-analysis.pt or meta-analysis.mp or systematic literature review.ti or this systematic review.tw or meta synthesis.ti or meta-analy*.ti or integrative review.tw or integrative research review.tw or rapid review.tw or umbrella review.tw
6. 4 or 5
7. exp Aged/
8. (senior*1 or elder* or old* or aged or ag?ing or postmenopausal or community dwelling).tw
9. 7 or 8
10. 3 and 6 and 9
11. limit 10 to yr="2012-Current"
12. limit 11 to English language

EMBASE (via OVID)

1. Falling/
2. (falls or fallers).tw
3. or/1-2
4. exp Aged/
5. (senior*1 or elder* or old* or aged or ag?ing or postmenopausal or community dwelling).tw
6. or/4-5
7. exp Randomized Controlled Trial/ or exp Controlled clinical trial/ or exp Systematic Review/ or Systematic literature review/ or Meta synthesis/ or Meta-analy*/
8. (random* or RCT or placebo or allocat*).ti,ab
9. 7 or 8
10. (exp Animal/ or Nonhuman/) not (exp Human)
11. 9 not 10
12. 3 and 6 and 11
13. limit 12 to exclude medline journals
14. limit 12 to yr="2012-Current"
15. limit 13 to English language

The Cochrane Library

1. MeSH descriptor Accidental Falls, this term only
2. falls or faller*
3. (#1 OR #2)
4. MeSH descriptor Aged explode all trees
5. (aged or senior* or elder* or old* or aged or ageing or postmenopausal or community dwelling)
6. (#4 OR #5)
7. (#3 AND #6) in Trials
8. limit 7to yr=”2012-Current”

CINAHL (via Ebsco)

1. (MH “Accidental Falls”)
2. (T1 (falls or faller*) OR AB (falls or faller*)
3. S1 OR S2
4. (MH “Aged+”)
5. TI (senior* or elder* or old* or aged or ag?ing or postmenopausal or community dwelling) OR AB (senior* or elder* or old* or aged or ag?ing or postmenopausal or community dwelling)
6. S4 OR S5
7. PT (randomized controlled trial or controlled clinical trial)
8. TI random* OR AB random*
9. S7 OR S8
10. S9 NOT (exp Animals/ not Humans/)
11. PT (systematic review)
12. S10 OR S11
13. S3 AND S6 AND S12
14. Limits since 2012 and English

AGELINE (via Ebsco)

1. Accidental and falls OR
2. falls or fall*
3. 1 or 2
4. (random* OR placebo OR trial OR randomized AND controlled AND trial) NOT (animals AND not humans)
5. systematic* AND review OR meta-analysis OR meta-analy*
6. 4 OR 5
7. aged
8. senior* or elder* or old* or age*or postmenopausal or community AND dwelling
9. 7 or 8

10. 3 and 6 and 9
11. limit 10 to yr="2012-Current"
12. limit 11 to English language

Scopus (via Ebsco)

1. Accidental and falls
2. Falls or fall*
3. 1 or 2
4. (random* OR placebo OR trial OR randomized AND controlled AND trial) NOT (animals AND not humans)
5. systematic* AND review OR meta-analysis OR meta-analy*
6. 4 OR 5
7. aged
8. senior* or elder* or old* or age*or postmenopausal or community AND dwelling
9. 7 or 8
10. 3 and 6 and 9
11. limit 10 to yr="2012-Current"
12. limit 11 to English language

PEDro

Advanced search option selected

Abstract and Title: Fall* and elderly*

Method: Systematic Review

Sub discipline: gerontology

Published since 2012

Advanced search option selected

Abstract and Title: Fall* and elderly*

Method: Clinical Trial

Sub discipline: gerontology

Published since 2012

Safety-Lit Central

A: fall*

B: old or elder

C: trial or systematic review

(A AND B AND C): Text words + Synonyms

Limits: 2012-2018, Journal Articles

Appendix 3B. PRISMA diagram: Interventions for prevention of falls in community-dwelling older adults

Figure 3 shows the process of identification, screening and selection using the PRISMA flowchart. There were 4,505 records identified from database searching. There were 2,822 records left after removing duplicates. At screening phase, 2,696 records were excluded following review of titles and abstracts. Full text articles were retrieved for the remaining 126 records to assess their eligibility. Of these records, 97 records were excluded as they were duplicates (3 records), included the wrong population (14 records), investigated the wrong outcome (68 records), or were included in systematic reviews (12 records). The reviews by Sherrington et al. (2019) and Hopewell et al. (2018) were published after the systematic search and was manually added. A total of 18 systematic reviews and 6 RCTs were included in this evidence synthesis.

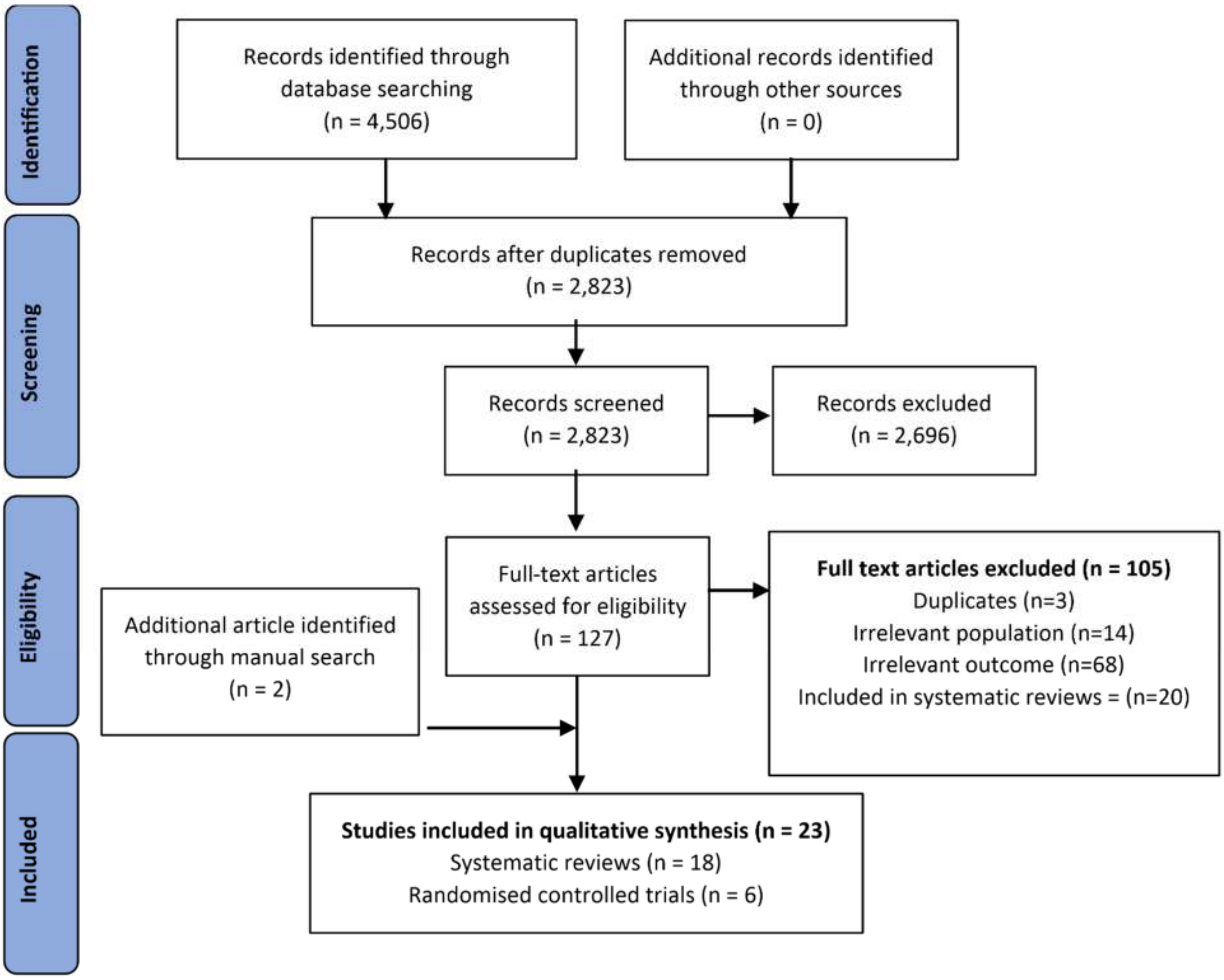

FIGURE 3 PRISMA FLOWCHART OF SEARCH METHODOLOGY FOR INTERVENTIONS FOR PREVENTION OF FALLS AMONG COMMUNITY-DWELLING OLDER ADULTS

TABLE3C. DATA EXTRACTION OF SYSTEMATIC REVIEWS INVESTIGATING FALLS PREVENTION INTERVENTIONS FOR COMMUNITY-DWELLING OLDER PEOPLE

Authors, year, name of study	Participant characteristics	Country	Intervention	Comparator	Outcome measures	Funding	Databases searched	Included studies	Methods of syntheses	Findings and conclusions
Booth et al (2016) Falls prevention interventions in older adults with cognitive impairment: A systematic review of reviews	Cognitively impaired older adults 65 years and older. Age: 65+ Mean ages: in included studies ranged from 70-83 Female NR	Brazil, India, Japan, China, Finland, Germany, Switzerland Korea	Multifactorial or multiple interventions in which physical and cognitive elements were included	Standard care or single element comparator (such as physical only or cognitive only intervention)	Number of falls Number of fallers Falls incidence rate	Clinical Fellow- ship award from the Alzheimer's Society, UK (grant number 206) with support from the Healthcare Managemen t Trust.	PubMed Medline EMBASE AMED CINAHL Cochrane library PsycINFO JBISRIR	Systematic reviews	Narrative	Exercise was shown to reduce falls: when delivered to an individual or to a group, delivered at home by an OT, as a single intervention and when incorporated in multifactorial interventions. Home and group-based exercise was shown to reduce falls reduced falls in 3 studies. There was no statistical difference in the total number of falls between the groups in the 12-month intervention presented by Zieschang et al. (p = 0.254). For community-dwelling older adults with cognitive impairment, lower incidence rate [IR ¼ 1.86 (1.51 – 2.26) versus 1.35 (1.07 – 1.67), p ¼ 0.005) indicating that an individualized approach had a greater effect on fall rates compared with a group exercise.
Bunn et al (2014) Preventing falls among older people with mental health problems: a systematic review	Age: 60+ Mean age range: 75-87 Gender: NR	Australia, UK, Finland	Single focus or multi-factorial interventions involving environmental, exercise, technological, psychological, educational, and health related components.	No intervention received	Rate of falls Number of falls	Partially funded by QR grant from the University of Hertfordshir e	PubMed NHS evidence Cochrane library Cochrane database of systematic reviews Database of abstracts of reviews and effects CENTRAL NHS Economic evaluation and health technology database CINAHL AMED	4; 3 RCTs 1 uncontrolled trial; before, after	Narrative	Multifactorial, multi-disciplinary interventions and those involving exercise, medication review and increasing staff awareness appear to reduce the risk of falls but evidence is mixed and study quality varied. Changes to the environment such as increased supervision or sensory stimulation to reduce agitation may be promising for people with dementia but further evaluation is needed. The multifactorial interventions for community-based older adults had mixed findings: Only one study reported a reduction in incidence of falls for their sub-group analysis of falls in people with depressive symptoms. A pilot RCT found a non-significant reduction in fallers and incidence of falls in older people receiving a home hazard reduction and exercise falls prevention programme. An uncontrolled pilot study of a falls prevention programme for people with dementia found no difference in fallers and another multifactorial intervention in a

Authors, year, name of study	Participant characteristics	Country	Intervention	Comparator	Outcome measures	Funding	Databases searched	Included studies	Methods of syntheses	Findings and conclusions
							BNI EMBASE HMIC Psycinfo Web of science Google scholar			geriatric outpatient clinic reported a non-significant increase in fallers and falls.
Burton et al. (2015) Effectiveness of exercise programs to reduce falls in older people with dementia living in the community: a systematic review and meta-analysis	Community - dwelling older people with dementia =>60 years old Gender: NR Age:>= 60 Mean: 79.8 Female:	Australia, Finland	Group and home-based exercise programs in populations with dementia	No intervention received	Number of falls Number of people falling Rate of falls	Not reported.	Medline CINAHL PubMed PsycInfo EMBASE Scopus	4 studies included; 3 RCTs 1 pre-post pilot study N=336	Meta-analysis	Exercise interventions lowered the number of falls experienced by people with dementia (MD=-1.06 [95%CI-1.67 to -0.46]); I^2=0%, and reduced the risk of an individual being a faller by 32% (RR=0.68 [0.55-0.85]); I^2=0% as compared to the control groups
Chan et al. (2015) Efficacy of Physical Exercise in Preventing Falls in Older Adults With Cognitive Impairment: A Systematic Review and Meta-Analysis	Age: Mean: 82.2 , Female 41-81%	Country: NR	Group and home-based physical exercise programs in populations with cognitive impairment	routine medical care or other controlled activities in preventing falls	Rate ratio of falls	Not reported.	Medline EMBASE PsycInfo CINAHL Cochrane Central Register of Controlled Trials Cochrane Bone, Joint and Muscle Trauma Group Specialized Register Clinical trials.gov	7 RCTs N=781	Meta-analysis	Physical exercise prevented falls in older adults with cognitive impairment (RR=0.68 [0.51-0.91]); I^2=79%

