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Interventions to Prevent Falls in Older Adults: A Systematic Review for the U.S. Preventive Services Task Force

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Structured Abstract

Objective: We conducted this systematic review to support the U.S. Preventive Services Task Force in updating its recommendation on the prevention of falls in older adults. Our review addressed the following questions: 1) Is there direct evidence that primary care interventions to prevent falls in community-dwelling older adults at average or high risk for falls, used alone or in combination, reduce falls or fall-related injury, improve quality of life, reduce disability, or reduce mortality? 1a) How is high risk assessed in the included trials? 2) What are the adverse effects associated with primary care interventions to prevent falls in community-dwelling older adults?

Data Sources: We searched MEDLINE, PubMed publisher-supplied records, Cumulative Index for Nursing and Allied Health Literature, and Cochrane Central Register of Controlled Trials for relevant English-language literature published between January 1, 2010, and August 30, 2016. Additionally, we re-evaluated all studies included in the 2010 review. We supplemented our searches with reference lists from relevant existing systematic reviews, suggestions from experts, and ClinicalTrials.gov to identify ongoing trials. We conducted ongoing surveillance through August 2, 2017 to identify any major studies published in the interim.

Study Selection: We included the following study designs: randomized placebo-controlled trials on the effectiveness of interventions to prevent falls in older adults; randomized controlled trials on the harms of fall interventions; and systematic reviews and randomized control trials on the harms of vitamin D to prevent falls in older adults. Two investigators independently reviewed identified abstracts and full-text articles against a set of *a priori* inclusion and quality criteria.

Data Analysis: One investigator abstracted data into an evidence table and a second investigator confirmed these data. Two investigators independently assessed study quality using methods developed by the USPSTF. We qualitatively synthesized the data for each key question and meta-analyzed trial results when appropriate.

Results: We identified 62 trials (n=35,058) examining seven intervention types aimed at reducing the risk of falls and fall-related outcomes. The largest bodies of literature evaluated multifactorial and exercise interventions with 26 and 21 trials, respectively. Our findings suggest that there is a fall-related benefit associated with both multifactorial and exercise interventions but evidence is most consistent across multiple fall-related outcomes for the exercise trials. Meta-analysis of multifactorial intervention trials showed a 21 percent reduction in falls with substantial heterogeneity (17 RCTs; n=9,737; incidence rate ratio [IRR], 0.79 [95% CI, 0.68 to 0.91]; I^2=87.2%) but no statistically significant effect on people experiencing a fall (24 RCTs; n=12,490; relative risk [RR], 0.95 [95% CI, 0.89 to 1.01]; I^2=56.4%), people experiencing a fall-related injury (16 RCTs; n=9,445; RR 0.94, [95% CI, 0.85 to 1.03]; I^2=34.3%) or mortality (23 RCTs; n=9,721; RR, 0.96 [95% CI, 0.79 to 1.17]; I^2=0%) at 6 to 36 months of followup. Small numbers of the multifactorial studies reported no statistically significant effect on fall-related injuries, fall-related fractures, people experiencing fall-related fractures, activities of daily living (ADL), quality of life (QOL), hospitalization and institutionalization, but were underpowered for these outcomes. Meta-analysis of exercise trials showed an 11 percent reduction in people experiencing a fall (15 RCTs; n=4,926; RR, 0.89 [95% CI, 0.81 to 0.97]; I^2=43.9%), a 13 percent

nonstatistically significant reduction in falls (14 RCTs, n=4,663; IRR, 0.87 [95% CI, 0.75 to 1.00]; I^2=57.3%), a 19 percent reduction in injurious falls (10 RCTs, n=4,622; IRR, 0.81 [95% CI, 0.73 to 0.90]; I^2=0.0%), and a qualitative reduction in people experiencing an injurious fall, with estimates ranging from 0.61 to 0.90 (5 RCTs, n=2,776) and no individual study reaching statistical significance. There was no effect on mortality (11 RCTs, n=4,263; RR, 0.93 [95% CI, 0.71 to 1.22; I^2=0%) at 12 to 60 months of followup. Hospitalizations, institutionalizations, QOL and instrumental activities of daily living (IADL) outcomes were reported in a few exercise trials showing no statistically significant effect. Seven heterogeneous trials (n=7,531) of different vitamin D formulations (with or without calcium), dosing schedules, and varying baseline fall risk show mixed results at 9 to 36 months of followup. The single trial of annual high-dose cholecalciferol (500,000 IU) showed an increase in falls, people experiencing a fall, and injuries, while one trial of calcitriol showed a reduction in falls and people experiencing a fall; the remaining five trials showed no statistical difference in falls, people experiencing a fall, or injuries. A single study reported no difference in QOL, and no studies reported on the outcomes of hospitalizations, institutionalizations, or ADL/IADL for vitamin D interventions. Three environment intervention trials (n=2,175) reported mixed results at 12 to 18 months of followup: one trial showed a 46 percent reduction in falls (IRR, 0.54 [95% CI, 0.36 to 0.83]), while two trials showed no statistically significant effect on falls. None of the trials reporting people experiencing a fall, injuries, QOL, or ADLs showed any statistically significant differences between the intervention group and control; and no environment trials reported mortality, hospitalization, institutionalization, or harms outcomes. Two underpowered medication management RCTs (n=266) showed no difference in fall-related outcomes or mortality. Two cognitive behavioral intervention trials (n= 886) showed mixed results in people experiencing a fall, a nonstatistically significant reductions in falls, mixed results for injuries, and no difference in mortality. Six trials (n=1,770) examined the effectiveness of multiple interventions, with one to two trials testing each of the following combinations of interventions compared to control: exercise+environment, exercise+psychological, exercise+knowledge+fall-risk assessment, exercise+vitamin D, and knowledge+environment. One trial of knowledge+environment (n=310), one trial of exercise+environment+vision (n=272), and one trial of exercise+psychological (n=378) interventions reported fewer falls and/or people experiencing a fall by 20 to 46 percent. Other multiple intervention combinations showed no statistically significant difference in falls, fallers, or injuries with the exception of a single exercise+vitamin D trial, which showed a large, statistically significant reduction in injurious falls (IRR, 0.38 [95% CI, 0.17 to 0.81]) despite no difference in falls or people experiencing a fall. In the 62 included trials, 65 percent of RCTs were conducted in high-risk populations. Multifactorial interventions were more likely to recruit high-risk populations (73%, 19 of 26), while other intervention types were equally or more likely to include average risk populations. Definitions of high risk were variably defined but most often included history of falls as at least one criterion. Harms were not consistently reported for any intervention type. Some exercise trials and multifactorial intervention trials with exercise components reported largely minor adverse effects associated with muscle soreness. One high-dose vitamin D trial reported an increase in falls outcomes, which has not been replicated in other trials; otherwise, vitamin D trials reported similar adverse events in the vitamin D and control groups.

Limitations: Our search was limited to English-language literature. We excluded trials specifically recruiting participants with neurologic conditions (e.g., Parkinson's disease) and

other specific diagnoses (e.g., vitamin D insufficiency, osteoporosis) so our findings may not be applicable to these populations. Our review protocol prioritized hard health outcomes (falls, fallers, injuries) and did not include changes in balance, endurance or walking speeds nor did it include falls efficacy or fear of falling.

Conclusions: The current evidence base demonstrates that exercise is associated with fewer people experiencing a fall and a reduced number of injurious falls in average- and high-risk older adults. Multifactorial interventions appear to reduce falls but not people experiencing a fall or injuries; trials are clinically and statistically heterogeneous. No specific effective exercise or multifactorial protocol has been replicated in larger population trials. Vitamin D, environment, and medication management interventions have either single trials showing no statistically significant effect or a few trials reporting mixed results. Single trials of cognitive behavioral, knowledge+environment, and exercise+environment+vision interventions showed moderate effectiveness in reducing falls and/or people experiencing a fall.

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Chapter 1. Introduction

Purpose

The U.S. Preventive Services Task Force (USPSTF) will use this report to update its 2012 recommendation on preventing falls in older adults.

Condition Background

Condition Definition

A fall is "an unexpected event in which the participant comes to rest on the ground, floor, or lower level." A severe fall is defined as a fall leading to medical care, fracture, injury (including serious injury or death), or hospital admission. The operationalization of these definitions varies considerably across studies, and in some studies no explicit definition is used at all. Ascertainment of a fall may be documented via retrospective reporting systems, such as a telephone interview, face-to-face interview, or postal questionnaire; prospective reporting systems using postcards, calendars, and diaries; or routine surveillance systems, including health care records.

Prevalence and Burden

People aged 65 years and older constitute the fastest-growing segment of the U.S. population. The U.S. Census Bureau projects that the number of people 65 years and older will be 83.7 million in 2050, almost double the estimated population of 43.1 million in 2012.[1] The number of people greater than 85 years old will increase from 5.9 million in 2012 to 8.9 million in 2030.[1] In 2050, this oldest age group is projected to account for 4.5 percent of the U.S. population.[1]

Falls are the leading cause of injury-related morbidity and mortality among older adults.[2] Nearly one-third (28.7%) of community-dwelling people aged 65 years or older fall at least once each year.[2, 3] The risk of falling increases with increasing age: 26.7 percent of those 65-74 years old report falling, while 36.5 percent of those 85 years and older report falling.[3] In 2014, an estimated 2.8 million nonfatal falls among this population were treated in emergency departments and approximately 800,000 of people experiencing a fall were hospitalized.[2, 3] In the same year, over 27,000 older adults died from unintentional injuries from a fall.[2] A recent study of coding patterns in fall-related mortality among the elderly in the United States found that current data on mortality due to a fall may underestimate the actual rate of these falls: states using coroners to investigate deaths due to injury from a fall reported 14 percent fewer incidences than did states in which a medical examiner completed the investigation.[4]

Disparities in falls exist by sex and race/ethnicity. Women are more likely to experience falls and fall-related injuries than men (30.3% of women versus 26.5% of men report a fall; 12.6% of women versus 8.3% men experience a fall-related injury).Whites are more likely to experience a

fall than blacks (29.6% v 23.1%).[3] After adjustment for age, men have a 40 percent higher rate of fall-related deaths than women.[2] Older whites are 2.7 times more likely to have a fatal fall than their black counterparts,[2] and older non-Hispanics have higher fatal fall rates than Hispanics.[5]

Falls predict quality of life, disability, admission to long-term care facilities, and death.[6-9] Between 20 and 30 percent of those who fall incur moderate to severe injuries, such as fractures, lacerations, and head trauma (including traumatic brain injury), that result in decreased mobility and potentially reduced independence.[10, 11] In an analysis conducted in the United Kingdom of almost 2,000 fractures in adults over the age of 65, the most common fractures occurred in the hip (32%), wrist (24%), shoulder (10%), and ankle (6%).[12] Among the very elderly (90 years or older), 56 percent of fractures occurred in the hip, but the prevalence was high for all femoral fractures.[13] Over 50 percent of deaths due to falls are a result of complications following a hip fracture,[14] and the highest mortality risks are observed in the first 6 months post-fracture.[15] For those people who are admitted to a hospital after a fall, the length of stay is longer and referral to long-term care facilities is significantly higher among older adults than younger people.[16] An estimated one-third of adults who lived independently before their hip fracture remain in a nursing home for 1 year or longer.[17]

Falls represent a significant burden on the U.S. health care system. In 2015, the direct medical cost was estimated to total $637.5 million for fatal falls and more than $31 billion for medically treated, nonfatal fall-related injuries.[18] A 2010 systematic review found the mean costs per person who fell in the United States ranged from $2,044 to $25,955, depending on severity of the fall (based on 18 studies).[19] Costs per fall ranged from $1,596 to $10,913, while costs per fall-related hospitalization ranged from $10,052 to $42,840.[19]

Etiology and Natural History

Falls are caused by complex interactions among multiple risk factors, including long-term or short-term predisposing factors. Interactions between these factors may be modified by age, disease, and factors in the person's environment.[20] A single fall may have multiple causes or contributors, and repeated falls may have different etiologies.[6, 21-23]

Risk Factors

Risk factors for falls can be classified as intrinsic (within an individual) or extrinsic (external to an individual). Intrinsic (i.e., patient-related) risk factors include age, cognitive, and sensory deficits; gait, strength, and balance deficits; acute and chronic conditions; and behaviors.[24, 25] Extrinsic factors include environmental hazards or hazardous activities, such as medications, footwear, assistive devices, home or neighborhood features, alcohol and drugs, and physical support provided by caregivers.[24] Certain risk factors may be modifiable through interventions: gait, strength, balance, and sensory deficits; behaviors; medications; footwear; assistive devices; home environment; alcohol or drug use; and physical support provided by caregivers.[24, 25]

A person's functional capacity may decrease as he or she ages because of physical and mental alterations that lead to impairments in balance, gait, and strength. A 2007 systematic review by

Ganz et al concluded that those with a history of falls are likely to fall again (likelihood ratio [LR], 2.3 to 2.8), and the most consistent predictor of future falls was a clinically detected gait or balance abnormality (LR, 1.7 to 2.4)[26] Other, more recent systematic and narrative reviews have likewise concluded that gait and balance abnormalities are the risk factors most consistently associated with falls;[25, 27] several other risk factors have also been associated with increased falls, including lower extremity weakness (OR, 1.76 [95% CI, 1.31 to 2.37]), cognitive impairment (OR, 2.13 [1.56 to 2.90]), psychoactive medications (e.g., benzodiazepines, antipsychotrics, antidepressants) (OR range, 1.36 to 1.41), and a host of other medications and medical conditions.[25]

As people age, they may also develop more than one risk factor. Appreciating the interaction and probable synergism among multiple risk factors is important in making a clinical assessment.[7] The risk for injuries that results from falling increases dramatically as the number of risk factors increases.[28]

Risk Assessment Tools Feasible for Primary Care

Several options exist for assessing risk and customizing fall-prevention interventions in primary care. One common approach is to administer a one- to three-item fall-risk questionnaire (history of falls, feeling unsteady, and/or worry about falling) followed by a brief physical function assessment of strength, gait, and balance in those with positive screening questionnaires.[29, 30] Older adults with abnormal physical function on testing would then be referred for a single fall-prevention intervention or multiple interventions, as needed. Alternatively, both a questionnaire and an assessment of physical function could be administered to all older adults; results indicating a risk of falls would trigger a referral to intervention.

A number of risk assessment tools is available for use in primary care settings to identify an adult's risk of falling (**Table 1**). Several physical function tests feasible for use in primary care focus on assessing lower extremity strength, endurance, balance, and/or mobility. These tests vary in their ability to predict future falls, and many were originally intended for research purposes rather than primary care practice.

The Timed Up and Go (TUG) test is a risk assessment tool routinely used by clinicians to identify patients at risk for falls.[31-33] A recent systematic review and meta-analysis of the overall predictive value of TUG in community-dwelling older adults found that the test has limited ability to predict falls in this population (OR, 1.01 [95% CI, 1.00 to 1.02], p=0.05) and should be used in conjunction with other tools to identify older adults at high risk of falls.[33] Reviewers also found that TUG was more useful at ruling in—rather than ruling out—risk for falls in older adults and had a higher pooled specificity (0.74, 95% CI, 0.52 to 0.88) than sensitivity (0.31, 95% CI, 0.13 to 0.57).[33]

A recent study of another risk assessment tool, the Short Physical Performance Battery (SPPB), which includes measures of balance, gait speed, and repeated chair stands, found that the chair stand test alone may be sufficient to predict injurious falls.[34] The poorest performance (≥16.7 seconds) was associated with a greater hazard of falling than all other time thresholds groups (hazard ratio, 1.96 [95% CI, 1.18 to 3.26] for ≥16.7 vs. 13.7–16.6 seconds, 1.65 [95% CI, 1.07 to

2.55] for ≥16.7 vs. 11.2–13.6 seconds, 1.60 [95% CI, 1.03 to 2.48] for ≥16.7 vs. <11.2 seconds).[34]

Interventions

Interventions to prevent falls in older adults are varied and complex, with multiple components involving multidisciplinary teams in different implementation settings.[35] For this reason, researchers from the Prevention of Falls Network Europe (ProFaNE) developed a taxonomy with the aim of improving the design and reporting of clinical trials on fall-prevention interventions and to classify existing intervention trials for analysis. The ProFaNE taxonomy groups interventions by type (i.e., descriptors), including the subdomains of exercise, medication (including pharmacotherapy [e.g., vitamin D] and medication management), surgery, management of urinary incontinence, fluid or nutrition therapy, psychological, environment/assistive technology, social environment, and interventions to increase knowledge.[35] Interventions are further categorized by their combination of intervention types: single, multiple, or multifactorial. Multiple and multifactorial interventions both require two or more types of interventions (or subdomains) to be provided to the study participants. For multifactorial interventions, the intervention types provided to each patient are linked to his or her risk profile (usually part of a formal assessment); not all participants receive the same combination of interventions. For multiple interventions, all participants receive the same intervention types.[35] For the purposes of this systematic review, we include interventions in accordance with *a priori* inclusion and exclusion criteria (**Appendix B Table 1**).

Current Clinical Practice in the United States and Recent Recommendations

There are many reported barriers to implementation of fall-prevention interventions in current U.S. clinical practice, including competing demands, clinician education, and logistical issues (limitations in patient transportation, mobility).[36, 37] Furthermore, one study reported that less than half of older adults who fall discuss their falls with their physician.[38] Nonetheless, there are several potential models for the implementation of fall-prevention interventions.

After an initial risk assessment in the context of a primary care visit or an annual prevention or wellness examination, primary care clinicians may elect to refer all patients identified as being at high risk of falls to individual or multiple services for further risk assessment and tailored intervention or interventions (e.g., home health, physical therapy, occupational therapy). Alternatively, where available, clinicians can refer a patient at high risk of falls to a "falls clinic." These clinics are not widely available in the United States and vary substantially in personnel staffing, content of the visit, and duration of the intervention. A falls clinic may have a single or multiple specialties staffed by advanced registered-nurse practitioners, physical therapists, occupational therapists, and/or a variety of physician specialists (e.g., geriatrician, physical medicine and rehabilitation physician, ophthalmologist, otolaryngologist, neurologist, orthopedist). The clinic can provide multicomponent risk assessments in a patient encounter lasting between 30 minutes to 3 hours and generate tailored referrals. It may also provide ongoing interventions to prevent falls.[39-42]

The Centers for Medicare and Medicaid Services (CMS) sponsors the Annual Wellness Visit and the Initial Preventive Physical Examination (IPPE, known as the "Welcome to Medicare Preventive Visit"), a one-time benefit for all new Medicare beneficiaries within the first 12 months of their first Medicare Part B coverage period.[43] As part of these visits, health care providers collect the plan member's medical history, including risk factors for depression and other mood disorders, and review the beneficiary's functional ability and level of safety. Appropriate screening questions and standardized questionnaires are used to review functional elements, including the risk of falls, hearing impairment, activities of daily living, and home safety.[43] To help incentivize primary care physicians to perform fall-risk assessment and intervention, CMS also provides a five-star quality rating to insurance plans that measure the percentage of plan members with a risk of falling who discussed this risk with their physicians and received a fall-prevention intervention.[44]

Health care providers can also use the CDC Stopping Elderly Accidents, Deaths, and Injuries (STEADI) toolkit, which was designed to help providers incorporate fall risk assessments and individualized fall interventions into current clinical practice.[45] Based on American and British Geriatrics Societies' guidelines, conceptual chronic disease management,[46, 47] literature reviews on provider knowledge and clinical practices regarding older adult falls, and qualitative research, this toolkit provides resources for risk assessment, including standardized and validated gait, strength, and balance assessments (i.e., Timed Up and Go [TUG] test,[48] 30-Second Chair Stand,[49] Four-Stage Balance Test[50]), as well as educational materials for patients (e.g., a validated clinical assessment brochure).[45, 51]

Recent recommendations from professional societies or organizations are listed in **Appendix A**. While all endorse interventions to prevent falls among older adults, the recommended interventions vary.