Authors, year, name of study	Participant characteristics	Country	Intervention	Comparator	Outcome measures	Funding	Databases searched	Included studies	Methods of syntheses	Findings and conclusions
							UK Clinical Research Network Study Portfolio			
Goodwin et al. (2014) Multiple component interventions for preventing falls and fall-related injuries among older people: systematic review and meta-analysis	Age: 60+ Mean: 69-89.9 Females: 38%-100%	Australia, Netherlands, NZ, Switzerland, Germany, Sweden, Taiwan and USA	Multicomponent	No intervention received	Rate of falls Number of falls	Funded by the National Institute for Health Research (NIHR) Collaboration for Applied Health Research and Care (CLAHRC) for the SW Peninsula.	Medline EMBASE CINAHL PsychInfo Cochrane AMED UK Clinical Research Network Portfolio Current Controlled trials register and Australian and NZ Clinical trials register	17 RCTs N=5304	Meta-analysis	Multicomponent interventions including exercise reduced the number of fallers (RR=0.85 [0.80-0.910} and fall rate (RR=0.80 [0.72-0.89]) I^2=20%.
Gillespie et al. **(2012**)Interventions for preventing falls in older people living in the community	Age: 60+ Mean: NR Females: 70%	Australia, NZ, UK, The Netherlands, Germany, Brazil, Canda, Chile, china, Denmark, Finland, France, Italy, Japan, Norway, Sweden, Switzerland, Taiwan, Thailan	Any intervention designed to reduce falls in older people	'usual care' or a 'placebo' control intervention (i.e., an intervention that is not thought to reduce falls	Rate of falls Risk of falling	National Health and Medical Research Council, Australia. National Institute for Health Research, UK. Department of Health Cochrane Review Incentive Scheme	Cochrane Bone, Joint and Muscle Trauma Group Specialised Register; CENTRAL; MEDLINE; CINAHL	159 Trials N=79 193	Meta-anaylysis & narrative	Multiple-component group exercise significantly reduced rate of falls (RaR 0.71, 95% CI 0.63 to 0.82; 16 trials; 3622 participants) and risk of falling (RR 0.85, 95% CI 0.76 to 0.96; 22 trials; 5333 participants), as did multiple-component home-based exercise (RaR 0.68, 95% CI 0.58 to 0.80; 7 trials; 951 participants and RR 0.78, 95% CI 0.64 to 0.94; 6 trials; 714 participants). For Tai Chi, the reduction in rate of falls bordered on statistical significance (RaR 0.72, 95% CI 0.52 to 1.00; 5 trials; 1563 participants) but Tai Chi did significantly reduce risk of falling (RR 0.71, 95% CI 0.57 to 0.87; 6 trials; 1625 participants). Exercise interventions significantly reduced the risk of sustaining a fall‐related fracture

Authors, year, name of study	Participant characteristics	Country	Intervention	Comparator	Outcome measures	Funding	Databases searched	Included studies	Methods of syntheses	Findings and conclusions
										(RR 0.34, 95% CI 0.18 to 0.63; 6 trials; 810 participants). Multifactorial interventions, which include individual risk assessment, reduced rate of falls (RaR 0.76, 95% CI 0.67 to 0.86; 19 trials; 9503 participants), but not risk of falling (RR 0.93, 95% CI 0.86 to 1.02; 34 trials; 13,617 participants). Vitamin D did not reduce rate of falls (RaR 1.00, 95% CI 0.90 to 1.11; 7 trials; 9324 participants) or risk of falling (RR 0.96, 95% CI 0.89 to 1.03; 13 trials; 26,747 participants). Home safety assessment and modification interventions were effective in reducing rate of falls (RaR 0.81, 95% CI 0.68 to 0.97; 6 trials; 4208 participants) and risk of falling (RR 0.88, 95% CI 0.80 to 0.96; 7 trials; 4051 participants). These interventions were more effective in people at higher risk of falling, including those with severe visual impairment or when delivered by an occupational therapist. Pacemakers reduced rate of falls in people with carotid sinus hypersensitivity (RaR 0.73, 95% CI 0.57 to 0.93; 3 trials; 349 participants) but not risk of falling. First eye cataract surgery in women reduced rate of falls (RaR 0.66, 95% CI 0.45 to 0.95; 1 trial; 306 participants), but second eye cataract surgery did not. Gradual withdrawal of psychotropic medication reduced rate of falls (RaR 0.34, 95% CI 0.16 to 0.73; 1 trial; 93 participants), but not risk of falling. A prescribing modification programme for primary care physicians significantly reduced risk of falling (RR 0.61, 95% CI 0.41 to 0.91; 1 trial; 659 participants). An anti‑slip shoe device reduced rate of falls in icy conditions (RaR 0.42, 95% CI 0.22 to 0.78; 1 trial; 109 participants). One trial (305 participants) comparing multifaceted podiatry including foot and ankle exercises with standard podiatry in

Authors, year, name of study	Participant characteristics	Country	Intervention	Comparator	Outcome measures	Funding	Databases searched	Included studies	Methods of syntheses	Findings and conclusions
										people with disabling foot pain significantly reduced the rate of falls (RaR 0.64, 95% CI 0.45 to 0.91) but not the risk of falling. No evidence of effect for cognitive behavioural interventions on rate of falls (RaR 1.00, 95% CI 0.37 to 2.72; 1 trial; 120 participants) or risk of falling (RR 1.11, 95% CI 0.80 to 1.54; 2 trials; 350 participants). Increase knowledge/educate about falls prevention alone did not significantly reduce the rate of falls (RaR 0.33, 95% CI 0.09 to 1.20; 1 trial; 45 participants) or risk of falling (RR 0.88, 95% CI 0.75 to 1.03; 4 trials; 2555 participants).
Hill et al. (2012) Psychotropic drug-induced falls in older people: a review of interventions aimed at reducing the problem	Age: 60+ Mean: 72.3 Female: 73-80%	Country: USA, NZ, Australia	Interventions aiming to reduce the use of psychotropic medications in older people and reporting effects on falls	Usual care	Rate of falls	Not reported.	Medline CINAHL PsycInfo Cochrane reviews on falls prevention	3 RCTs N=1564	Narrative	1 RCT with high quality data showed reducing psychotropic medication use through general practice can reduce falls: reduction of falls: (RR=O.34 [0.16-0.74) 2 RCTs showed mixed findings: No difference in mean number of medications at FU. No significant difference in falls follow up Significant improvement in decreased medication use at 4 months but not maintained; non-significant reduction in benzodiazepine use; significant reduction in falls
Hill, Hunter et al. (2015) Individualized home-based exercise programs for older people to reduce falls and improve physical performance: A systematic review and meta-analysis	Age: 60+ Mean: 80.1 Female: 70%	Country: UK, NZ, Australia, Taiwan, Canada, USA	Individualised Home-based exercise	No intervention received	Number of falls, rate of falls, number of fallers, time to first fall	No funding received	Medline CINAHL PubMed Psych Info EMBASE Scopus	11 RCTs 1 Pragmatic trial (IG= 1466) (CG= 1054)	Meta-analysis	There was no significant difference in number of fallers between both groups (RR=0.93 [0.72-1.21]) I^2=71% No significant between-group difference in number of injuries requiring medical attention (RR [95% CI] = 0.96 [0.78–1.19]) and fractures (RR [95% CI] = 0.75 [0.40–1.41]). Sensitivity analysis conducted; the exclusion of one study involving participants with high fall rates caused significant differences between both groups (RR= 0.84 [0.72-0.99]) I^2=0%

Authors, year, name of study	Participant characteristics	Country	Intervention	Comparator	Outcome measures	Funding	Databases searched	Included studies	Methods of syntheses	Findings and conclusions
Hill, Sutton et a. (2018)	Age: 50+ Mean: 75.1 Female: mean 71.9% Median n=160	Country: Asia 9%: Japan, Taiwan, Thailand, China/Hong Kong Malaysia Singapore	Group based exercise, Tai Chi, Home exercise Home safety assessment, Education, Multi-component, Mulit-factorial, Medication: VK2, VD2, and Calcium,, CBT, Nutrition, Discharge planning	Usual care, falls prevention brochure/education, placebo, community based group activities, no intervention, exercise class, outdoor walking program,	Rate of falls, number of falls RR, OR	No funding received	Medline CINAHL PubMed Psych Info SPORTDiscus Scopus	26 RCTs	Meta-analysis	Intervention types with ≥1 effective RCT in reducing fall outcomes were exercise (6 effective), home modification (1 effective), and medication (vitamin D) (1 effective). One multiple and one multifactorial intervention also had positive falls outcomes. Meta-analysis of exercise interventions identified significant benefit (number of fallers: Odds Ratio 0.43 [0.34,0.53]; number of falls: 0.35 [0.21,0.57]; and number of fallers injured: 0.50 [0.35,0.71]); but multifactorial interventions did not reach significance (number of fallers OR = 0.57 [0.23,1.44]).”
Huang et al. (2017) Systematic review and meta-analysis: Tai Chi for preventing falls in older adults	Age: 65+ Mean age range:69-85 Female: 61% (14-100%)	Country: USA, China, Taiwan, Australia Netherlands, NZ, Canada	Group based exercise (Tai Chi)	Usual care, stretching or other low-level exercises, education or standard lifestyle modification.	Rate of falls, number of falls	Guangdong Outstanding young teacher training program	Cochrane Library Medline EMBASE	15/18 (Rate of falls) 16/18 (Number of fallers); N=3539 All RCTs	Meta-analysis	Tai chi exercise significantly reduced the rate of falls compared with controls (IRR=0.69 [0.60-0.80]) I^2=57%. The chance of falling at least once was significantly lower in the Tai Chi group than the control group (RR= 0.80 [0.71-0.88] I^2=32%
Mansfield et al. (2015) Does Perturbation-Based Balance Training Prevent Falls? Systematic Review and Meta-Analysis of Preliminary Randomized Controlled Trials	Older adults (60 years old) or individuals with neurological conditions Age: 60+ Mean: Female:: NR	Country: NR	Perturbation-based balance training, delivered to individuals	No intervention received	Rate of falls, number of falls	Supported by a Focus on Stroke Personnel award from the Heart and Stroke Foundation and the Canadian stroke network	Medline EMBASE Pedro Central Google Scholar	8 RCTs N=404	meta-analysis	Participants who completed perturbation based balance training were less likely to report a fall (RR=0.54 [0.34-0.85]) p=0.007, I^2=73%, and reported fewer falls (RR=0.71 [0.52-0.96]) p =0.2, I^2=31%.

Authors, year, name of study	Participant characteristics	Country	Intervention	Comparator	Outcome measures	Funding	Databases searched	Included studies	Methods of syntheses	Findings and conclusions
Martin et al. (2013) The effectiveness of physical therapist-administered group-based exercise on fall prevention: a systematic review of randomized controlled trials	Age: 65+ Mean: 75.9Female: NR	Country: NR	Physical therapist developed or supervised Group-based exercise	No intervention received or traditional individual PT intervention	Rate of falls, balance, physical performance, health-related quality of life, fear of falling	Not reported.	PubMed CINAHL	10 RCT/ clinical trial N= 2293	Narrative	Fall rates: Group-based exercise is more effective in decreasing fall frequency, increasing balance, and improving quality of life, than no exercise. There is no significant difference in outcome between group-based exercise programs and a physical therapist–prescribed home exercise program (p=0.87). All studies reported a decrease in the number of falls compared to the control group (P <.02; risk ratio 0.60-0.82), with effect sizes ranging from trivial to small (0.19-0.25). Falls injury rates: One study reported significant difference in the injury rates associated with accidental falls, with a trivial effect size favoring the intervention group (0.17), and Barnett et al. showed a protective effect of the intervention group, which was not significant (0.66, 95% CI: 0.38-1.15). Conclusion: group-based exercise can be utilized as a valid option for falls prevention in older adults with comparable results to a physical therapist–prescribed HEP, and with greater results than education alone or no intervention.
Okubo et al. (2016) Step training improves reaction time, gait and balance and reduces falls in older people: a systematic review and meta-analysis	Age: 60+ Mean age range:68-86 Female: 50-84%	Country: NR	Step training, delivered to individuals	Controlled studies with non-intervention or other training control groups were included	Rate of falls Number /proportion of fallers	Not reported.	PubMed EMBASE CINAHL Cochrane CENTRAL	12 RCTs and 4 CCTs	Meta-analysis	Meta-analysis of 7 studies(n=660): Stepping interventions reduced the rate of falls by 52% and the proportion of fallers by 49% Rate of falls: (RR=0.48 [0.36-0.65]), p<0.0001; I^2=0% Number of fallers: (RR=0.51 [0.38-0.68]) p<0.0001; I^2=0%