Previous USPSTF Recommendation

In 2012, the USPSTF recommended "exercise or physical therapy and vitamin D supplementation to prevent falls in community-dwelling adults aged 65 years or older who are at increased risk for falls" (Grade B recommendation).[52] The Task Force did not recommend routinely "performing an in-depth multifactorial risk assessment in conjunction with comprehensive management of identified risks to prevent falls in community-dwelling adults aged 65 years or older because the likelihood of benefit is small" (Grade C recommendation). Instead, the Task Force recommended that in determining whether this service is appropriate in individual cases, the patient and clinician should together consider the balance of the benefits and harms on the basis of the circumstances of prior falls, comorbid medical conditions, and the patient's values.[52]

Chapter 2. Methods

Scope and Purpose

This current review is an update of the 2010 review[53] that supported the 2012 USPSTF recommendation to prevent falls among older adults.[52] The USPSTF will use this report to update its recommendation. Our update includes all studies from the previous review that met our updated inclusion criteria as well as studies published since the previous review.

Key Questions and Analytic Framework

We developed an Analytic Framework (**Figure 1**) and two key questions (KQs) to guide the literature search, data abstraction, and data synthesis:

1. Is there direct evidence that primary care interventions to prevent falls in community-dwelling older adults at average or high risk for falls, used alone or in combination, reduce falls or fall-related injury, improve quality of life, reduce disability, or reduce mortality?
    a. How is high risk assessed in the included trials?
2. What are the adverse effects associated with primary care interventions to prevent falls in community-dwelling older adults?

Data Sources and Searches

In addition to re-evaluating all studies included in the 2010 review,[53, 54] we searched the following databases for relevant English-language literature published between January 1, 2010, and August 30, 2016: MEDLINE, PubMed publisher-supplied records, Cumulative Index for Nursing and Allied Health Literature, and Cochrane Central Register of Controlled Trials. We worked with a research librarian to develop our search strategy (**Appendix B**) which was peer-reviewed by a second research librarian. We also examined the reference list of a previously published systematic review[55] to identify additional studies for inclusion. We supplemented our searches with suggestions from experts and articles identified through news and table-of-contents alerts. We also searched ClinicalTrials.gov and the World Health Organization International Clinical Trials Registry Platform (ICTRP) (www.who.int/ictrp) for ongoing trials. We imported the literature from these sources directly into EndNote® X7 (Thomson Reuters, New York, NY). Since August 30, 2016, we have continued to conduct ongoing surveillance through article alerts and targeted searches of high-impact journals to identify major studies published in the interim that may affect conclusions. The last surveillance was conducted on August 2, 2017 and identified no such studies.

Study Selection

We developed criteria for including or excluding studies based on the previous review[53] and our

understanding of the literature (**Appendix B Table 1**). We included randomized placebo-controlled trials (RCTs) and cluster RCTs for intervention studies. All harms were restricted to studies included for KQ1, with the exception of medications and supplements. For the harms of vitamin D, we expanded our criteria to include systematic reviews. The population of interest was community-dwelling older adults (aged ≥65 years), including those residing in independent living facilities. We excluded trials that specifically recruited participants with specific diagnoses (e.g., neurologic diagnoses like dementia, Parkinson's disease, stroke) because those populations may require specialized approaches to preventing falls. We also included any older adults the study investigators determined were at high risk of falling. Because age and a host of other individual and environmental factors determine fall risk, control group fall rates were calculated and presented in results sections as another indicator of fall-risk status. Studies were required to have a primary or secondary aim of preventing falls or an aim related to it (e.g., fear of falling) and falls measured as a primary or secondary outcome. If a study did not have an aim of fall prevention or a related aim (e.g., pneumonia prevention and walking capacity, increasing physical activity levels) or did have a fall-related aim without measuring falls as a primary or secondary outcome, we excluded the study. Interventions that were feasible or referable from primary care were included; while many fall-prevention interventions are implemented in the community (e.g., exercise, medication management, environmental hazard reduction), primary care clinicians may have a role in referring their patients to these programs. The intervention descriptors and how they were combined were based on taxonomy developed by researchers from the Prevention of Falls Network Europe (ProFaNE) group[35]:

- Multifactorial: Interventions in which two or more intervention components were given to participants but the interventions were linked to each individual's risk profile. Each participant received a unique combination of intervention components.
  - Single: Only one major intervention component was provided to participants. Included intervention components: Exercise, Medication (including Medication Management and Vitamin D), Psychological, Environment/Assistive Technology, Knowledge
  - Multiple: Interventions in which two or more intervention components were offered to every participant in the intervention group of the fall-prevention program. Included intervention components: Exercise, Medication (including Medication Management and Vitamin D), Psychological, Environment/Assistive Technology, Knowledge

Certain intervention components (surgery, fluid or nutrition therapy, management of urinary incontinence, optical aids, hearing aids, body-worn protective aids) were excluded unless they were one possible component of a multifactorial or multiple intervention. Studies had to have reported an outcome of falls, mortality, or fall-related morbidity. For health-related quality of life (QOL), studies had to have reported an overall measure (e.g., the physical and mental component scores from the SF-36); subscales were not abstracted. Only studies conducted in countries categorized as "very high" on the 2014 Human Development Index were included. We limited these studies to those we determined were of either good or fair quality by the USPSTF quality-rating standards (described below); studies of poor quality were excluded.

Using the inclusion and exclusion criteria as a guide, two independent reviewers independently screened in abstrackr[56] all records in the updated searches on the basis of the titles and abstracts. Subsequently, at least two reviewers assessed the full text of potentially relevant studies in DistillerSR (Evidence Partners, Ottawa, Canada), including all of the previously included studies, using a standard form that outlined the eligibility criteria. Disagreements were resolved through discussion and consensus. We kept detailed records of all included and excluded studies, including the reason for exclusion.

Comparison of 2010 and Current Review

Similar to the 2010 Michael review, this review includes trials recruiting average and high-risk participants. In contrast to the 2010 review, which included trials of participants recruited based on low vitamin D levels, this review excluded trials solely recruiting vitamin D insufficient/deficient participants because the clinical question is whether routine vitamin D supplementation in all older adults presenting for clinical care reduces falls and fall-related outcomes. Based on epidemiologic data,[57] a high proportion of older adults will have vitamin D insufficiency/deficiency; however, in clinical practice, identification of these individuals requires screening for vitamin D deficiency, and screening effectiveness is outside of the scope of this review. A sensitivity analysis including trials recruiting participants with vitamin D insufficiency/deficiency is presented in this report. Similar to the prior review, this review excludes trials solely recruiting participants with Parkinson's disease as interventions customized to patients with Parkinson's or other neuromuscular disorders may not be generalizable to the larger population of older adults. The included interventions are similar to the 2010 review with the exception of nutritional and fluid interventions and hip protectors which have been excluded in this review because their use is generally limited to more frail populations in institutionalized settings. This review excluded interventions for vision abnormalities and incontinence as there are outcomes more clinically important than falls requiring consideration when treating these conditions. Compared to the 2010 Michael review, this update expands the number of included and pooled (when appropriate) outcomes to include 11 outcomes (falls, people experiencing a fall, fall injuries, fractures, people experiencing fall injuries, people experiencing fractures, hospitalizations, institutionalizations, activities of daily living [ADL], instrumental activities of daily living [IADL], mortality and harms). In the prior review, meta-analysis was performed only on people experiencing a fall, but results were abstracted for the following outcomes: number of falls, number of people experiencing a fall, number of people experiencing recurrent/frequent falls, number of fall-related fractures, quality of life as measured by the SF-12, SF-36, or EuroQol, disability as measured by ADL and IADL, and mortality. In order to capture harms of vitamin D for falls prevention, we included systematic reviews of vitamin D harms as an included study design.

Quality Assessment and Data Abstraction

Two reviewers independently used USPSTF criteria[58] to assess the methodological quality of all eligible studies by using DistillerSR (Evidence Partners, Ottawa, Canada), including the studies from the 2010 review.[53, 58] We assigned each study a quality rating of "good," "fair," or "poor" according to study design-specific criteria (**Appendix B Table 2**). Good-quality RCTs had

adequate randomization procedures and allocation concealment, similar groups at baseline, well-defined interventions, reliable outcome measures, blinded outcome assessment, and low attrition (≥90% of participants had followup data, with a less than 10 percentage-point difference in loss to followup between groups), and they used conservative data substitution methods for missing data. Trials were given a quality rating of fair if they were unable to meet the majority of the good-quality criteria but were not of poor quality. Trials were rated as poor quality if attrition was greater than 40 percent or differed between groups by 20 percentage points, the falls outcome was self-reported solely by the participant with recall more than 6 months and no other outcome of interest was reported, or there was any other flaw that seriously affected internal validity, as agreed upon by the two independent reviewers.

We abstracted descriptive and outcome data from each included study (both the original and updated studies) into detailed abstraction forms using DistillerSR. One reviewer completed primary data abstraction and a secondary reviewer checked all data for accuracy and completeness. Data collection included general characteristics of the study (e.g., author, year, study design), characteristics of the sample (e.g., age and clinical characteristics of a population, setting, country), description of the intervention (e.g., type, provider, frequency, duration), methods to collect information on falls, and results. A study in which participants prospectively collected information (e.g., onto calendars, postcards, or diaries) about their falls and sent the information to the research team was referred to as "diary" collection. When multiple intervention and/or control groups were available, we abstracted the most intense intervention group and the control group most similar to no intervention or usual care. If at any point followup in a study fell below 60 percent, we did not abstract and analyze outcomes at or past that point. We attempted to contact authors when data reporting was incomplete or particular data points required clarification.