Authors, year, name of study	Participant characteristics	Country	Intervention	Comparator	Outcome measures	Funding	Databases searched	Included studies	Methods of syntheses	Findings and conclusions
Rimland et al. (2016) Effectiveness of Non-Pharmacological Interventions to Prevent Falls in Older People: A Systematic Overview. The SENATOR Project ONTOP Series	Age: 60+ Mean: Female:	Country: NR	Non-pharmacological interventions: Group and home-based exercise, environment modifications, home safety assessment, education, surgery and cognitive behavioral interventions	No intervention received	Rate of falls, number of fallers	Study part of ONTOP project by EU funded FP7 research project named SENATOR	PubMed Cochrane database of systematic reviews EMBASE CINAHL PsycInfo Pedro TRIP	159 RCTs N=79 193	Meta-analysis/ Narrative dependent on appropriateness for different categories	Exercise had a consistent effect in reducing fall rate and number of fallers. Falls decreased on participation in multicomponent exercise programs: in groups or individually at home and with Tai Chi. Vision: Overall, this intervention did not influence falls (falling rate or number of fallers), Older people appear to be at increased risk during the period following changes to their prescription and while adjusting to new glasses and/or multifocal glasses. Assessment and modification of home saefty reduced falls (fall rate (RaR 0.81, 95% CI 0.68–0.97; I2 = 64%, p = 0.02; 6 trials, 4,208 participants) and number of fallers ((RR 0.88, 95% CI 0.80–0.96; I2 = 0%, p = 0.73; 7 trials, 4,051 participants) –however effective only in in individuals with a greater risk of falling or when delivered by an OT. Footwear: A non-slip shoe device diminished outside fall rate in winter while insoles to improve balance had no effect on the number of fallers. Incerased knowledge on falls prevention had no effect on fall rate or number of fallers. There is evidence that cardiac pacing in subjects with cardio-inhibitory carotid sinus hypersensitivity and cataract surgery can reduce falls, although the evidence for the latter surgical intervention was not consistent. Cognitive behavioral interventions had mixed results. Few multiple interventions (different combinations of specific interventions such as exercise, home safety, vision assessment, education, clinical assessment etc.) were effective Multifactorial interventions : decreased fall rate, but not the number of fallers

Authors, year, name of study	Participant characteristics	Country	Intervention	Comparator	Outcome measures	Funding	Databases searched	Included studies	Methods of syntheses	Findings and conclusions
Santesso et al. (2014)	Older people residing in the community or in institutional care Age:>65 Mean age: 78 – 86 Female: NR	Australia, Finalnd, Japan, Germany, Denmark, UK, Netherlands, Sweden, USa, Switzerland,	Use of body-worn protective aids (hip protectors). External hip protectors (plastic shields (hard) or foam pads (soft), usually fitted in pockets in specially designed underwear)	Control group not provided with hip protectors	Primary outcomes • Risk of sustaining a hip fracture • Risk of sustaining a pelvic fracture • Overall rate of pelvic and other fractures • Rate of fall events • Secondary outcomes • Acceptance of and adherence to wearing protectors • Complications arising from the use of hip protectors (including skin damage or breakdown) • Economic outcomes	Cochrane Bone, Joint and Muscle Trauma Group (funded by Department of Health) incentive payment, UK.	theCochrane Bone, Joint andMuscle TraumaGroup Specialised Register, CENTRAL, MEDLINE, MEDLINE In-Process, EMBASE, CINAHLL, BioMed Central.	19 Studies: 9 RCT N= 17000	Meta-analysis	Studies conducted in community setting: There is moderate quality evidence when pooling data from five trials in the community (5614 participants) that shows little or no effect in hip fracture risk (RR 1.15, 95% CI 0.84 to 1.58); the absolute effect is two more people (95% CI 2 fewer to 6 more) per 1000 people having a hip fracture when provided with hip protectors. Other fractures, pubic ramus and other pelvic fractures: - Little to no effect on falls (RR 1.02, 95% CI 0.9 - 1.16) - Little to no effect on other fractures (rate ratio 0.87, 95% CI 0.71 to 1.07). - Risk ratio for pelvic fractures is RR 1.27 (95% CI 0.78 - 2.08); - The absolute effect of one more person per 1000 (95% CI 1 fewer to 5 more) will get a pelvic fracture when provided with a hip protector. Authors' conclusions Hip protectors probably reduce the risk of hip fractures if made available to older people in nursing care or residential care settings, without increasing the frequency of falls. However, hip protectors may slightly increase the small risk of pelvic fractures. Poor acceptance and adherence by older people offered hip protectors is a barrier to their use. Better understanding is needed of the personal and design factors that may influence acceptance and adherence.

Authors, year, name of study	Participant characteristics	Country	Intervention	Comparator	Outcome measures	Funding	Databases searched	Included studies	Methods of syntheses	Findings and conclusions
Sherrington et al (2019) Exercise for preventing falls in older people living in the community	Age: 60+ Mean: 76 Female: 77%	Australia, New Zealand, Spain, Germany, Belgium, Israel, Italy, Netherlands, UK, Brazil, Canda	All types of exercise and all delivery methods.	Usual care or control intervention (one that is not thought to reduce falls, such as general health education, social visits, very gentle exercise, or 'sham' exercise).	Rate of falls, risk of falling, no. of people who experienced one or more fall-related fractures, number of people who experience one or more falls that resulted in hospital admission, Number of people who experienced one or more falls that required medical attention, Health-related quality of life, measured using validated scale, e.g. EQ-5D or similar (newly listed outcome April 2018), Number of people who experienced one or more adverse events (see below)	The National Institute for Health Research (NIHR)	CENTRAL, MEDLINE, Embase CINAHL. PEDro, the WHO ICTRP ClinicalTrials.gov	108 RCTs N=23,407	Meta-analysis	1. For the overall risk category, based on an illustrative risk of 850 falls per 1000 person-years in the control group, there were 195 (23%) fewer falls per 1000 person-years in the exercise group (95% confidence interval (CI) 144 (17%) to 246 (29%) fewer). Based on an illustrative risk of 480 fallers per 1000 older people in the control group, there were 72 (15%) fewer fallers per 1000 older people in the exercise group (95% CI 52 (11%) to 91 (19%) fewer). 2. For the non-selected lower risk category, based on an illustrative risk of 605 falls per 1000 person-years in the control group, there were 139 (23%) fewer falls per 1000 person-years in the exercise group (95% CI 102 (17%) to 175 (29%) fewer).Based on an illustrative risk of 380 fallers per 1000 older people 3. For the selected higher risk category, based on an illustrative risk of 1200 falls per 1000 person-years in the control group, there were 276 (23%) fewer falls per 1000 person-years in the exercise group (95% CI 204 (17%) to 348 (29%) fewer). Based on an illustrative risk of 500 fallers per 1000 older people in the control group, there were 75 (15%) fewer fallers per 1000 older people in the exercise group (95% CI 55 (11%) to 95 (19%) fewer). Conclusion: Exercise programmes reduce the rate of falls and the number of people experiencing falls in older people living in the community (high certainty evidence).The effects of such exercise programmes are uncertain for other non-falls outcomes where reported adverse events were predominantly non-serious. Exercise programmes that reduce falls primarily involve balance and functional exercises, while programmes that probably reduce falls include multiple exercise categories (typically balance and functional exercises plus resistance exercises). Tai Chi may also prevent falls but we are uncertain of the effect of resistance exercise (without balance and functional exercises), dance, or walking on the rate of falls.

Authors, year, name of study	Participant characteristics	Country	Intervention	Comparator	Outcome measures	Funding	Databases searched	Included studies	Methods of syntheses	Findings and conclusions
Wang et al. (2015) Cognitive motor interference for preventing falls in older adults: a systematic review and meta-analysis of randomised controlled trials	Age: 60+ Mean: NR Studies both males and females (ratio NR)	Country: NR	Cognitive motor interference, delivered to individuals	Control group: which performed single-task exercise (e.g. walking or strength and balance exercises) or no intervention.	Rate of falls	Key laboratory of exercise and health sciences (Shanghai University of Sport); Ministry of Education, the First-class disciplines of Shanghai colleagues and universities Psychology; Science and technology commission of Shanghai municipality	Medline EMBASE Cochrane library Web of Science CINAHL Pedro China biology medicine disc.	30 RCTs N=1206	Meta-analysis (2 trials)	Participants who received cognitive motor interference had a decreased fall rate (SMD=-3.03[-4.33 to -1.73]) (p <0.0001; I^2= 0.004) s compared to the control group.
Zozula et al. (2016) Pre-hospital emergency services screening and referral to reduce falls in community-dwelling older adults: a systematic review	Age: 60+ Mean: 81 Mean age range: 78 -88 Female:61%,	Country: USA, UK, Australia	Pre-hospital emergency services screening and referral programmes	No intervention received	Rate of falls	Not reported.	PubMed EMBASE CINAHL Web of Science Scopus Cochrane library OT seeker	2 RCT	Narrative	1st RCT: The rate of falling per person-year decreased from 7.68 in control to 3.46 in intervention [RR 0.45 (95% CI 0.35 to 0.58)] 2nd RCT: 30-day risk of falling 57.2% vs 64.0% (ARR 6.8% (95% CI −2.7% to 16.3%)) Neither of the two RCTs reported any difference in all-cause mortality or hospital admissions

TABLE 3D. DATA EXTRACTION OF RANDOMISED CONTROLLED TRIALS INVESTIGATING FALLS PREVENTION INTERVENTIONS FOR OLDER PEOPLE

Authors, year, name of study	Country	Inclusion	Exclusion	Intervention	Comparator	Other therapies	Outcomes	Funding
Chu, M.M. et al. (2017) An Occupational Therapy Fall Reduction Home Visit Program for Community-Dwelling Older Adults in Hong Kong After an Emergency Department Visit for a Fall	Hong Kong	65+ years, community dwelling, are ambulatory with or without a walking aid and have visited an ED primarily because of a fall.	Individuals who fell because of excess alcohol intake or sustained a sudden blow or loss of consciousness or sudden onset of paralysis due to an epileptic seizure. Individuals with a telephone mini mental state examination (MMSE) score less than 15 and those who were unable/ unwilling to provide consent, and those in nursing homes. Individuals who did not speak Cantonese.	One occupational therapy home visit program (recommendations for environmental modification, prescription of assistive devices where appropriate, provision of customized fall reduction care plans to participants or caregivers, provision of on-site skills training in fall reduction to participants or caregivers, and referrals to community agencies for other services if needed) within 2 weeks after discharge from hospital.	Well-wishing visit from a research assistant not trained in falls prevention	Environmental hazard evaluation and daily fall risk behaviour identification	Percentage of fallers over one year was 13.7% in IG and 20.4% in CG. Significant difference in the number of fallers (p=.03) and number of falls (p=0.2) between both groups over 6 months. Significant differences found in survival analysis for first fall at 6 months (p=0.2) but not 9 or 12 months.	Supported by a grant from the Health and Medical Research Fund, Food and Health Bureau, Government of the Hong Kong Special Administrative region, Peoples republic of China.
Clemson et al. 2012 Integration of balance and strength training into daily life activity to reduce rate of falls in older people (the LiFE study): randomised parallel trial	Australia	70+ years, had two or more falls or one injurious fall in the past 12 months	Moderate to severe cognitive problems; no conversational English; inability to ambulate independently; a neurological condition which severely influenced their gait and mobility; resident in a nursing home or hostel, or any unstable or terminal illness that would preclude the planned exercises and was unlikely to resolve.	LiFE Programme: movements specifically prescribed to improve balance or increase strength are embedded within everyday activities, so that the movements can be done multiple times during the day. Structured Program: 7 balance exercises and 6 for lower limb strength using ankle cuff weights and performed 3 times a week; taught over 5 sessions with 2 booster sessions and 2 follow-up phone calls over a six-month period.	The control programme (two sessions, one booster session, and six follow-up phone calls) comprised 12 gentle and flexibility exercises while seated, lying down, or standing while holding on (for example, hip rotation, leg swings).		The overall incidence of falls in the LiFE programme was 1.66 per person years, compared with 1.90 in the structured programme and 2.28 in the control group. Participants in the LiFE programme had a 31% reduction in the rate of falls compared with the control programme (incidence rate ratio 0.69 (95% CI 0.48 to 0.99), n=212). No significant reduction in the fall rate for participants in the structured programme compared with the control programme (0.81 (0.56 to 1.17), n=210).	The trial was funded by a project grant from the National Health and Medical Research Council.