Data Synthesis and Analysis

We synthesized data separately for each KQ. Many outcomes did not allow for quantitative pooling due to the limited number of contributing studies, so those data are summarized narratively. For outcomes with enough contributing studies (at least 50% of the included studies for that intervention component with very low heterogeneity or 5 or more studies in the presence of nontrivial statistical heterogeneity), we ran random-effects meta-analyses using the method of DerSimonian and Laird[59] to calculate the pooled relative risks. We did not pool study data for studies with interventions categorized as "multiple" because the interventions were clinically heterogeneous. When available, we favored the author-reported relative risks over those we calculated. When authors did not report relative risks, we calculated a crude effect estimate. If a CI for a relative risk was not reported, we calculated it from the reported p-value.[60] Within each study, we selected the longest followup available for pooled analyses and figures. Data from other followup times are presented in tables. As noted above, only one intervention and one control arm for each intervention category were abstracted and included in the analysis.

We grouped our outcomes as follows: falls, injurious falls, fractures, people experiencing a fall, people experiencing an injurious fall, people experiencing a fracture, and mortality, people transitioning to institutionalized care, people hospitalized, quality of life, ADL, and IADL. All

fall and fall-related injury outcomes were reported either as an incident event (where a person could contribute more than one event to the analysis, e.g., falls, fractures) or the number of persons experiencing the event (where a person could contribute only once to an analysis, regardless of the number of times the event occurred, e.g., people experiencing a fall, people experiencing an injurious fall). For injurious fall outcomes, we included minor or severe injuries resulting from a fall, falls resulting in medical care, or any fall-related outcome the author categorized as injurious. The most inclusive outcome was used in meta-analysis if multiple outcomes in that injury category were reported (e.g., fall-related injuries instead of fall-related hospital admissions). For studies that did not report a composite injury outcome, we used the most prevalent outcome (e.g., falls leading to an emergency department visit was selected over falls leading to hospital admission). The number of injurious falls analyzed in the forest plots included both the number of fall-related injuries and the number of falls resulting in injury as reported in the trials. For fracture outcomes, we first selected fall-related fractures, but if that outcome was not available, we included data on hip fractures and overall fractures, even if the study may not have reported if the fracture was associated with a fall.

In cases where a cluster RCT was used but the authors did not account for the nested nature of the data, we adjusted for the clustering effect by applying a design effect, which was based on an estimated average cluster size (i.e., the total number of randomized participants divided by the total number of clusters) and multiplied by an estimated intraclass correlation. We estimated the intraclass correlation to be 0.05.

We examined statistical heterogeneity among the pooled studies by applying standard χ^2 tests and estimated the proportion of total variability in point estimates by using the I^2 statistic.[61] We applied the Cochrane Collaboration's rules of thumb for interpreting heterogeneity[62]: less than 40 percent likely represents unimportant heterogeneity; 30 to 65 percent, moderate heterogeneity; 50 to 90 percent, substantial heterogeneity; and more than 75 percent, considerable heterogeneity. In addition, we generated funnel plots to evaluate small-study effects (a possible indication of publication bias) and ran the Egger test to assess the statistical significance of imbalance in study size and findings that suggest a pattern.[63]

We investigated whether the heterogeneity among the main results (the outcome of falls and the outcome of people who fall) was associated with any prespecified population or intervention characteristics of the studies. First, we used visual displays and tables grouped or sorted by these potentially important characteristics. Specifically, we examined the recruitment setting (emergency department, clinic, or a combination), mean age, percentage female, risk of falls (high or average risk, as defined by the authors), fall rate of the control group or the percent falling, country (United States vs. others), and study quality (fair vs. good) as they related to the effect estimates. For exercise interventions, we also examined the duration and intensity, exercise components (e.g., balance, flexibility, strength), number of components, and format (group, individual, or both). On the basis of visual examination of forest plots, we used meta-regression to test for potentially significant sorting variables or groups, namely the recruitment setting for the falls outcome for multifactorial interventions. Due to the general lack of statistically significant meta-regression results, we ordered forest plots alphabetically. We used Stata version 13.1 (Stata Corp LP, College Station, TX) for all quantitative analyses. All significance testing was two-sided. Results were considered statistically significant if the p-value

was 0.05 or less.

Grading the Strength of the Body of Evidence

We graded the strength of the overall body of evidence for each key question. We adapted the Evidence-based Practice Center approach,[64] which is based on a system developed by the Grading of Recommendations Assessment, Development and Evaluation (GRADE) Working Group.[65] Our method explicitly addresses four of the five Evidence-based Practice Center-required domains: consistency (similarity of effect direction and size), precision (degree of certainty around an estimate), reporting bias (potential for bias related to publication, selective outcome reporting, or selective analysis reporting), and study quality (i.e., study limitations). We did not address the fifth required domain—directness—as it is implied in the structure of the key questions (i.e., pertains to whether the evidence links the interventions directly to a health outcome).

Consistency was rated as reasonably consistent, inconsistent, or not applicable (e.g., single study). Precision was rated as reasonably precise, imprecise, or not applicable (e.g., no evidence). Reporting bias was rated as suspected, undetected, or not applicable (e.g., when there is insufficient evidence for a particular outcome). Study quality reflects the quality ratings of the individual trials and indicates the degree to which the included studies for a given outcome have a high likelihood of adequate protection against bias. The body of evidence limitations field highlights important restrictions in answering the overall key question (e.g., lack of replication of interventions, nonreporting of outcomes important to patients).

We graded the overall strength of evidence as high, moderate, or low. "High" indicates high confidence that the evidence reflects the true effect and that further research is very unlikely to change our confidence in the estimate of effects. "Moderate" indicates moderate confidence that the evidence reflects the true effect and that further research may change our confidence in the estimate of effect and may change the estimate. "Low" indicates low confidence that the evidence reflects the true effect and that further research is likely to change our confidence in the estimate of effect and is likely to change the estimate. A grade of "insufficient" indicates that evidence is either unavailable or does not permit estimate of an effect. Two independent reviewers rated each key question according to consistency, precision, reporting bias, and overall strength of evidence grade. We resolved discrepancies through consensus discussion involving more reviewers.

Expert Review and Public Comment

A draft of the Analytic Framework, KQs, and inclusion and exclusion criteria was posted on the USPSTF Web site for public comment from August 6, 2015, through September 2, 2015. Minor changes were made to the inclusion and exclusion criteria to clarify the included populations, interventions, and settings. No major changes were made to the research plan that altered the scope of the review or our approach to synthesizing the evidence.

Content experts reviewed a draft of this report. Their comments were presented to the USPSTF during its deliberation of the evidence and were considered in preparing the final evidence review.

USPSTF Involvement

We worked with USPSTF liaisons at key points throughout this review to develop and refine the Analytic Framework and KQs and to resolve issues regarding the scope for the final evidence synthesis.

This research was funded by the Agency for Healthcare Research and Quality (AHRQ) under a contract to support the work of the USPSTF. AHRQ staff provided oversight for the project, coordinated systematic review work with other related topics in the portfolio, reviewed the draft report, and assisted in the external review of the draft evidence synthesis.

Chapter 3. Results

We reviewed 3,441 abstracts and 418 articles for both KQs (**Appendix B Figure 1**). The list of included studies (62 trials, 88 publications) and excluded studies (with reasons for exclusion) are available in **Appendixes C** and **D**. Because of the numerous interventions analyzed for this report, the results for all KQs (KQ1 [effectiveness] and KQ2 [harms]) are displayed sequentially under each type of intervention.

KQ 1. Is There Direct Evidence That Primary Care Interventions to Prevent Falls in Community-Dwelling Older Adults at Average or High Risk for Falls, Used Alone or in Combination, Reduce Falls or Fall-Related Injury, Improve Quality of Life, Reduce Disability, or Reduce Mortality?

KQ 2. What Are the Adverse Effects Associated With Primary Care Interventions to Prevent Falls in Community-Dwelling Older Adults?

Multifactorial Interventions

Summary of Results

Our examination of the evidence of multifactorial interventions to prevent falls consists of a heterogeneous set of 26 trials. These trials recruited community-dwelling older adults with varying fall risk. The vast majority of the trials recruited participants determined to be at high risk for falls; history of falls was the most common risk factor used for trial recruitment. Each trial examined uniquely designed interventions, such as direct interventions and referrals customized to participants based on an initial risk assessment. Pooled results from 17 RCTs (n=9,737) show that multifactorial interventions reduce the incidence rate of falls at the longest followup time (6–12 months) compared to the control group but also that there is substantial heterogeneity and a lack of precision in the effect size (incidence rate ratio [IRR], 0.79 [95% CI, 0.68 to 0.91]; p=0.001; I^2=87.2%). Pooled results from 24 trials (n=12,490) show that there is no statistically significant effect on people experiencing a fall (RR, 0.95 [95% CI, 0.89 to 1.01]; p=0.002; I^2=56.4%). While most studies consistently show no or minimal benefit with nonstatistically significant point estimates near 0.9, the effect is imprecise. Multifactorial interventions appear to have no statistically significant effect on mortality (k=23; n=9,721; RR, 0.96 [95% CI, 0.79 to 1.17]; p=0.659; I^2=0%). Narrative analysis demonstrates no effect on hospitalization, institutionalization, ADL, IADL, or QOL, but these outcomes are reported in just a small proportion of multifactorial studies.

There is sparse evidence on the harms of multifactorial interventions; conclusions are limited to a

few studies (k=4; n=1,466) with incomplete reporting of adverse events. The harms, which are generally minor, include musculoskeletal complaints related to the exercise component of the multifactorial intervention.