Authors, year, name of study	Country	Inclusion	Exclusion	Intervention	Comparator	Other therapies	Outcomes	Funding
Cockayne, S. et al. (2017) Randomized Controlled Trial of a Multifaceted Podiatry Intervention for the Prevention of Falls in Older People (The REFORM Trial)	England and Ireland	65+ years and community-dwelling; have had a fall within the last 12 months or an injurious fall in the last 24 months; Have returned at least one monthly falls calendar during their observational phase of the study; Have fear of falling Participants who had amputations up to metatarsals	Participants with neuropathy; dementia or other neurological conditions; unable to walk more than 10 metres without assistance; having a lower limb amputation; and unwilling or unable to attend the podiatry clinic	Podiatry intervention including foot and ankle exercises, foot orthoses and if required, new footwear	Control group accessed usual podiatry services and were given a falls prevention leaflet	N/A	Small, non-significant 12% reduction in incidence rate of falls in IG (IRR=0.88 [0.71-1.05]) p=0.16. Participants in the IG reported fewer one or more falls (n = 245 (49.7%) vs. n = 284 (54.9%) CG participants; adjusted odds ratio (OR) 0.78, 95% CI 0.60 to 1.00, p = 0.05). Lower proportion of IG participants than the CG reported two or more falls on their falls calendars following randomization (n = 136 (27.6%) vs. n = 179 (34.6%); adjusted OR 0.69, 95% CI 0.52 to 0.90, p = 0.01).	Funded by the National Institute of Health Research Sponsored by University of York
Cohen MA et al. (2015) Prevention program lowered the risk of falls and decreased claims for long-term services	USA	75+ years, had private long term care insurance but who were not receiving payments for long term services and support, had insurance policy for at least 5 years	Not reported.	4 components: a. At home clinical assessment performed by nurse b. Customized recommendations and education c. Coaching, follow up call (Over 6-week period) d. d) Quarterly newsletter	Active control group: baseline assessment by telephone and quarterly data collection Administrative control group: no contact after agreeing to participate	N/A	IG group had a significantly lower (p<0.05) rate of falls than those in active control group. At 3 months FU, participants in IG group had a reduced rate of falls than participants in the active control group (RR=0.72 [0.60-0.87]). At the 6th and 9th month follow-ups, observed rate ratios: 0.79 (95% CI: 0.69, 0.91) and 0.80 (95%CI: 0.71, 0.89), respectively. The intervention effects continued at the 1-year follow up, when IG had 0.87 (95%CI: 0.79, 0.96) times the rate of falls, compared to those in the active CG. IG effects were sustained over 1 year but had a shrinking effect.	Funded by a contract from the Office of the Assistant Secretary for Planning and Evaluation (APSE) for aging, disability and long-term care policy of the Department of Health and human services

Authors, year, name of study	Country	Inclusion	Exclusion	Intervention	Comparator	Other therapies	Outcomes	Funding
Gawler, S. et al. (2016) Reducing falls among older people in general practice: the ProAct65+ exercise intervention trial	London and Nottingham	Community dwelling, 65+ years, physically able to attend group exercise and registered with participating GP.	Frequent fallers (=>3 falls in the past year), those achieving sufficient exercise to benefit health (_150 min of MVPA self-reported), people with uncontrolled medical conditions and significant cognitive impairment	Home based exercise programme (OEP); 30 min set of home exercises 3x weekly Community centre based exercise programme (FAME); once weekly, 1hr supervised session supplemented with 2x weekly 30 min sessions of home exercise program	Usual care	N/A	FAME: significant reduction in both injurious and non-injurious falls in FAME compared to control (RR=0.74 [0.55-0.99]) p=0.04. Significant reduction in injurious falls compared to control (RR: 0.55 [0.31-0.96]) p=0.04, which continued 12 months post intervention (RR: 0.73 [0.54-0.99]) p=0.05. Continual use of FAME- significant reduction in falls (RR=0.49 [0.30-0.79]) p=0.004 OEP: non-significant reduction in fall incidence compared with control (RR:0. 76 [0.53-1.09]) p=0.14	Funded by the HTA stream of the NIHR.
Möller, U.O. et al (2014) Effects of a One-Year Home-Based Case Management Intervention on Falls in Older People: A Randomized Controlled Trial	Sweden	65+ years, resident in study municipality, need help with at least 2 activities of daily living, admitted to hospital at least 2x or at least 4 outpatient contacts during last 12 months.	Cognitive impairments, cannot communicate verbally.	Monthly home visits over 12 months by nurses and physiotherapists employing a multifactorial preventive approach: (1) Case management tasks (e.g., assessment, planning, evaluation, advocacy, home visits, and care coordination). (2) General information (e.g., exercise, nutrition, social activities, the health system, and more). (3) Specific information (e.g., the participant's individual needs, medication) (4) Safety and continuity (the case managers were contactable by phone during office hours)	not reported	N/A	Not decrease in falls or injurious falls; 96 falls occurred in the IG during the intervention period compared with 85 falls in the CG (p=. 900). 40 (IG) and 38 (CG) injurious falls p=0.669 No statistically significant differences were found between the groups at any time point (3 months, p = .864; 6 months, p = .641; 9 months, p = .218; and 12 months, p = .174). No significant differences were found between the groups in self-reported falls, injurious falls, and falls resulting in medical care.	Funded by Faculty of Medicine at Lund University, the Swedish Institute for Health Sciences, Region Skane, the Governmental Funding of Clinical Research within the NHS (ALF), the Swedish Research Council, the Greta and Johan Kock Foundation, and the Magnus Bergvall Foundation

Appendix 4A. Search strategy: Interventions for prevention of falls in residential care settings

MEDLINE (via OVID)

1. Accidental Falls/
2. (falls OR faller$).tw.
3. 1 OR 2
4. exp Residential Facilities/
5. exp Nursing Homes/
6. exp Long-Term Care/
7. assisted living facilities/ OR group homes/ OR halfway houses/ OR homes for the aged/ OR orphanages/
8. costodial care/ OR foster home care
9. 4 OR 5 OR 6 OR 7 OR 8
10. 3 AND 9
11. (randomized controlled trial.pt. OR controlled clinical trial.pt. OR randomized.ab. OR placebo.mp. OR clinical trials as topic/ OR randomly.ab. OR trial.ti.) NOT (exp Animals/ not Humans/)
12. 12 systematic review.mp. OR meta-analysis.pt. OR meta-analysis.mp. OR systematic literature review.ti. OR this systematic review.tw. OR meta synthesis.ti. OR meta-analy*.ti. OR integrative review.tw. OR integrative research review.tw. OR rapid review.tw. OR umbrella review.tw.
13. 11 OR 12
14. 10 AND 13

EMBASE (OVID)

1. Falling/
2. (falls OR fallers).tw.
3. 1 OR 2
4. exp residential care/ OR exp residential home/
5. exp orphanage/ OR exp foster care/ OR custodial care/
6. exp home for the aged/ OR exp nursing home/
7. 4 OR 5 OR 6
8. 3 AND 7
9. (crossover-procedure/ OR double-blind procedure/ OR randomized controlled trial/ OR single-blind procedure/ OR (random* or factorial* OR crossover* OR cross over* OR placebo* OR (doubl* adj blind*) OR (singl* adj blind*) OR assign* OR allocat* OR volunteer*).tw.) NOT ((exp Animal/ OR Nonhuman/) NOT (exp Human))
10. exp review/ or (literature adj3 review$). ti,ab. or meta analysis/ or "Systematic Review"/ or (meta?anal$ or meta anal$ or meta-anal$ or metaanal$ or metanal$).ti,ab.

11. 9 OR 10
12. 8 AND 11
13. remove duplicates from 12

The Cochrane Library

1. Accidental Falls
2. falls or faller*
3. (#1 OR #2)
4. residential care OR residential facilit* OR residential unit* OR residential aged care OR assisted living or assisted care OR nursing home* OR long-term care or assisted living facilit* OR group home* OR halfway house* OR homes for the aged OR orphanage* OR custodial care or foster care
5. 3 AND 4

CINAHL

1. (MH “Accidental Falls”)
2. (T1 (falls or faller*) OR AB (falls or faller*)
3. S1 OR S2
4. MH residential care or MH nursing home or MH long term care or MH care home
5. MJ orphanages or MJ foster home
6. S4 OR S5
7. PT (randomized controlled trial or controlled clinical trial)
8. TI random* OR AB random*
9. S7 OR S8
10. S9 NOT (exp Animals/ not Humans/)
11. PT (systematic review)
12. S10 OR S11
13. 3 AND 6 AND12

Scopus

1. fall*
2. “residential care" OR "residential facilit*" OR "residential unit*" OR "residential aged care" OR "assisted living" OR "assisted care" OR "nursing home*" OR "retirement village*" OR "long-term care" OR "foster care" OR "institutional care" OR "care home*"
3. (("clinical trials" OR "clinical trials as a topic" OR "randomized controlled trial" OR "Randomized Controlled Trials as Topic" OR "controlled clinical trial" OR "Controlled Clinical Trials as Topic" OR "random allocation" OR "randomly allocated" OR "allocated randomly" OR "Double-Blind Method" OR "Single-Blind Method" OR "Cross-Over Studies" OR "Placebos" OR "cross-over trial" OR "single blind" OR "double blind" OR "factorial design" OR "factorial trial"))) OR (TITLE-ABS (clinical trial* OR trial* OR rct* OR random* OR blind*))

4. “systematic review” OR “meta-analysis” OR “systematic literature review” OR “this systematic review” OR “meta synthesis” OR “meta-analy*” OR “integrative review” OR “integrative research review” OR “rapid review” OR “umbrella review”
5. #3 OR #4
6. #1 and #2 AND #5

SafetyLit

1. Accidental fall* OR fall*
2. (residential care OR residential facilit* OR residential unit* OR residential aged care OR assisted living OR assisted care OR nursing home* OR retirement village* OR long-term care OR foster care OR institutional care OR care hom*)
3. (random* OR placebo OR trial OR randomized AND controlled AND trial) NOT (animals AND not humans)
4. systematic* AND review OR meta-analysis OR meta-analy*
5. 3 OR 4
6. 1 AND 2 AND 5

AgeLine (Ebsco)

1. falls*
2. residential facilities OR nursing homes or long-term care OR assisted living facilities OR group homes OR halfway houses OR homes for the aged OR orphanages
3. (random* OR placebo OR trial OR randomized AND controlled AND trial) NOT (animals AND not humans)
4. systematic* AND review OR meta-analysis OR meta-analy*
5. 3 OR 4
6. 1 AND 2 AND 5

Appendix 4B. PRISMA diagram: Interventions for prevention of falls in residential care settings

Figure 4 shows the process of identification, screening and selection using the PRISMA flowchart. There were 6,140 records identified from database searching. There were 5,984 records left after removing duplicates. At screening phase, 5,877 records were excluded following review of titles and abstracts. Full text articles were retrieved for the remaining 107 records to assess their eligibility. Of these records, 100 records were excluded due to being published prior to 2014 (81 records), published in Spanish (2 records), having an irrelevant outcome (6 records), having an irrelevant population (2 records), not meeting the sample size requirements (2 records), inaccessible full text (3 records), or having an irrelevant aim (3 records), not specifying the study setting (1 record). A total of 3 RCTs and 4 systematic reviews were included from the systematic search. Citations from the systematic search were supplemented with an additional 1 RCT (Hewitt, Goodall et al. 2018) and 2 systematic reviews(Stubbs, Denkinger et al. 2015, Cameron, Dyer et al. 2018). This resulted in a total of 6 systematic reviews and 4 randomized controlled trials.

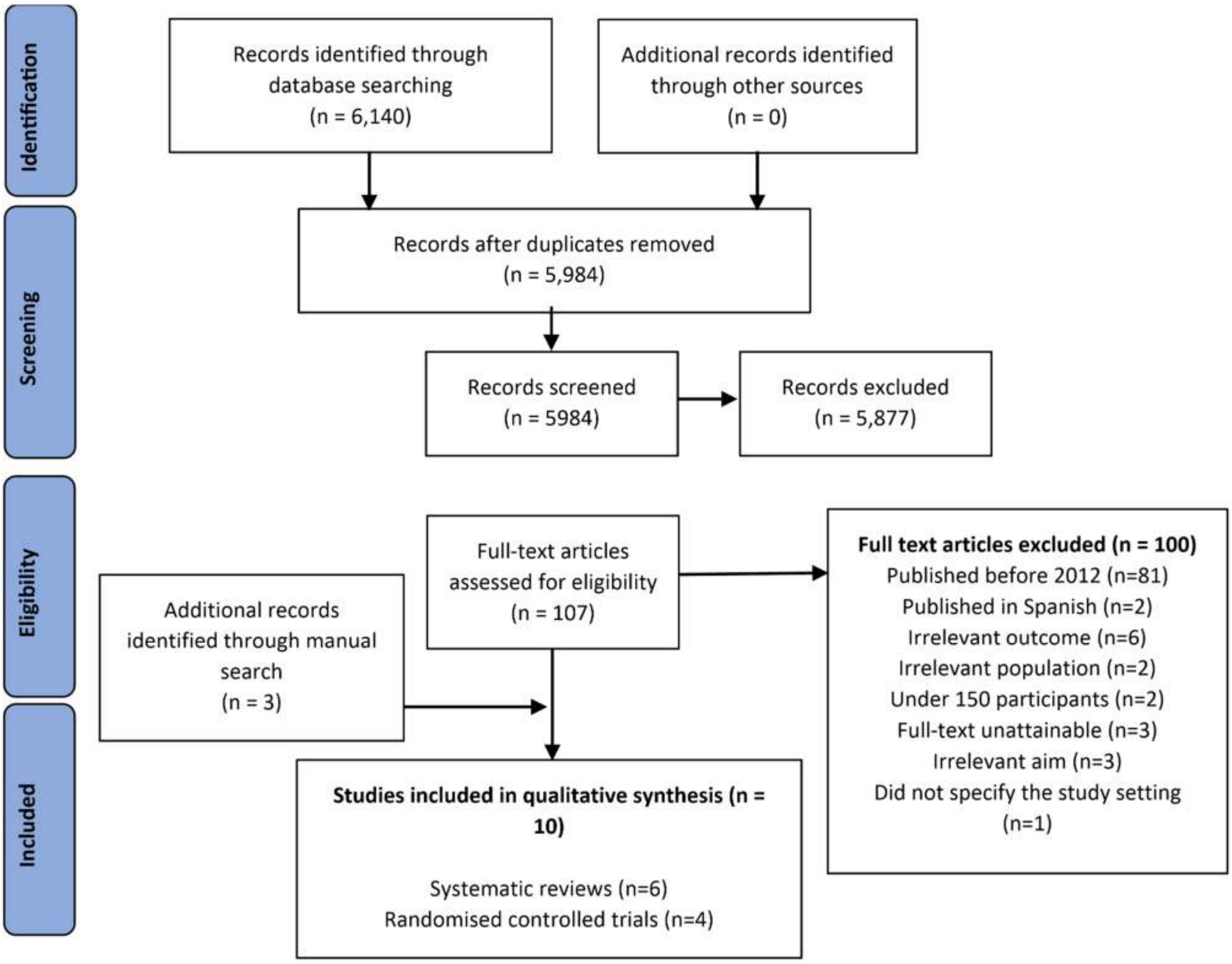

FIGURE 4. PRISMA FLOWCHART OF SEARCH METHODOLOGY FOR INTERVENTIONS FOR PREVENTION OF FALLS IN RESIDENTIAL CARE FACILITIES.