Characteristics of Included Studies

Of the included 26 multifactorial trials (31 articles[66-96]), 15 were from the previous review[66, 67, 70, 72, 75, 76, 78, 80, 82, 86-91] and 11 were new.[68, 69, 71, 73, 74, 77, 79, 81, 83-85] Three trials from the previous review were excluded for population,[97] lack of feasibility for primary care to refer to the intervention,[98] or poor quality.[99]

Study Characteristics

We identified seven good-quality[69, 73, 79, 80, 86, 88, 90] and 19 fair-quality RCTs[66-68, 70-72, 74-78, 80-85, 87, 89, 91] (n=15,506) with a primary or secondary aim of examining the effectiveness of multifactorial interventions on falls and/or fall-related injuries (**Table 2**). The majority of the trials were conducted outside of the United States. Six trials were conducted in the United Kingdom,[67, 69, 70, 78, 79, 87] four in Australia,[73, 80, 82, 85] three in the United States,[68, 88, 91]three in the Netherlands,[71, 75, 89] two in Canada,[66, 76] two in Spain,[74, 84] two in Finland,[83, 86] and one each in Denmark,[90] Switzerland,[77] Sweden,[81] and New Zealand.[72] The size of trials (intervention plus control groups randomized for our analysis) ranged from 100 to 5,310 participants. The fall-related outcomes reported in the trials that we included for analysis were falls (k=17; n=9,737), people experiencing a fall (k=24; n=12,490, injurious falls (k=9; n=4,306), fractures (k=5, n=3,236), people experiencing an injurious fall (k=16; n=9,445), people experiencing a fracture (k=5, n=1,937), mortality (k=23; n=9,721), people hospitalized (k=4; n=2,134), people transitioning to institutional care (k=7; n=2,143), QOL (k=4; n=1,104), ADL (k=7; n=2,106), and harms (k=4; n=1,466).

Population Characteristics

Most recruited participants were 65, 70, or 75 years of age or older (**Table 3**). The recruitment age thresholds were ≥55 years,[66] ≥60 years,[79, 85] ≥65 years,[67, 70, 71, 75, 76, 78, 81, 86, 87, 90, 91] ≥70 years,[69, 73, 83, 88, 89] ≥75 years,[68, 72, 80, 82, 84] ≥80 years,[77] and ≥85 years.[74]

Mean age ranged from 71.9 years[66] to 85 years.[74, 77] The percentage of women in the studies ranged from 53.2 percent[84] to 94 percent.[66] Race and ethnicity were not reported in any of the studies except Wagner et al,[91] a U.S. study in which 94 percent of participants were white. Measures of socioeconomics status, such as education or income level, varied widely.

Nearly all studies solely recruited older adults living in the community; four RCTs included at least 94 percent community-dwelling older adults.[70, 71, 79, 86] Trials recruited participants from clinics,[69, 72-74, 82, 84, 87, 89] emergency departments, hospitals, or ambulances following a fall,[67, 70, 75, 78, 79, 85, 90] or multiple settings (e.g., a combination of clinic, emergency department, hospital, self-referral, and/or community).[66, 71, 76, 77, 81, 83, 86] Two U.S. trials recruited patients from health maintenance organizations[88, 91]; the third U.S. trial recruited patients from a health insurance database.[68] An additional RCT recruited patients in Australia from health insurance member

databases.[80]

A total of 21 of 26 studies excluded patients with cognitive impairment or inability to provide consent/understand instructions. Half of the included studies specifically excluded participants with cognitive impairment based on the results of various tests (e.g., Mini-Mental State Examination [MMSE], mental status questionnaire, abbreviated mental test, clinical dementia rating scale, or clinical diagnosis documented in medical record).[67, 70-73, 75, 77, 80, 81, 86-88, 90] An additional eight studies excluded those who could not understand instructions or provide their own informed consent.[66, 69, 72, 77-79, 83, 84]

Seven trials recruited patients at average risk of falling where the only risk factor for falls was age.[68, 74, 77, 80, 82, 84, 91] Nineteen trials solely recruited patients at high risk for falls according to various definitions.[66, 67, 69-73, 75, 76, 78, 79, 81, 83, 85-90] Nearly half of the studies (12 of 26) defined high risk as having a history of falling based on either historical recall of one or more falls in the previous 3 months[72] or 12 months,[76, 86, 87] or seeking medical attention in an emergency department, hospital, ambulance, or clinic following a fall.[67, 70, 71, 75, 78, 79, 85, 90] The remainder of the trials recruited participants who fulfilled one or more risk factor criteria from a list of possible risk factors. The most common risk factors included a history of one or more falls;[69, 83, 89] gait, balance, mobility, high risk medication usage, or high health care utilization;[69, 81, 83, 88, 89] ADL impairment;[81, 88] osteoporosis or a history of osteoporotic fracture;[66, 83] TUG score of >14 seconds;[66] or frailty (3+ Cardiovascular Health Study frailty criteria: slow gait, weak grip, exhaustion, low energy expenditure, or weight loss).[73]

The baseline risk factor measures reported in the studies varied. Measures included a history of falls, fear of falling, comorbidities, number of medications, self-rated health status, ADL/IADL measurements, the MMSE, and/or measures of mobility/balance. In the trials reporting the percentage of participants with falls in the previous year, the range was 31 percent[84] to 100 percent.[76, 86, 87] Trials reporting some measure of ADL function generally reported fairly independent ADLs,[67, 68, 71, 74, 76, 78, 82, 87, 90] although there were a few exceptions, such as the trial by Moller et al,[81] which required participants to need assistance with at least two ADLs, and the trial by Russell et al,[85] in which a third of participants needed some assistance with ADLs.

Intervention Details

The 26 multifactorial RCT publications described to various degrees the complex assessment and intervention components for the treatment group (**Table 4**). A trial by Newbury et al[82] sent only initial risk assessment results to primary care providers (PCPs); there was no further treatment intervention or referrals by the research team. For the remainder of the trials, the intervention groups underwent both an initial assessment and treatment intervention that was largely individualized and based on the risk factors identified in the initial assessment. Treatment and referrals were generally managed by the research team.

Initial assessment. All 26 RCTs used an initial assessment of modifiable fall risk factors to customize the intervention for each participant. This initial assessment could include a multidisciplinary comprehensive geriatric assessment or an assessment of the risk of falls with any number of the following components: balance, gait, vision, cardiovascular health (e.g.,

postural blood pressure or pulse, carotid sinus stimulation), medication, environment (e.g., home hazards or personal needs), cognition, and psychological health. The initial assessment occurred in a clinical setting and/or the participant's home. Nursing professionals nearly always performed the initial assessment, with or without additional professionals (e.g., physical therapists, exercise instructors, occupational therapists, medical doctors, dieticians or nutritionists).

Treatment interventions. Treatment interventions varied substantially across the studies. They generally included multiple targeted intervention components, such as exercise (unsupervised or supervised, group or individual), psychological (cognitive behavioral therapy), nutrition therapy, knowledge (e.g., via DVDs, lectures, pamphlets), medication management, urinary incontinence management, environment (e.g., assistive technology or dwelling recommendations), and referral to physical or occupational therapy, social or community services, and specialists (e.g., ophthalmologist, neurologist, cardiologist).

In the vast majority of trials (22 of 26 trials), treatment interventions were implemented through a combination of direct treatment administered by the research team as well as specialty referrals generated by the research team. In a minority of trials, the research team administered all of the interventions[77, 88] or treatment recommendations were solely communicated with the PCP and/or the participant for further action.[68, 82] In more than half of the trials (k=14), in addition to making direct referrals or directly implementing the recommended interventions, the research team communicated with PCPs (generally to communicate specific or comprehensive risk assessment results);[66, 67, 71, 72, 74-76, 79, 83, 84, 86-88, 91] in two of these trials, PCPs were contacted only to discuss medication changes.[67, 88] In the majority of trials, the protocols included one or more home visits for initial assessment, environment interventions, and/or physical therapy/exercises. The vast majority of interventions in the trials, however, occurred in the outpatient setting.

We could not quantify the intensity of the multifactorial interventions because total contact time was rarely reported. Most trials reported that they directly offered or referred participants to an exercise or physical therapy intervention. This offer was available either to all participants for one session or serially, or was targeted to those with balance or gait issues identified in the risk assessment.

Control groups. Control groups in the trials received usual care[66-71, 73-75, 77-82, 87, 89-91] or usual care plus minimal control (pamphlet, social visit, brief fall-risk advice, letter).[72, 76, 83-86, 88]

Nearly all of the 26 trials reported randomization methods that were likely to be adequate. (Cohen et al[68] modified the probability of assignment to a particular group to ensure reaching target analysis numbers to balance groups for attrition.) Three studies were cluster RCTs by physician[88] or clinical practice site.[84, 87] Fifteen studies clearly reported adequate outcome assessor blinding,[67, 70, 72-76, 79, 82, 85, 86, 88-91] and nine reported having unblinded outcome assessors (e.g., those administering interviews or abstracting medical records were not blinded).[66, 68, 69, 71, 77, 81, 83, 84, 87] For the remaining studies, reporting about assessor blinding was unclear.[78, 80] The multifaceted and customized nature of these multifactorial interventions precluded analysis of intervention adherence rates. With two exceptions,[68, 78] nearly all trials used intention-to-treat analysis where all randomized participants were included in the analysis regardless of their

participation at the conclusion of the study. To ascertain falls, most studies had the patient prospectively record falls on a calendar or in a diary, with or without additional confirmation (e.g., medical records or 3–6 recall phone calls).[66-84] Six studies recorded falls by patient's recall every 1 to6 months,[85-90] and one study recorded falls as recorded by the patient's recall at >6 months and in hospital discharge summaries.[91] Completion rates ranged from 68.6 to 100 percent (all respondents had at least one data point, allowing them to be included in analysis). Eight trials were designed to have enough power to detect differences in the rate of falls,[67, 69, 78, 79, 83, 84, 86, 90] and nine trials were powered for people experiencing a fall.[70-72, 75, 76, 83, 84, 87, 89, 91]

Falls

Meta-analysis of 17 multifactorial RCTs[67-70, 72, 74, 76, 78-81, 83, 85, 86, 88, 90, 94] (n=9,737) demonstrated a lower rate of falls at the longest followup (6–12 months) in the multifactorial group than in the control group with substantial heterogeneity (IRR, 0.79 [95% CI, 0.68 to 0.91]; I^2=87.2%) (**Figure 2; Table 5**). In the control group, the rate of falls per person-year ranged from 0.38 to 7.7 events per person-year at the longest followup. Individual RCTs reported substantial variation in effect size, with wide and overlapping CIs and IRR point estimates ranging from 0.42 to 1.12. Two RCTs particularly notable for much greater beneficial effect sizes were conducted by Close et al[67] and Logan et al,[79] with IRR point estimates of 0.42 and 0.45, respectively. Those studies recruited participants from the emergency department[67] or an ambulance[79] following a fall; one had specific intervention protocols outlined in the publication,[67] and the other included intensive interventions (6 physical therapy sessions, 12 group sessions of supervised exercise or education on preventing falls, and up to 12 home sessions[79]). We explored heterogeneity by examining the number of falls by country, date of publication, recruitment setting, fall rate of the control group, recruitment inclusion criteria of average or high risk of falls, mean age, followup period, and study quality. We were unable to explain the high heterogeneity by any single variable except recruitment setting (**Appendix E Figure 1**). In meta-regression, both clinical and multiple recruitment settings were statistically different than that of the emergency department (p=0.030 and p=0.023, respectively). Caution should be used in interpreting this *post hoc* subanalysis because heterogeneity was high and formal *a priori* subgroup credibility ratings were not performed.[58] Visual examination of the funnel plot (not included in this report) for the 17 pooled studies did not suggest a risk of small study bias and the result of the Egger test was not statistically significant (p=0.678).

Injurious Falls

Approximately one-third (k=9; n=4,306) of the 26 multifactorial trials reported injurious falls at 6 to 36 months (**Figure 3; Table 6**).[72, 73, 78, 81, 83, 85, 86, 88, 90] Injuries were largely defined as severe injuries (e.g., dislocation, severe sprain, fracture, head injury)[86, 88] or those requiring medical care,[78, 90] although some trials also included soft tissue bruises and contusions.[72, 83] Three trials did not define the types of injuries sustained.[73, 81, 85] Only one study, by Palvanen et al,[83] reported a statistically significant reduction in injurious falls in the multifactorial group compared to the control group (IRR, 0.74 [95% CI, 0.61 to 0.89]). The remaining eight trials showed no notable differences: half of these studies showed point estimates near 1.

Fracture

Five trials (n=3,236) reported falls resulting in any fall-related fracture or hip fracture[73, 83, 85, 86, 90] at 12 to 36 months of followup. The results showed no statistically significant difference between the multifactorial and control groups. Individual IRR point estimates ranged from 0.55 to 1.09 at longest followup (**Figure 4; Table 7**).

People Experiencing a Fall

Meta-analysis of the 24 multifactorial RCTs[66-76, 78-81, 83-91] (n=12,490) reporting the number of people experiencing a fall demonstrated no difference at the longest followup (6–18 months) in the multifactorial group compared to the control group (RR, 0.95 [95% CI, 0.89 to 1.01]; I^2=56.4%) (**Figure 5; Table 8**). Four RCTs[67, 79, 83, 91] reported a statistically significant modest reduction in people experiencing a fall (range of RR, 0.62 to 0.84). The remaining 20 RCTs[66, 68-76, 78, 80, 81, 84-90] showed no statistically significant difference in the number of people experiencing a fall, with one outlier study (Ciaschini et al[66]) reporting a point estimate of 1.51. The Ciaschini study had the youngest population (mean age 71.9 years), which was recruited from the emergency department after a fall.[66] While one cluster RCT by Tinetti et al[88] reported an RR of 0.76 (95% CI, 0.58 to 0.98), after adjustment for clustering, this result was no longer statistically significant. Almost half of the studies (9 of 22) showed point estimates greater than 1.0, indicating that the control group had fewer people experiencing a fall, although none of the point estimates was statistically significant. The percentage of people experiencing a fall in the control group ranged from 17.0 to 94.1 percent. We examined variables as listed in the falls results above and were unable to identify any individual factors to explain the heterogeneity.

People Experiencing an Injurious Fall

Meta-analysis of 16 trials[67-70, 75-77, 80, 81, 85-91] (n=9,445) showed no difference in people experiencing an injurious fall in the multifactorial group compared to the control group at the longest followup (9–36 months) (RR, 0.94 [95% CI, 0.85 to 1.03]; I^2=34.3%) (**Figure 6; Table 9**).

People Experiencing a Fracture

Only five trials (n=1,937) reported on people with fragility,[66] hip,[70] fall-related peripheral,[85] or any fall-related fracture[84, 87] at 6 to 12 months of followup (control group prevalence range, 0.7% to 6.0%). There was no statistically significant difference between the multifactorial and control groups (**Figure 7; Table 10**). RR point estimates ranged from 0.17 to 1.02 in the studies with relatively few events, which made estimates unstable.

Mortality

Pooled analysis of 23 RCTs[66, 67, 69, 70, 72, 74-89, 91] (n=9,721) showed no difference in all-cause mortality at 6 to 36 months in the multifactorial group compared to the control group (RR, 0.96 [95% CI, 0.79 to 1.17]; I^2=0%) (**Figure 8**). Individual study results varied widely, with RRs ranging from 0.20 to 5.03 and wide CIs reflecting a relatively uncommon outcome with few

events in most studies (**Table 11**); not surprisingly, none was statistically significant as the trials were not intended nor powered to affect mortality outcomes.

People Transitioning to Institutional Care

Seven RCTs[67, 69, 74, 76, 77, 82, 87] (n=2,143) reported mixed results on institutionalization (**Figure 9; Table 12**). The prevalence of institutionalization in the control groups varied substantially, from 0.6 to 20.1 percent. The RR from individual trials ranged from 0.43 to 3.07 with wide confidence intervals, which reflected the relatively few institutionalization events in most trials.

People Hospitalized

Four RCTs[67, 79, 88, 91] (n=2,134) reported the outcome of people hospitalized, which revealed no difference in the prevalence of hospitalization in the multifactorial versus control group (**Figure 10; Table 13**). RR and OR point estimates ranged from 0.57 to 0.98. There was wide variation in the prevalence of hospitalization in the control group (1–53%), indicating that the studies had heterogeneous populations with different baseline risks.

QOL

Four RCTs (n=1,104) reported QOL outcomes as measured using 12-Item Short Form Survey (SF-12),[71] 36-Item Short Form Survey (SF-36),[72, 90] EuroQol EQ-5D,[73] or EuroQoL EQ-5D Visual Analog Scale (VAS).[73] Overall, there was no difference between the intervention group and the control group at 12 months of followup (**Table 14**). Only the study by Vind et al[90, 96] showed a statistically significant difference in changes in the SF-36 physical health component score from baseline in the intervention group compared to the control group at 12 months of followup, but these changes are unlikely to be clinically meaningful. SF-36 mental health-component mean changes from baseline to 12 months of followup were similar between the intervention group and the control group. In the studies by Elley et al,[72] Fairfall et al,[73, 93] and deVries et al,[71] the changes in QOL scale scores (SF-12, SF-36, EQ5D VAS, EuroQol EQ 5D) from baseline to 12 months were similar between the intervention group and the control group.

ADL and IADL

Seven studies (n=2,106) reported ADL outcomes as measured by the Barthel Index (**Table 14**).[67, 71, 73, 78, 79, 87, 90] These studies compared baseline to the longest followup (6 months[78] or 12 months[67, 71, 73, 79, 87, 90]) and showed no statistically significant difference in six of seven studies. The one exception was the trial by Logan et al,[79] with a statistically significant difference between the intervention and control groups in the proportion of participants with scores above or below the median value of 15 (OR, 2.91 [95% CI, 1.18 to 7.20]); however, the clinical meaningfulness of this difference is uncertain.

Four RCTs (n=1,102) used the Frenchay Activities Index (FAI)[75, 89, 90] or the Lawton and Brody scale[71] to report IADL, which showed mixed results (**Table 14**). The RCT conducted by van Haastregt et al[89] showed a statistically significant difference in adjusted mean difference in the FAI (1.6 [95% CI, 0.6 to 2.7]) at 12 months that did not persist at 18 months (adjusted mean

difference, 1.0 [95% CI, -0.2 to 2.2]). The other three studies showed no statistically significant difference in IADL changes between the intervention and control groups.[71, 75, 90]

Three studies (n=637) reported a combination of ADL and IADL using the Nottingham Extended Activities of Daily Living scale[72, 79] or Sonn and Asberg[81] to compare mean differences in scores over 12 months; the results were mixed (**Table 14**). An RCT by Logan et al[79] reported that the Nottingham Extended ADL scale was statistically significantly different between the intervention and control groups (mean difference, 3.47 [2.13 to 4.81]).[79] Two studies reported no statistically significant difference in ADL and IADL combination score changes between the intervention and control groups.[72, 81]

Fall Risk Status

As mentioned above, most multifactorial trials (19 of 26) recruited participants defined as at high risk for falls using a host of different risk-factor criteria. The most common risk factor used for recruitment was history of falls. For any given outcome, the vast majority of the pooled trials recruited high-risk participants (falls: 14/17; people experiencing falls 19/22), and our exploratory analyses did not suggest differential treatment effect based on whether the trials recruited high-risk individuals, nor did we see a linear association between control-group fall rate and treatment effect. Nonetheless, trials recruiting from emergency settings following a fall demonstrated a greater statistically significantly treatment benefit on falls reduction and in general, these trials recruiting from emergency settings had higher control group fall rates compared to the trials recruiting from clinic settings or a combination of clinic and emergency settings. This exploratory analysis suggests that there may be an association between fall risk and treatment effectiveness.

Harms

Four RCTs (n=1,466) reported any harm in the intervention group.[73, 75, 86, 88] Only one of these RCTs reported harms (back pain) in the control group for comparison, which showed no difference between the intervention and control groups (2/120 vs. 0/121).[73] One RCT reported three falls without injury during the exercise component of the intervention.[86] In general, adverse events were rare, minor, and associated with the exercise component of the multifactorial intervention.

Critical Appraisal

Populations and intervention design, components, intensity, and personnel are heterogeneous in these 26 trials. This heterogeneity makes it challenging to understand why the statistical results of the rate of falls varied so widely. Our attempts to explore the heterogeneity yielded one apparently consistent finding: studies recruiting participants from emergency settings exhibited greater benefit related to the rate of falls than did participants in other settings. Otherwise, we were unable to identify any trial or participant characteristic that was more likely to be associated with the rate of falls. Our examination of trials with statistically significant reductions in falls or the number of people experiencing a fall did not reveal an association even after we considered the adequacy of the power of the trial for these outcomes.