Appendix 4C. Data extraction of systematic reviews investigating falls prevention interventions implemented in residential care facilities

Authors, year, name of study	Participant characteristics	Country	Intervention	Comparator	Outcome measures	Funding	Databases searched	Included studies	Method of syntheses	Findings and conclusions
Cameron et al. 2018 Interventions for preventing falls in older people in care facilities and hospitals	Participant living in care facilities or patients in hospital. Age:65+ Mean:84 Female:75%	Australia, Brazil, Belgium, Denmark, Canada, China, Finland, France, Germany, Hungary, Israel, Korea, Japan, The Netherlands, Singapore, Spain, Sweden, Switzerland, Taiwan, Turkey, UK, USA	Any intervention designed to reduce falls in older people Exercise Medication Vit D Environmental mod Social environment and service mod change Pt ed multifactorial	any other intervention, usual care or placebo	Rate of falls (falls per unit of person time) and/or the number of fallers (risk of falling)	National Institute for Health Research (NIHR) via Cochrane Infrastructure funding to the Cochrane Bone, Joint and Muscle Trauma Group	Cochrane Bone, Joint and Muscle Trauma Group Specialised Register (to 3 August 2017), the Cochrane Central Register of Controlled Trials (CENTRAL) (2017, Issue 8), MEDLINE (including Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid MEDLINE Daily, Ovid MEDLINE and Versions) (1946 to 3 August 2017), Embase (1980 to 2017 Week 31), and CINAHL (1982 to 3 August 2017); ongoing trial registers via the World Health Organization's ICTRP Search Portal (3 August 2017) and ClinicalTrials.gov (3 August 2017)	95 randomised controlled trials (71 in care facilities, 24 in hospitals)	Meta-analyses	Seventeen trials compared **exercise** with control (typically usual care alone). We are uncertain of the effect of exercise on rate of falls (RaR 0.93, 95% CI 0.72 to 1.20; 2002 participants, 10 studies; I^2 = 76%; very low-quality evidence). Exercise may make little or no difference to the risk of falling (RR 1.02, 95% CI 0.88 to 1.18; 2090 participants, 10 studies; I^2 = 23%; low-quality evidence). There is low-quality evidence that **general medication review** (tested in 12 trials) may make little or no difference to the rate of falls (RaR 0.93, 95% CI 0.64 to 1.35; 2409 participants, 6 studies; I^2 = 93%) or the risk of falling (RR 0.93, 95% CI 0.80 to 1.09; 5139 participants, 6 studies; I^2 = 48%). There is moderate-quality evidence **that vitamin D** supplementation (4512 participants, 4 studies) probably reduces the rate of falls (RaR 0.72, 95% CI 0.55 to 0.95; I^2 = 62%), but probably makes little or no difference to the risk of falling (RR 0.92, 95% CI 0.76 to 1.12; I^2 = 42%). The population included in these studies had low vitamin D levels.

Authors, year, name of study	Participant characteristics	Country	Intervention	Comparator	Outcome measures	Funding	Databases searched	Included studies	Method of syntheses	Findings and conclusions
										Multifactorial interventions were tested in 13 trials. We are uncertain of the effect of multifactorial interventions on the rate of falls (RaR 0.88, 95% CI 0.66 to 1.18; 3439 participants, 10 studies; I^2 = 84%; very low-quality evidence). They may make little or no difference to the risk of falling (RR 0.92, 95% CI 0.81 to 1.05; 3153 participants, 9 studies; I^2 = 42%; low-quality evidence). In care facilities: we are uncertain of the effect of exercise on rate of falls, and it may make little or no difference to the risk of falling. General medication review may make little or no difference to the rate of falls or risk of falling. Vitamin D supplementation probably reduces the rate of falls but not risk of falling. We are uncertain of the effect of multifactorial interventions on the rate of falls; they may make little or no difference to the risk of falling.
Lee et al. (2017) Exercise interventions for preventing falls among older people in care facilities: A meta-analysis	\living in care facilities Age:65+ Mean:82.6 Female: 81%	Spain, USA, Hungary, New Zealand, Sweden, Netherlan ds, Japan, Korea	Any exercise interventions structured to lower falls	Usual care, or placebo	Falls rates and number of fallers	Gachon University research fund of 2015	Ovid-Medline, Embase, CINAHL, Cochrane Library, KoreaMed, KMbase, KISS, and KisTi Articles published up to December 28, 2014.	21 RCTs: 15 studies included exercise as a single interventio n. 6 studies included exercise combined with 2 or more fall interventio ns tailored to each resident's	Meta-analysis	Exercise had a preventive effect on the rate of falls (RR 0.81, 95% CI 0.68–0.97) This effect was stronger when exercise combined with other fall interventions [RR 0.61, 95% CI 0.52–0.72] Sensitivity analyses showed that exercise interventions led to a reduced number of recurrent fallers: RR= 0.71, 95% CI 0.53–0.97.

Authors, year, name of study	Participant characteristics	Country	Intervention	Comparator	Outcome measures	Funding	Databases searched	Included studies	Method of syntheses	Findings and conclusions
								fall risk (i.e., medication review, environmental modification and staff education)		
Rimland et al. (2016) Effectiveness of non-pharmacological interventions to prevent falls in older people. The SENATOR Project ONTOP Series	6 living in the community, care facilities and hospitals Age:60+ Mean:NR Female: NR	NR	<u>Exercises</u>: gait, balance, and functional training, strength/resistance training, flexibility, 3D (Tai Chi), general physical activity, endurance, or other kinds of exercise. <u>Environment/assistive technology:</u> environmental modifications to increase safety and mobility, low beds, walking aids, hip protectors, identification bracelets, vision assessment / correction, bed alarms and footwear. <u>Knowledge:</u> patient education. Social environment: staff training. Management of urinary incontinence	No exposure to intervention/s	Fall rate (rate ratio 'RaR', ratio of total number of falls per person-time in the intervention group to that in the control group) Number of fallers (risk ratios 'RR')	The European Union Seventh Framework program The ICT PSP (Policy Support Program) as part of the Competitiveness and Innovation Framework Program of the EU	PubMed Cochrane Database of Systematic Reviews, EMBASE, CINAHL, PsycINFO, PEDRO and TRIP. Literature from January 1st, 2009 to March 2015.	59 systematic reviews	Systematic overview	Exercises Exercise did not statistically significantly reduce fall rate in residential care. Mixed residential location (home and care facilities): 6/8 reviews reported statistically significant reduction in fall, or beneficial or promising in fall reduction; 2/8 were unable to reach any conclusion. Environment / assistive technology: Hip protectors - residential/nursing care and hospitals: evidence was inconclusive, but the authors recommended the use of hip protectors. Social environment - residential/nursing care and hospitals: neither staff training nor service model change in care facilities and hospitals reduced fall rate or the number of fallers. Social environment - mixed locations: no effect on fall rate or number of fallers. Identification bracelets - residential/nursing care and hospitals: using identification bracelets had no effect on fall reduction. Knowledge or educational interventions:

Authors, year, name of study	Participant characteristics	Country	Intervention	Comparator	Outcome measures	Funding	Databases searched	Included studies	Method of syntheses	Findings and conclusions
			<u>Other:</u> physical therapy and treatment of postural hypotension. --- Intervention mode of delivery: Single Multiple (combination of interventions to all subjects) Multifactorial (different combination based on evaluation of individual risk factors)							Residential/nursing care and hospitals: the finding was mixed. One RCT found that patient education associated with a decrease in fall rate. The other found no effect on either fall rate or number of fallers. <u>Management of urinary incontinence:</u> Residential/nursing care and hospitals: according to one RCT report, fewer people fell following a multiple non-pharmacological intervention consisting of 'management of urinary incontinence, fluid therapy and exercise'. Other: Residential/nursing care and hospitals: Neither lavender patches and increased exposure to sunlight affected the fall rate or number of fallers. Multiple interventions: Residential/nursing care and hospitals: Increased sunlight paired with calcium supplementation, and supervised exercises combined with fluids and regular toileting, did not influence fall rate or the number of fallers Multifactorial interventions: Residential/nursing care and hospitals: Neither fall rate nor the number of fallers was affected by the multifactorial interventions.

Authors, year, name of study	Participant characteristics	Country	Intervention	Comparator	Outcome measures	Funding	Databases searched	Included studies	Method of syntheses	Findings and conclusions
Santesso et al. (2014) Hip protectors for preventing hip fractures in older people	Older people residing in the community or in institutional care Age:65+ Mean age range: 78-86 Female: NR	Australia, Finalnd, Japan, Germany, Denmark, UK, Netherlands, Sweden, USa, Switzerland,	External hip protectors (plastic shields (hard) or foam pads (soft), usually fitted in pockets in specially designed underwear)	Control group not provided with hip protectors	Primary outcomes -Risk of sustaining a hip fracture -Risk of sustaining a pelvic fracture -Overall rate of pelvic and other fractures -Rate of fall events Secondary outcomes -Acceptance of and adherence to wearing protectors -Complications arising from the use of hip protectors (including skin damage or breakdown) -Economic outcomes	Cochrane Bone, Joint and Muscle Trauma Group (funded by Department of Health) incentive payment, UK.	Cochrane Bone, Joint and Muscle Trauma Group Specialised Register (December 2012), the Cochrane Central Register of Controlled Trials (CENTRAL) (The Cochrane Library 2012, Issue 12), MEDLINE (1950 to week 3 November 2012), MEDLINE In-Process (18 December 2012), EMBASE (1988 to 2012 Week 50), CINAHL (1982 to December 2012), BioMed Central (January 2010), trial registers and reference lists of relevant articles.	19 randomised or quasi-randomised controlled trials	Meta-analysis	Studies conducted in institutional settings: -Small reduction in hip fracture risk (RR=0.82, 95% CI 0.67-1.00). - The absolute effect is that 11 fewer people per 1000 (95% CI, from 20 fewer to 0) will get a hip fracture when provided with hip protectors. Other fractures, pubic ramus and other pelvic fractures: - Little to no effect on falls (RR 1.02, 95% CI 0.9 - 1.16) - Little to no effect on other fractures (rate ratio 0.87, 95% CI 0.71 to 1.07). - Risk ratio for pelvic fractures is RR 1.27 (95% CI 0.78 - 2.08). - The absolute effect of one more person per 1000 (95% CI 1 fewer to 5 more) will get a pelvic fracture when provided with a hip protector.
Stubbs et al. (2015) What works to prevent falls in older adults dwelling in long term care facilities and hospitals? An umbrella review of meta-analyses of randomised controlled trials	dwelling in long term care facilities or hospitals. Age:60+ Female: NR	Taiwan, USA, Australia, Belgium, Canada, New Zealand	any intervention that sought to reduce falls in older adults dwelling in long term care facilties or delivered in hospitals were included. (including the rate, number, risk or odds of falling) Multifactorial interventions	Not specifically stated	Rate of falls and/or the number of fallers	No funding	MEDLINE, EMBASE, CINAHL, AMED, BNI, PsycINFO, Cochrane Library, PubMed and the PEDro databases	10 Meta-analyses	Meta-analyses? Umbrella? Narrative?	**Exercise:** inconsistent evidence exists with evidence from 2from 3 meta-analyses or 3 out of 10 pooled results demonstratingthat exercise can reduce falls. Therefore, the benefits of exercise onreducing falls in hospitals and LTCF are not consistently evident inthe literature to date. This is based primarily on moderate and highquality evidence. Vitamin D supplementation in LTCF

Authors, year, name of study	Participant characteristics	Country	Intervention	Comparator	Outcome measures	Funding	Databases searched	Included studies	Method of syntheses	Findings and conclusions
										the current evidencedoes not support vitamin D supplementation to reduce falls in LTCFcurrently. This is based primarily on moderate and high qualityevidence. Other single interventions in LTCF LTCFIn a large meta-analysis, Santesso et al. [27] found that hip pro-tectors were not effective in reducing the rate of falls among older adults dwelling in LTCF (RaR 1.02 (0.90–1.16), N = 16, n = 11,275,I2= 92%). Guo et al. [20] investigated the influence of nutritional supplements on the odds of falling and found it has no significant effect (OR 0.93 (0.77–1.13), N = 6, n = 4934). Finally, Cameron et al.[4] found no evidence to suggest that implementing a medication review reduces the rate of falls in older adults dwelling in LTCF (RR1.00 (0.91–1.10), N = 4, n = 4857, I2= 47%). Multifactorial interventions in LTCFT although sparse, there is evidence to suggest that mul-tifactorial interventions are effective in reducing falls in LTCF. Conclusion In conclusion, multifactorial interventions appear to be the most effective interventions to prevent falls in LTCF and hospital settings. This is not without limitations and more high quality RCTs are needed in hospital settings in particular.

Authors, year, name of study	Participant characteristics	Country	Intervention	Comparator	Outcome measures	Funding	Databases searched	Included studies	Method of syntheses	Findings and conclusions
Vlaeyen et al. (2015) Characteristics and Effectiveness of Fall Prevention Programs in Nursing Homes: A Systematic Review and Meta-Analysis of Randomized Controlled Trials	Nursing home residents Age:65+ Mean age range:82 to 88 Female: 81%	Germany, UK, New Zealand, USA, The Netherlands, Northern Ireland, Germany, Australia	Variety of single, multiple, or multifactorial falls prevention programs	No exposure to intervention/s	Number of falls, fallers, and recurrent fallers	Flemish Ministry of Welfare, Public Health and Family, Belgium, and the Universiteit Derde Leeftijd Leuven vzw	MEDLINE, EMBASE, Cochrane Central Register of Controlled Trials, PEDro, CINAHL, SportDiscus Literature from database inception to September 2013.	13 original or a priori secondary analysis of individual-level or cluster randomized controlled trials	Meta-analysis	Single interventions: Staff training and education increased falls (RR 1.29, 95%CI 1.23–1.36). No effect observed from medical intervention/Vitamin D supplementation. Multicomponent interventions: Incontinence care + low intensity exercise program had no effect on falls Multifactorial interventions: Significant benefit was associated with multifactorial interventions for number of falls (RR 0.67, 95%CI = 0.55–0.82), recurrent faller (RR = 0.79, 95% CI = 0.65–0.97) but not number of fallers (RR = 0.83, 95% CI = 0.68–1.01).

Appendix 4D. Data extraction of randomised controlled trials investigating falls prevention interventions implemented in residential care facilities

Authors, year, name of RCT	Country and setting	Inclusion	Exclusion	Intervention	Comparator	Co-interventions	Outcomes	Funding
Hewitt et al. (2018) Progressive Resistance and Balance Training for Falls Prevention in	Australia Long-term residential aged care	Permanent residents of aged care.	diagnosed terminal illness, no medical clearance, permanent bed- or wheelchair-bound status, advanced Parkinson's disease, or insufficient cognition to	Individually prescribed progressive resistance training plus balance exercise performed in a group setting for 50 hours over a 25-week period,	Usual care – regular activity schedule without the introduction of the program.	Not reported	The rate of falls was reduced by 55% in the exercise group (incidence rate ratio ¼ 0.45, 95% confidence interval 0.17-0.74); an improvement was also seen in physical performance (P ¼ .02). There were no serious adverse events. Throughout the 12-month follow-up period,142 falls were recorded in the intervention group and 277 in the usual care	HUR Health and Fitness equipment provided in kind support with the use of the resistance training equipment for this trial and contributed funds toward some travel expenses for research assistants. Feros Care and Domain Principal Group

Authors, year, name of RCT	Country and setting	Inclusion	Exclusion	Intervention	Comparator	Co-interventions	Outcomes	Funding
Long-Term Residential Aged Care: A Cluster Randomized Trial of the Sunbeam Program			participate in group exercise.	followed by a maintenance period for 6 months			group. There was a 60% reduction in falls during the intervention period and a 40% reduction in falls during the maintenance period. There were fewer fallers in the intervention group (n ¼ 52, 46%) than in the usual care group (n ¼ 74, 69%). Participants in the usual care group were more likely to have multiple falls. There were 72 injurious falls (fracture, laceration, pain, bruising) in the intervention group and 157 injurious falls in the usual care group. This represents a significant reduction of 54% in the rate of injurious falls in the intervention group (incidence rate ratio ¼ 0.46). Conclusion: The Sunbeam Program significantly reduced the rate of falls and improved physical performance in residents of aged care. This finding is important as prior work in this setting has returned inconsistent outcomes, resulting in best practice guidelines being cautious about recommending exercise in this setting. This work provides an opportunity to improve clinical practice and health outcomes for long-term care residents.	donated funds to support masked assessors.
Juola et al. (2015) Nurse Education to Reduce Harmful Medication Use in Assisted Living Facilities: Effects of a Randomized Controlled Trial	Finland Assisted living facilities	Residents living permanently in assisted living facilities in Helsinki, Finland; aged 65 and above; Finnish speaking; using at least one drug; estimated life expectancy > 6 months; able to provide written informed consent	Inability to speak Finnish; not being given any form of medication; having an estimated life expectancy of less than 6 months; inability to provide written informed consent	Educational intervention: Nursing staffs underwent two interactive training sessions of 4 hours each. This was based on constructive learning theory to recognise harmful medications	Nursing staff in the control wards could participate in any other form of continuing education including programmes relating to medication use. Staff of the control wards	Not reported.	1. In the intervention wards, the prevalence of harmful medication use decreased [-11.7 % (95 % CI -20.5 to -2.9); p = 0.009]. However, in the control wards, the prevalence remained constant [+3.4 % (95 % CI -3.7 to 10.6); p = 0.34]. 2. The number of psychotropic medications decreased significantly in the intervention wards [-0.45 (95% CI -0.68 to -0.21)] compared with the control wards [-0.10 (95% CI -0.27 to 0.077)]. 3. There were 171 falls in the intervention wards (2.25 falls per person each year, 95% CI 1.93 - 2.62) and 259 falls in the control wards (3.25 falls per person each year, 95 % CI 2.87 - 3.67) [age,	Päivikki and Sakari Sohlberg Foundation, the Uulo Arhio Foundation, Helsinki University Hospital, Societas Gerontologica Fennica, and the Medical Society of Kouvola

Authors, year, name of RCT	Country and setting	Inclusion	Exclusion	Intervention	Comparator	Co-interventions	Outcomes	Funding
on Falls and Cognition		n = 227	(not explicitly described in the paper)	and adverse drug events. n = 118	received intervention training after the study was completed. n = 109		sex and comorbidity adjusted incidence rate ratio 0.72 (95 % CI 0.59–0.88); p < 0.001]. 4. When residents were stratified according to their baseline Mini-Mental State Examination (MMSE) score, residents in the intervention group with a MMSE score □10 had significantly fewer falls compared with residents that had this same characteristic in the control group (p <0.001). There were no differences between the intervention and control wards in the case of residents with an MMSE score of < 10. 5. Changes in verbal fluency and the clock drawing test were not significantly different between the groups. Conclusion: In institutional settings, the provision of education to nurses through activating learning methods is capable of reducing the prevalence of harmful medications as well as the incidence of falls among residents.	
Sitjà-Rabert et al. (2015) Whole body vibration (WBV) exercise intervention Effects of a whole-body vibration (WBV) exercise intervention for institutionalized older people: a randomized, multicentre,	Spain Nursing homes in the metropolitan area of Barcelona	Volunteers of any sex aged 65 years and above who were residing in a nursing home and were able to adopt a squat position on a vibrating platform. n = 159	Having an acute illness that was not resolved within a period of 10 days (including epilepsy); having severe heart disease; using a pacemaker; having a high risk of thromboembolism; having a hip or knee replacement; having a musculoskeletal disorder; having a cognitive or physical disorders that could interfere with the training methods.	WBV plus exercise Group: Each participant in this group actively performed the static/dynamic exercises individually on a vibratory platform (Pro5 Airdaptive Model; PowerPlate, Amsterdam, The Netherlands).	Exercise group: Performed the static/dynamic exercises in groups. n = 78	The two groups underwent the same static/dynamic exercises (balance and strength training): 3 sessions (30 minutes each) a week for 6 weeks. At each session, both groups performed warm-up and cool-down exercises that consisted of walking around	Measurements were performed at baseline, at the end of the intervention at 6 weeks, and 6 months after the study. Primary outcome: Balance, gait and functional mobility at 6 weeks Secondary outcomes: 1. Balance, gait, and functional mobility at 6 weeks and 6 months. The Tinetti total score indicated a significant overall advancement over time for the two groups at 6 weeks (p < 0.001) and at 6 months (p = 0.012), with no significant differences between the groups (P = 0.890 at 6 weeks and p = 0.718 at 6 months). The Time Up and Go test showed no significant improvement over time in either group at 6	The Spanish Institute for Older Persons and Social Services (IMSERSO), Spanish Ministry of Health, Social Policy and Equality, Project 180/ 2010

Authors, year, name of RCT	Country and setting	Inclusion	Exclusion	Intervention	Comparator	Co-interventions	Outcomes	Funding
parallel, clinical trial				A frequency of 30-35 Hz was applied to the vibratory platform, and the amplitude was varied between 2 and 4 mm. n = 81		the room for 3 - 5 minutes. During the follow-up period, all the participants were invited to perform a physical exercise (group classes, 2 sessions per week) with other institutionalised elderly people.	weeks (p = 0.599) or at 6 months (p = 0.368). There were no differences between the groups at 6 weeks (p = 0.757) or at 6 months (p = 0.959). 2. Muscle performance at 6 weeks and 6 months. Muscle performance results from the 5 Sit-To-Stand tests showed a significant improvement in both groups over time (p = 0.001), but there were no statistically significant differences between the groups at 6 weeks (p = 0.709) or at 6 months (p =0 .841) 3. The maximum speed (Vmax) at 6 weeks. The Vmax showed a significant improvement of 0.05 m/s (from 0.59 to 0.64 m/s) in the exercise groups and a deterioration of 0.03 m/s (from 0.60 to 0.57 m/s) in the WBV plus exercise groups (p = 0.038) 4. The number of falls at 6 months. There was a total of 57 falls (35.8%) during the follow-up period, with no differences between the groups (p = 0.406). 5. Adverse effects at 6 weeks and 6 months. No severe adverse effects were observed in relation to the intervention, and the statistical results showed no differences between the groups (p = 0.430). Conclusion: The WBV exercise intervention provided benefits equivalent to exercise interventions without vibration in relation to body balance, gait, functional mobility, and muscle strength in institutionalised elderly people.	
Whitney et al. (2017) ProF-Cog (Prevention of	United Kingdom Care homes (nursing	Permanent residents living in care homes who were likely to survive for the entire 6-month	Reasons for exclusion included death before recruitment	Two linked processes: Process one: a multifactorial	Usual care with no falls risk assessment and no therapeutic interventions.	Not reported	All outcomes were measured once at baseline and again at 6-month follow up. Primary outcome: Standing balance rating scale.	National Institute for Health Research (NIHR)

Authors, year, name of RCT	Country and setting	Inclusion	Exclusion	Intervention	Comparator	Co-interventions	Outcomes	Funding
falls in older adults with cognitive impairment) Feasibility and efficacy of a multi-factorial intervention to prevent falls in older adults with cognitive impairment living in residential care (ProF-Cog). A feasibility and pilot cluster randomised controlled trial	homes and residential care homes)	study period and had sufficient understanding of the English language to participate. n = 191	(n = 5), temporary residence (n = 4), insufficient English language (n = 4) and life expectancy of <6 months (n = 15) (Fig. 1).	fall risk assessment (MFRA) Process two: a tailored 'therapeutic' intervention, which could include dementia care mapping, comprehensive geriatric assessment, occupational therapy input and twice-weekly exercise for 6 months as required to target identified risk factors. n = 103 (lost to follow-up 17)	n = 88 (lost to follow-up 17)		Other outcomes: fall, timed up and go, grip strength and sit to stand ability, the EQ5D, iconographical FES-I, Cornell depression scale, and Addenbrooke's Cognitive Examination (ACE-R). The balance scores reduced by 3.90 on average in the control groups and 5.14 in the intervention groups; there was no significant difference (p = 0.90). With the exception of a significant increase in staff-rated Cornell depression scores in the intervention group, no other secondary outcome measures differed between the two groups. There was no significant difference in the risk of being a faller (RR = 1.09, 95% CI 0.58-2.03) or the rate of falls (IRR = 1.59, 95% CI 0.67-3.76). Conclusion: The intervention was considered safe but did not meet the threshold of being clinically effective.	