Harms were inconsistently reported in a small proportion of the total studies (k=4). The harms reported were generally minor and related to rare musculoskeletal complaints associated with the exercise component of the multifactorial intervention. The lack of collection of adverse events from the control groups further limits conclusions regarding harms.

Single Interventions: Exercise

Summary of Results

The evidence examining exercise interventions to prevent falls consists of a heterogeneous set of 21 trials (n=7,297). About half of the trials recruited participants determined to be at high risk for falls; physical function/mobility limitation was the most common risk factor (alone or in combination) used for trial recruitment. The trials included single or multiple exercise components, and the exercise interventions were primarily conducted in a group setting. Pooled results from 14 RCTs (n=4,663) showed that exercise interventions may reduce the rate of incident falls at 6 to 24 months of followup compared to the control group (IRR, 0.87 [95% CI, 0.75 to 1.00]; p=0.052; I^2=57.3%). Pooled results from 10 RCTs (n=4,622) showed a 19 percent reduction in injurious falls (IRR, 0.81 [95% CI, 0.73 to 0.90]; I^2=0.0%]). Pooled analysis of 15 RCTs (n=4,926) demonstrated that exercise interventions may reduce the number of people experiencing a fall at 6–24 months compared to the control group (IRR, 0.89 [95% CI, 0.81 to 0.97]; I^2=43.9%). Pooled results from 11 RCTs (n=4,263) suggested that exercise interventions have no statistically significant effect on mortality (RR, 0.93 [95% CI, 0.71 to 1.22]; I^2=0.0%). There is limited evidence of the effect of exercise on fracture, people hospitalized, people transitioning to institutional care, QOL, or IADLs based on one to three trials for each of these outcomes.

Conclusions about the harms of exercise interventions are limited by a small number of studies (k=8; n=4,107) and incomplete reporting of adverse events. Harms, including musculoskeletal complaints associated with exercise, were generally minor.

Characteristics of Included Studies

Of the 21 included exercise trials[100-120] (35 articles[100-134]), nine were from the previous review[100-107, 117] and 12 were new.[108-116, 118-120] Eight trials from the previous review were excluded because the population was not representative of general primary care populations,[135-139] they had less than 6 months of followup,[140, 141] or they were of poor quality.[136-142]

Study Characteristics

We identified 16 fair-quality[100-106, 109-113, 116-119] and 5 good-quality[107, 108, 114, 115, 120] RCTs (n=7,297) with a primary or secondary aim of examining the effectiveness of exercise on reducing falls and/or fall-related injuries at 6 to 60 months of followup (**Table 15**). Three trials were conducted in the United States,[100, 106, 120] eight in Europe (not including the United Kingdom),[102, 103, 108-110, 114-116] seven in Australia or New Zealand,[101, 104, 105, 107, 111, 112, 117] two in Asia,[118, 119] and one in the United Kingdom.[113] Trial sizes ranged from 55[100] to 1,635[120] participants randomized to exercise and control arms (for our analysis).

The outcomes reported in the trials we included for analysis were falls (k=14; n=4,663), people experiencing a fall (k=15; n=4,926), injurious falls (k=10; n=4,622), fractures (k=3, n=2050), people experiencing an injurious fall (k=5; n=2,776), mortality (k=11; n=4,263), IADL (k=3; n=363), QOL (k=3; n=1,179), people hospitalized (k=1; N=98), and people transitioning to institutional care (k=2; n=206). No studies reported ADLs.

Two studies (n=2,480) reported adverse events for intervention and control groups.[113, 120, 126] An additional six studies (n=1,627) reported adverse events for participants in intervention groups only.[108, 110, 112, 115, 116, 118]

Population Characteristics

The most common target population was aged 65 years or older (7 of 20 studies[100, 104, 111, 113, 116, 118, 119]) (**Table 16**). Other age target thresholds were 60 years or older,[106, 107, 112, 114] 70 years or older,[103, 108, 109, 115, 117, 120] 75 years or older,[101, 110] 80 years or older,[105] and at least 85 years.[102] The mean age ranged from 68 years[114] to 88 years.[102] Six of the studies were conducted exclusively with women,[105, 108-110, 114, 119] while in one study less than half of the participants were female (42%).[115] The majority of participants in the remaining studies were women. Three studies reported race/ethnicity; in those studies, participants were almost exclusively white.[100, 113, 120] Ten studies reported a measure of socioeconomic status (primarily education).[100, 103, 107, 110, 111, 113, 115, 116, 118, 120] Each study reported socioeconomic status differently, making it difficult to summarize this measure, but most participants who reported socioeconomic status had a high socioeconomic status (e.g., higher level of education).

Twelve of the 21 studies recruited from a community setting (e.g., population-based registries)[102, 107-111, 114, 116-120]; the remaining studies recruited from a clinic or hospital[101, 103-106, 112, 113] or from insurance rolls.[100, 115] All studies recruited community-dwelling adults.

Nine trials did not specify any fall-risk criteria as a condition for inclusion of participants.[100, 101, 105, 107, 109, 111, 114, 117, 119] The remaining 12 trials specified fall-risk criteria as a condition for inclusion of participants; the criteria varied widely.[102-104, 106, 108, 110, 112, 113, 115, 116, 118, 120] Two identified participants with history of falls only,[108, 115] one identified participants upon discharge from the hospital,[112] and one used balance or gait.[110] Seven studies defined fall risk using multiple risk factors (e.g., functional test, self-reported limitation in mobility, health status, history of falls, health care use) or used a risk assessment tool to determine risk status.[102-104, 106, 113, 116, 118, 120] Overall, the most common fall-risk criterion was physical function/mobility limitation alone or in combination with other factors, self-reported or assessed using performance measures.[102-104, 110, 116, 118, 120]

The baseline measures of health or functional status reported in the studies varied. The measures included living alone, experiencing a fall in the past year, physical function, ADL or IADL baseline score, QOL or self-reported health rating, number of medications, and other factors. Overall, about half of the participants included in these RCTs lived alone and forty percent reported falling in the past year.

Intervention Details

The 21 exercise interventions varied along several dimensions: supervision, individual versus group exercise, duration, frequency, and exercise components (**Table 17**).

Supervision. With one exception,[111] participants in all 21 exercise RCTs were supervised during the intervention. Supervision was conducted by a specialized exercise instructor,[103, 104, 107, 109, 110, 113, 115, 116] physical or occupational therapist,[102, 105, 106, 108, 112, 114, 117, 119] health professional,[101, 118] or unspecified supervisor.[100, 120] Participants in the unsupervised trial were self-directed using a written program.[111]

Individual versus group exercise. Fifteen of the interventions included group exercise alone[100, 106, 107, 109, 114-116] or in combination with home-based exercise.[102-104, 110, 113, 117, 118, 120] The remaining five interventions included only individual-based exercise.[101, 105, 111, 112, 119]

Duration. Exercise programs ranged from 2 months[106] to 42 months.[120] The most common duration was 12 months in five trials.[101, 104, 105, 109, 112]

Frequency. Exercise sessions were scheduled once per week[107, 110, 116, 117] up to six times a week.[112, 120] The most common number of sessions was three per week in seven trials.[100, 101, 105, 106, 109, 113, 119]

Exercise component. The ProFaNE taxonomy[35] defines the following exercise components: gait, balance, and functional training; strength and resistance; flexibility; tai chi/3-D training; general physical activity; and endurance (**Table 18**). Eight of the RCTs employed a single exercise component.[103, 106, 107, 110-112, 116] The maximum number of components was five.[104, 113] The most common type of exercise component was gait, balance, and functional training; 17 of the 21 RCTs employed this component alone[106, 110, 112, 116, 117] or in combination with another type of exercise.[101, 102, 104, 105, 108, 109, 113-115, 118-120]

Thirteen of the RCTs employed resistance training in combination with another exercise component,[100, 101, 104, 105, 108, 109, 113-115, 117-120] eight included flexibility in combination with another exercise component,[102, 104, 105, 113, 114, 117, 119, 120] and five included endurance training in combination with another exercise component.[100, 103, 105, 113, 115] Three of the RCTs included 3-D training, specifically tai chi alone[103, 107] or in combination with another exercise component.[102, 104, 113] Five of the RCTs employed general physical activity alone[111] or in combination with another exercise component.[101, 102, 114, 120]

Control groups. Control groups in the trials were instructed to maintain usual activity levels[100-103, 106-109, 113-119] and/or received minimal written information about health or preventing falls, or a social visit.[104, 105, 110-112]One study assigned control group participants to receive a health education workshop that included weekly in-person sessions and 5- to 10-minute instructor-led stretching.[120]

Two studies reported the use of unblinded outcome assessors (e.g., those administering an interview who were not blinded or those abstracting medical records unblinded),[100, 111] and an

additional three studies[109, 116, 119] did not provide enough information to determine whether the outcome assessors were blinded. To ascertain falls, most studies used prospectively recorded falls diaries with or without additional confirmation (i.e., medical records)[100, 101, 103, 105-117]; five studies recorded fall outcomes by recall every 1 to 6 months.[102, 104, 118-120] Adherence to the intervention was reported by 11 of the RCTs as the average percentage of exercise sessions attended, which ranged from 57 percent[112] to 95 percent.[104] Eight of the RCTs reported adherence to the intervention as the percentage of participants classified as "adherent."[103-105, 110, 112, 113, 115, 117] "Adherent" was defined by the investigators and ranged from any sessions to all sessions. In some cases, adherence was defined as still participating in exercise after 12 months. The percentage of adherent participants reported for the studies ranged from 17 percent[113] to 82 percent.[115] Several studies did not adjust results for differences in baseline characteristics.[100, 101, 104, 105, 109, 110, 112, 120] In addition, several studies reported poor retention of participants during followup[103, 106, 113] or minor to moderate differences between intervention and control groups in attrition.[100, 103, 111, 115, 117, 119]