Appendix 5A. Search strategy: Interventions for prevention of falls in hospitals

MEDLINE

1. Accidental Falls/
2. (falls or faller$).tw.
3. 1 or 2
4. exp Hospitals/
5. Hospital Units/
6. Rehabilitation Centers/
7. ((hospital) adj3 (care or ward$1)).tw.
8. ((rehabilitation or geriatric) adj (ward$1 or hospital$1 or unit$1)).tw. w.
9. 4 or 5 or 6 or 7 or 8
10. (randomized controlled trial.pt OR controlled clinical trial.pt. OR randomized.ab. OR placebo.mp. OR clinical trials as topic/ OR randomly.ab. OR trial.ti.) NOT (exp Animals/ not Humans/)
11. systematic review.mp. OR meta-analysis.pt. OR meta-analysis.mp. OR systematic literature review.ti. OR this systematic review.tw. OR meta synthesis.ti. OR meta-analy*.ti. OR integrative review.tw. OR integrative research review.tw. OR rapid review.tw. OR umbrella review.tw.
12. 10 or 11
13. 3 and 9 and 12

Appendix 5B. PRISMA diagram: Interventions for prevention of falls in hospital settings

Figure 5 shows the process of article identification, screening and selection using the PRISMA flowchart. A total of 2,181 records were identified from database searching. After removing duplicates, 1,285 records remained. At the screening phase, 1,185 records were excluded following review of title and screening of abstract. Full text articles were retrieved for the remaining 93 records to assess their eligibility. Overall, a total of 6 systematic reviews were eligible. Citations from the systematic search were supplemented with one additional systematic review published subsequently (Cameron, Dyer et al. 2018). This resulted in a total of 7 systematic reviews being included in this rapid review.

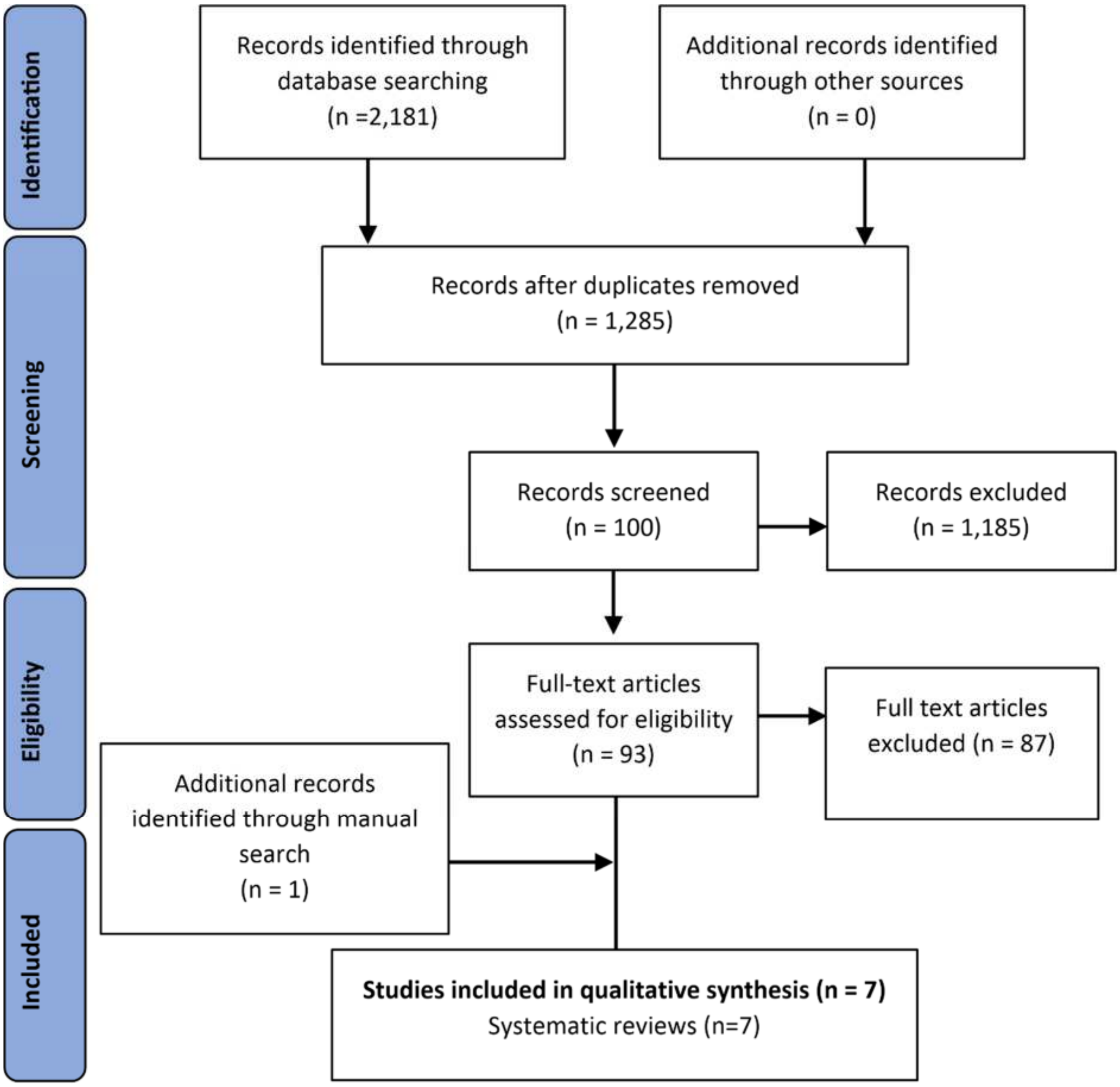

FIGURE 5. PRISMA FLOWCHART OF SEARCH METHODOLOGY FOR INTERVENTIONS FOR PREVENTION OF FALLS IN HOSPITALS

Appendix 5C. Data extraction of systematic reviews of falls prevention interventions in hospitals

Name of SR	Participant characteristics	Intervention	Comparator	Outcome measures	Funding	Databases searched	Included studies	Methods of syntheses	Findings and conclusions
Cameron et al. 2018 Interventions for preventing falls in older people in care facilities and hospitals	Participant aged 65 years and over living in care facilities or patients in hospital.	Any intervention designed to reduce falls in older people Exercise Medication Vit D Environmental mod Social environment and service mod change Pt ed multifactorial	any other intervention, usual care or placebo	Rate of falls (falls per unit of person time) and/or the number of fallers (risk of falling)	National Institute for Health Research (NIHR) via Cochrane Infrastructure funding to the Cochrane Bone, Joint and Muscle Trauma Group	Cochrane Bone, Joint and Muscle Trauma Group Specialised Register (to 3 August 2017), the Cochrane Central Register of Controlled Trials (CENTRAL) (2017, Issue 8), MEDLINE (including Epub Ahead of Print, In-Process & Other Non-Indexed Citations, Ovid MEDLINE Daily, Ovid MEDLINE and Versions) (1946 to 3 August 2017), Embase (1980 to 2017 Week 31), and CINAHL (1982 to 3 August 2017); ongoing trial registers via the World Health Organization's ICTRP Search Portal (3 August 2017) and ClinicalTrials.gov (3 August 2017)	95 randomised controlled trials (71 in care facilities, 24 in hospitals)	Meta-analyses	Additional physiotherapy (supervised exercises) uncertain of the effect of additional physiotherapy on the rate of falls (RaR 0.59, 95% CI 0.26 to 1.34 risk of falling (RR 0.36, 95% CI 0.14 to 0.93. Bed and chair sensor alarms in hospitals: rate of falls (RaR 0.60, 95% CI 0.27 to 1.34), risk of falling (RR 0.93, 95% CI 0.38 to 2.24. Multifactorial interventions: may reduce rate of falls in hospitals (RaR 0.80, 95% CI 0.64 to 1.01; subgroup analysis by setting: 0.64 to 1.01, (RaR 0.67, 95% CI 0.54 to 0.83), risk of falling (RR 0.82, 95% CI 0.62 to 1.09

Name of SR	Participant characteristics	Intervention	Comparator	Outcome measures	Funding	Databases searched	Included studies	Methods of syntheses	Findings and conclusions
Hempel et al. 2013 Hospital Fall Prevention: A Systematic Review of Implementation, Components, Adherence, and Effectiveness	Hospitalised patients of either sex in acute care U.S. hospital settings with length of stay that are 30 days or shorter.	Implementation Strategies Intervention components Intervention components for high-risk patients only Adherence strategies and fidelity	The control group received usual care or no intervention	Incidence rate ratios of fall rate post-intervention or treatment group to the fall rate pre-intervention or control group	Agency for Healthcare Research and Quality, The Veterans Affairs Greater Los Angeles Health Services Research & Development Center of Excellence	Database of Abstracts of Reviews of Effects (DARE), the Cochrane Database of Systematic Reviews, PubMed, (CINAHL), Web of Science from January 2005 were searched to August 2011	59 studies meeting inclusion criteria	Meta-Analysis	The pooled intervention effect (IRR) was 0.92 (95% CI 0.65–1.30). Five of the eight successful approaches (IRR < 1) described an implementation strategy such as staff education; combined a number of intervention components such as fall risk assessment, education, alert signs, and bed-exit alarms; and with one exception, audited adherence to the care processes, but other multifaceted approaches were not successful.
Lee, Prtichard et al. 2014	Hospitalised or ED attended adult patients of either sex, mean age ≥ 60 years of age.	Multifactorial falls prevention programme that consisted of patient education intervention (8 studies) Patient education intervention only (5 studies)	The control group received usual care, no routine intervention or placebo.	The proportion of participants who became fallers Rate of falls Rate of injurious falls The proportion of participants who had an injurious fall	No funding	Ovid Medline, PsycINFO, CINAHL, Scopus and Cochrane central register of controlled trials	19 studies were included in quantitative synthesis; 11 studies were included in qualitative synthesis	Meta-analysis	Falls prevention education programs were effective in reducing fall rates amongst hospital inpatients, and in reducing the proportion of patients who became fallers in hospital. Risk of fall (patients who became fallers): Pooled data: no significant effect (RR 0.88, 95% CI 0.75 to 1.04), Subgroup meta-analysis focusing only on hospital-based studies, showed that education reduced risk of fall (RR 0.78, 95% CI 0.70 to 0.87); Post-hospitalization studies: no significant effect (RR 1.07, 95% CI 0.87 to 1.33). cognitively intact participants only: no effect (RR 1.15, 95% CI 0.67 to 1.97), mixed groups of cognitively intact and impaired participants showed borderline reduction (RR 0.84, 95% CI 0.71 to 1.00), cognitively impaired participants only showed no significant effect (RR 1.22, 95% CI 0.71 to 2.07). Rate of fall:

Name of SR	Participant characteristics	Intervention	Comparator	Outcome measures	Funding	Databases searched	Included studies	Methods of syntheses	Findings and conclusions
									Pooled data: significant reduction (RR 0.77, 95% CI 0.69 to 0.87), cognitively intact participants only: significant reduction (RR 0.56, 95% CI 0.4 to 0.77, mixed groups of cognitively intact and impaired participants: significant reduction (RR 0.82, 95% CI 0.75 to 0.89), cognitively impaired participants: no significant effect (RR 1.04, 95% CI 0.45 to 2.41), Rate of injurious falls: Pooled data: no significant (RR 0.94, 95% CI 0.82 to 1.08), mixed groups of cognitively intact and impaired participants: no significant effect (RR 0.97, 95% CI 0.83 to 1.13), cognitively intact participants only: no significant effect (RR 0.79, 95% CI 0.57 to 1.10). Proportion of fallers with injury: no significant effect (RR 0.94, 95% CI 0.56 to 1.59) Patient education generally increased knowledge about falls and awareness of prevention strategies.
Marques Queirós et al. 2017	Hospitalized adult patients with any clinical condition in non-intensive care unit of either sex, age 65 years and over.	Use of bedrails	No use of bedrails or any type of physical restraints (wrist or ankle ties)	Primary outcome: number of patients who fell or the number of falls per patient Secondary outcome: number of head trauma, bone fractures or soft tissue injuries	Not reported	13 databases: Search for published articles (published in Portuguese, English and Spanish beginning from 1980): CINAHL, PsycINFO, Web of Science Core Collection, Cochrane Central Register of Controlled Trials, PubMed, Scielo, MedicLatina,	No studies were found to meet selection criteria (lack of information in the titles and abstracts to verify if the articles met the inclusion criteria)	Data extraction and synthesis were not conducted since there were no articles included in this systematic review.	There is no scientific evidence comparing the effectiveness of the use of bedrails in preventing falls among hospitalized older adults when compared with no use of bedrails or any type of physical restraints.

Name of SR	Participant characteristics	Intervention	Comparator	Outcome measures	Funding	Databases searched	Included studies	Methods of syntheses	Findings and conclusions
						Academic Search Complete, Nursing and Allied Health Collection: Comprehensive. Search for unpublished articles: RCAAP – Reposito´ rio Cientifico de Acesso Aberto de Portuga,l Banco de teses da CAPES , ProQuest – Nursing and Allied Health Source Dissertations, ''Grey Literature Report'' from New York Academy of Medicine	intervention: use of bedrails to prevent falls; participants: inpatients aged 65 years and over; context of care: in hospital; outcome measures: number of patients who fell or the number of falls per patient; or number of head trauma, bone fractures or soft tissue injuries.		
(Miake-Lye, Hempel et al. 2013) Miake-Lye, Hempel et al. 2013 Inpatient Falls prevention Programs as a Patient Safety Strategy: A Systematic Review	'Older adults in hospitals' Further detail not specified	Multicomponent falls prevention interventions: patient education, bedside risk sign, staff education, alert wristband, footwear, review after fall, toileting schedules, medication review, environment modification, movement alarms, bedrail review , exercise, hip protectors, urine screening, vest, belt, or cuff restraint	The control group received usual care or no intervention	Number of falls	Agency for Healthcare Research and Quality, The Veterans Affairs Greater Los Angeles Health Services Research & Developmen t Center of Excellence	PubMED, CINAHL, and the Web of Science from 2005 to September 2012	4 meta-analyses involving 19 studies; and new, large, randomized, controlled trials	Systematic review	Multicomponent programs to prevent falls among inpatients reduce relative risk for falls by as much as 30% in hospitals varying in size and locations. Dykes et al 2010: Falls Prevention Tool Kit, which includes a risk assessment and tailored signage, patient education, and plan-of-care components: Adjusted fall rates in the intervention units (3.15 per 1000 patient days [CI, 2.54 to 3.90]) were lower than those of control units (4.18 per 1000 patient days [CI, 3.45 to 5.06]), yielding a rate difference of 1.03 (CI, 0.57 to 2.01).

Name of SR	Participant characteristics	Intervention	Comparator	Outcome measures	Funding	Databases searched	Included studies	Methods of syntheses	Findings and conclusions
									A particularly strong effect was found in patients aged 65 years or older (rate difference, 2.08 per 1000 patient days [CI, 0.61 to 3.56]). Ang et al 2011 (An assessment tool was used to match high-risk patients with appropriate interventions, in addition to an educational session tailored to patient-specific risk factors: The proportion of patients with at least 1 fall in the intervention group was 0.4% (CI, 0.2% to 1.1%), whereas in the control group it was 1.5% (CI, 0.9% to 2.6%), for a relative risk reduction of 0.29 (CI, 0.1 to 0.87). There is no strong evidence about which program components are most important for success. Evidence about successful implementation of multicomponent interventions suggests that the following are important factors: leadership support, engagement of front-line clinical staff in the design of the intervention, guidance by a multidisciplinary committee, pilot-testing the intervention, and changing nihilistic attitudes about falls.
Rimland, Abraha et al. 2016 Effectiveness of Non-Pharmacological Interventions to Prevent Falls in Older People: A Systematic Overview. The SENATOR Project ONTOP Series	People aged 60 and above living in the community, care facilities and hospitals	Exercises: gait, balance, and functional training, strength/resistance training, flexibility, 3D (Tai Chi), general physical activity, endurance, or other kinds of exercise; Environment/assistive technology: environmental modifications to increase safety and mobility (low height beds, bed exit alarms, identification bracelets);	No exposure to intervention/s	Fall rate (rate ratio 'RaR') Number of fallers (risk ratios 'RR')	The European Union Seventh Framework program The ICT PSP (Policy Support Program) as part of the Competitiveness and Innovation Framework Program of the EU	Pubmed, the Cochrane Database of Systematic Reviews, EMBASE, CINAHL, PsycINFO, PEDRO and TRIP Literature from January 1st 2009 to March 2015 (in English, Italian or Spanish	59 systematic reviews	Systematic overview	In hospital settings Exercise: Cameron et al 2010: In subacute wards, supplementary physiotherapy, consisting of supervised exercises, did not statistically significantly decrease fall rate (RaR 0.54, 95% CI 0.16–1.81) but was associated with a decline in number of fallers (RR 0.36, 95% CI 0.14–0.93). Mixed location: Ishigaki et al 2014 concluded that based on the methodologically high-quality studies, this type of exercise is effective for falls prevention in older people (no outcome measure reported). Schoene et al 2014: One small RCT (70 participants) reported that fewer people fell in the intervention group.

Name of SR	Participant characteristics	Intervention	Comparator	Outcome measures	Funding	Databases searched	Included studies	Methods of syntheses	Findings and conclusions
		Social environment: staff training; Knowledge: patient education Intervention mode of delivery: Single Multiple (combination of interventions to all subjects) Multifactorial (different combination based on evaluation of individual risk factors) Multifactorial							Environment/assistive technology Anderson et al 2012: Environmental modifications, assistive technologies (e.g. low height bed, bed exit alarm, identification bracelets, position monitoring devices) and other sensor technologies showed no difference in fall rates in hospital settings and care facilities. Cameron et al 2012: Carpeted floor increased falls when compared to vinyl flooring (RaR not reported). Batchelor et al 2010: environmental modification, in hospitals, did not affect fall rate or number of fallers of older people following stroke. Choi et al 2011(single and multifactorial interventions): falls were lower on vinyl floors than on floors with carpeting. Kosse et al 2013: no significant differences in number of falls in 2 RCTs that investigated bed and chair sensors. Social environment: neither staff training nor service model change in care facilities/hospitals reduced fall rate or the number of fallers. Social environment - mixed locations: no effect on fall rate or number of fallers. Identification bracelets - residential/nursing care/hospitals: using identification bracelets had no effect on fall reduction. Knowledge or educational interventions: Cameron et al 2012: One RCT found that patient education associated with a decrease in fall rate. The other found no effect on either fall rate or number of fallers. Multiple interventions: Mixed locations: Goodwin et al 2014 (exercises together with vitamin D, calcium, management of urinary incontinence, fluid or nutritional therapy, psychological measures, environment/assistive aids, knowledge, vision

Name of SR	Participant characteristics	Intervention	Comparator	Outcome measures	Funding	Databases searched	Included studies	Methods of syntheses	Findings and conclusions
									improvement and others; vitamin D with calcium and nutritional supplements or calcium with exposure to sunlight) - By pooling the RCTs in a meta-analysis, the authors observed a decrease in fall rate ratio (RaR 0.80, 95% CI 0.73–0.88; I2 = 19%, P = 0.23; 11 trials) and the number of people falling (RR 0.85, 95% CI 0.80–0.91; I2 = 0%, P = 0.80; 12 trials). Multifactorial interventions: Cameron et al 2012: these interventions were associated with lower fall rate (RaR 0.69, 95% CI 0.49–0.96) and the number of fallers (RR 0.71, 95% CI 0.46–1.09. Fox et al 2012: pooled results from 2 trials demonstrated a decline in falls (RR 0.51, 95% CI 0.29–0.88. DiBardino et al 2012 (exercise, mobility aid, medication modification, education, bed interventions (e.g. bed alarm, rail adjustment and toileting schedule): fall rate declined, although at the limit of statistical significance (OR 0.90, 95% CI 0.83–0.99). Hempel et al 2013 (low beds, bed alarms, non-skid socks and slippers, hip protectors, suitable lighting, side rails, non-skid shower mats, falls prevention poster, patient and family education and restraints to prevent falls of older patients in the hospital (acute, rehabilitation wards): not associated with a decrease of the fall incidence rate (IRR 0.92, 95% CI 0.65–1.30). Kosse et al 2013: There was no difference in fall rate, in elderly care wards in hospitals, with a multifactorial intervention. Lee et al 2014: There was a statistically significant decrease in fall rate when different types of studies were combined (RaR 0.77, 95% CI 0.69–0.87), while there was a non-statistically significant reduction in the proportion of fallers again when pooling various types of studies (RR 0.88, 95% CI 0.75–1.04).

Name of SR	Participant characteristics	Intervention	Comparator	Outcome measures	Funding	Databases searched	Included studies	Methods of syntheses	Findings and conclusions
									Mixed location: Bunn et al 2014: seven trials found a statistically significant reduction in the number of falls/fall rate and 4 studies reported a decrease in the number of fallers. Voigt-Radloff et al 2013: no consistent effect on falls among the trials.
Stubbs, Denkinger et al. 2015 (Stubbs, Denkinger et al. 2015) What works to prevent falls in older adults dwelling in long term care facilities and hospitals? An umbrella review of meta-analyses of randomised controlled trials	Older adults aged 60 years and over dwelling in long term care facilities or hospitals.	Any intervention that sought to prevent falls (including the rate, number, risk or odds of falling) Multifactorial interventions	Not specifically stated	Rate of falls and/or the number of fallers	No funding	MEDLINE, EMBASE, CINAHL, AMED, BNI, PsycINFO,Cochrane Library, PubMed and the PEDro databases	2 studies (Cameron eta al.'s Cochrane SR 2012 & Coussement et al.'s SR 2008)	Meta-analyses	Rate of falling and risk of falling were both significantly reduced by multifactorial interventions (Cameron: RaR 0.69 (0.49–0.96); Coussement: RR 0.74 (0.58–0.96) There was no significant effect on the risk of falls when pooling single and multifactorial interventions (RR 0.87 (0.70–1.08)). Thus, although sparse, there is evidence that multifactorial interventions are effective in reducing falls (both the rate and risk) in hospital settings.

Appendix 5D. Data extraction of 2 key randomised controlled trials of falls prevention interventions in hospitals within Cameron SR

Authors, year, name of RCT	Country setting	Inclusion	Exclusion	Intervention	Comparator	Co-interventions	Outcomes	Funding
Barker et al 2016 6-PACK programme to decrease fall injuries in acute hospitals: cluster randomised controlled trial	Australian acute wards from six Australian hospitals	Wards were eligible to participate if they were nominated by participating hospitals as being wards where falls commonly occurred, had an average length of stay of patients of less than 10 days, had one or fewer low-low beds to each six standard beds on medical wards and one or fewer low low beds to each 29 standard beds on surgical wards, and did not include a fall risk tool or intervention checklist on the daily patient care plan documentation.	There were no patient level exclusion criteria.	a nine item fall risk tool,20 as well as six interventions: "falls alert" sign, supervision of patients in the bathroom, ensuring patients' walking aids are within reach, establishment of a toileting regimen, use of a low-low bed, and use of a bed/chair alarm. Nurses were asked to update the fall risk tool foreach of their patients each shift and to apply a fallsalert sign and one or more of the remaining 6-PACKinterventions to patients classified as being at high risk.	Usual care		falls and fall injuries per 1000 occupied bed days. During the trial period: The fall rate in intervention wards was 7.46 (7.00 to 7.50) per 1000 occupied bed days compared with 7.03 (6.59 to 7.51) per 1000 occupied bed days in control wards; the rates of falls (incidence rate ratio 1.04, 0.78 to 1.37; P=0.796) and The rate of fall injuries was 2.33 (2.07 to 2.83) and 2.53 (2.26 to 2.82) per 1000 occupied bed days, fall injuries (0.96, 0.72 to 1.27; P=0.766)	This project was funded by the National Health and Medical Research Council (NHMRC), Australia
Hill, McPhail et al 2015 Fall rates in hospital rehabilitation units after individualised patient and staff education programmes: a pragmatic, stepped-wedge, cluster-randomised controlled trial	Australia publicly funded, rehabilitation units in general hospitals (clusters) that admit patients for rehabilitation from disorders such as hip fracture or medical illness.	Patients aged more than 60 years, had a projected length of stay of at least 3 days, had basic cognitive functioning, and when the treating clinical team judged that the patient had a high enough level of cognition to benefit from the education		Safe Recovery programme: an individualised patient falls-prevention education programme: Educator component: 6h of video conference-based training Patient component: a multimedia education package (a digital video disc [DVD] and written workbook) and individually tailored follow-up sessions from the educator. Each patient viewed the DVD at their bedside and received a workbook to review and keep. The educator then provided follow-up sessions for each patient which weretailored for the patient's individual circumstances. Staff component: face-to-face staff training in the week of the start of the intervention; weekly feedback to staff about the goals the patients had set and patient's feedback about barriers they perceived.	Usual care		rate of falls during 1000 patient-days: fewer in the intervention group (7.80/1000 patient-days vs 13.78/1000 patient-days; adjusted rate ratio 0.60 [robust 95% CI 0.42–0.94]), the proportion of patients who had a fall: fewer fallers, (8.38%] vs. [12·51%], adjusted odds ratio 0.55 [robust 95% CI 0·38 to 0·81]).the rate of injurious falls while in the study units: injurious falls (2.63/1000 patient-days 4.75/1000 patient-days, 0.65 [robust 95% CI 0.42–0.88]) length of stay by patients in a unit participating in the trial: no significant difference in length of stay (intervention median 11 days [IQR 7–19], control 10 days [6–18])	State Health Research Advisory Council, Department of Health, Government of Western Australia

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