Falls

Meta-analysis of the 14 exercise RCTs (n=4,663) reporting the outcome of falls demonstrated a significant reduction in the rate of incident falls at the longest followup (6–24 months) in the exercise group compared to the control group, with substantial heterogeneity (IRR, 0.87 [95% CI, 0.75 to 1.00]; p=0.052; I^2=57.3%) (**Figure 11; Table 19**). The baseline fall rate of control groups varied widely, from 0.04 per person-year[119] to 1.6 per person-year.[116] Individual RCTs reported substantial variation in effect and effect size, with IRR point estimates ranging from 0.47[105] to 1.43,[112] and wide and overlapping CIs. One RCT was notable for the higher fall rate in the exercise group (IRR, 1.43 [95% CI, 1.07 to 1.93]).[112] That study recruited patients (mean age of 81 years) discharged from geriatric care, rehabilitation, and orthopedic wards at any of four public hospitals in Sydney, Australia. The intervention was an individually based program designed to improve balance; participants received instruction from a physical therapist and were asked to do the exercises at home six times a week. At 12 months, 57 percent were participating in exercise sessions and 29 percent were no longer exercising.[112]

We were unable to explain the high heterogeneity by any single variable, despite examining the outcome of falls by country, date of publication, rate of falls in the control group, inclusion criteria for average or high risk of falls, mean age, followup period, and intervention hours. We also evaluated variability based on the intervention exercise components (e.g., gait, balance, and functional training; strength or resistance; flexibility; tai chi/3-D training; general physical activity; endurance), the number of components in each intervention, and whether the intervention was group only, individual only, or group and individual. None of these characteristics was significant in explaining the variability. Visual examination of the funnel plot for the 14 pooled studies (not included in this report) did not suggest a small study bias, and the Egger test was not statistically significant (p=0.472).

Injurious Falls

Meta-analysis of the 10 exercise RCTs (n=4,622) reporting the outcome of injurious falls demonstrated a significant reduction in the rate of injurious falls at the longest followup (12–60

months) in the exercise group compared to the control (IRR, 0.81 [95% CI, 0.73 to 0.90]; I^2=0.0%) (**Figure 12; Table 20**).[101, 104, 108-110, 112, 113, 115, 117, 120] Specific definitions for fall-related injury outcomes were reported as injurious falls,[101, 104, 108-110, 115, 117] fall-induced serious injuries,[120] or falls with injuries resulting in health care.[112] Nine of the ten RCTs reported an effect consistent with a benefit of exercise intervention.[101, 104, 108-110, 113, 115, 117, 120] Three of the RCTs reported statistically significantly reduced rates of fall-related injuries,[108-110] with significant effects ranging from 0.46[108] to 0.80.[110] One RCT reported a nonstatistically significant increase in the rate of injuries among the intervention group compared to the control group (IRR, 1.14 [95% CI, 0.76 to 1.73]).[112]

Fractures

Three RCTs (n=2,047) reporting fall-related fractures show mixed results. One small RCT (n=72) reported a large reduction in the number of fall-related fractures at 60 months followup (IRR, 0.26 [95% CI, 0.07 to 0.97]).[109] Two RCTs reported no statistically significant reduction in the rate of fractures in the exercise group compared to the control group (IRR, 0.92 [95% CI, 0.45 to 1.91][112] and IRR, 0.87 [95% CI, 0.63, 1.19][120]) (**Figure 4; Table 21**). One study additionally reported a nonsignificant reduction in risk of hip fracture (IRR, 0.76 [0.37 to 1.57]) [120]

People Experiencing a Fall

Meta-analysis of the 15 exercise RCTs (n=4,926) reporting the number of people experiencing a fall demonstrated a reduced risk of falling at the longest followup (6–24 months) in the exercise group compared to the control group (RR, 0.89 [95% CI, 0.81 to 0.97]; I^2=43.9%) (**Figure 13; Table 22**).[100, 102-107, 110-112, 114, 116-118] Individual RCTs reported substantial variation in effect and effect size, with wide and overlapping CIs and RR point estimates ranging from 0.40[114] to 1.38.[112] The results from three RCTs were consistent with a statistically significant reduction in the number of people experiencing a fall in the exercise group compared to the control group (14–60 percent reduced risk).[110, 114, 117] One RCT reported a statistically significant increase in the number of people experiencing a fall in the exercise group compared with the control group (RR, 1.38 [95% CI, 1.11 to 1.73]).[112] The remaining 11 RCTs showed a nonsignificant benefit in terms of fewer people experiencing a fall in the exercise group than in the control group.[100, 102-107, 111, 113, 116, 118] We explored heterogeneity by examining country, date of publication, prevalence of people experiencing a fall in the control group, average or high fall risk, mean age, followup period, and intervention hours, yet were unable to explain the high heterogeneity by any single variable. When trials with specific exercise components were examined separately for the number of people experiencing a fall, none of these characteristics was significant in explaining the variability.

Six RCTs[104, 105, 107, 111, 116, 117] (n=1,890) reported results for the number of people experiencing two or more falls (**Table 22**). The results of these trials were consistent with a reduced risk of falling for those in the exercise group compared to the control group. Three of these studies reported a statistically significant reduced risk, which ranged from 0.21[116] to 0.54.[107] Two studies reported small or moderate nonsignificant reductions of risk of falling at least twice.[105, 117] One study reported a risk estimate of 1.0.[111]

People Experiencing an Injurious Fall

Five RCTs (n=2,776) reported at least one outcome related to the number of people experiencing an injurious fall, with longest followup ranging from 12 to 60 months.[104, 105, 109, 110, 120] All five trials reported results consistent with a reduced risk of injury, although none of the results was statistically significant. Reductions in risk among the exercise group ranged from 0.61[109] to 0.90[110] (**Figure 14; Table 23**).

People Experiencing a Fracture

One trial (n=1,635) showed a nonsignificant, decreased risk for people with fall-related fractures (RR, 0.87 [95% CI, 0.63 to 1.19]) and people with hip fractures (RR, 0.87 [95% CI, 0.41 to 1.81]) at 31 months in the exercise group compared to the control group (**Table 23**).[120]

Mortality

Pooled analysis of 11 RCTs (n=4,263) showed no significant association with all-cause mortality at longest followup (12–60 months) in the exercise group compared to the control group (RR, 0.93 [95% CI, 0.71 to 1.22]; I^2=0.0%) (**Figure 15; Table 24**).[101, 102, 104, 105, 108-110, 112, 116, 118] Individual study results showed no statistically significant differences, and RRs varied widely (0.16[101] to 1.13[120]), with wide CIs. The few deaths in most trials made estimates unstable.

People Transitioning to Institutional Care

Two RCTs (n=206) reported no statistically significant difference in the number of people transitioning to institutional care between the exercise and control groups at longest followup (6–12 months). The wide confidence intervals reflect the rare event rate; the prevalence of institutionalization in the control groups varied from 2.8 percent over 6 months[114] to 1.5 percent over 12 months[116] (**Figure 9; Table 25**).

People Hospitalized

One RCT (n=98) reported the outcome of people hospitalized, which showed no statistically significant difference in hospitalization in the exercise group compared to the control group at 12 months[118] (**Figure 10; Table 26**).

QOL

Three RCTs (n=1,179) reporting QOL outcomes as measured by SF-12,[112] EuroQol EQ-5D,[113] and the Australian Quality of Life scale[111] at longest followup (6–12 months) showed no statistically significant differences between the exercise and control groups (**Table 27**). In general, mean changes in exercise group from baseline to followup were small and not clinically meaningful.

IADL

Three studies (n=363) reporting IADL outcomes as measured with the Lawton and Brody scale (original or modified) at longest followup (6–12 months)[100, 105, 118] showed no statistically significant differences between the exercise and control groups (**Table 27**). In general, mean changes in exercise group from baseline to followup were small and not clinically meaningful.

Fall Risk Status

A little over half of the exercise trials (12/21) recruited participants defined as at high risk for falls using a variety of risk factor criteria. The most common risk factor used for recruitment alone or in combination with other risk factors was physical function/mobility limitation (self-reported or measured objectively). For any given outcome, more than half of the pooled trials recruited high-risk participants (falls, 8/14; people experiencing falls, 9/15; injurious falls, 7/10), and our exploratory analyses did not suggest differential treatment effect based on whether or not the trials recruited high-risk individuals, nor did we see an association between control group fall rate and treatment effect.

Harms

Eight RCTs (n=4,107) reported on harms[108, 109, 112, 113, 115, 116, 118, 120, 126] in the intervention group. Two of these trials also reported harms in the control group for comparison and reported no difference in the rate of serious injuries between the intervention and control groups.[113, 120, 126] Several studies reported that intervention participants experienced pain, bruising, or both, related to the exercise.[110, 112, 113, 118, 126] One RCT[110] reported a wrist fracture in a participant in the intervention group. Another RCT reported three serious fall injuries during 114,100 physical activity sessions (for a rate of 2.6 per 100,000 sessions).[120] Several of the studies reported no severe or significant adverse effects or injuries.[108, 115, 116] In general, adverse events reported for these exercise interventions were minor.

Critical Appraisal

The recruitment strategies in these exercise interventions generally represent community-dwelling older adults and primary care populations at risk of falling. Most of the studies were small, with eight RCTs enrolling fewer than 200 participants and only four including more than 500 participants. In general, interventions were heterogeneous in terms of duration, frequency, and exercise components. With one exception, interventions included exercise supervised by a professional, and in the majority of interventions participants exercised as part of a group rather than exercising alone. We were unable to determine any trial or participant characteristic associated with a reduced risk of falling or the number of falls. The magnitude of effects was generally small or moderate, and the CIs were generally wide and overlapping. Harms were inconsistently reported in a small proportion of the total studies, and those that were reported were generally minor or rare musculoskeletal complaints. The lack of collection of adverse events from the control groups limits further conclusions regarding the potential harms.

Single Interventions: Vitamin D

Summary of Results

Evidence from seven heterogeneous trials[108, 143-148] (11 articles[108, 130, 133, 143-150]) (n=7,531) of different vitamin D3 formulations and dosing schedules and varying baseline fall risk in community-dwelling older adults shows mixed results. The single trial of annual high-dose cholecalciferol (500,000 International Units [IU]) showed an increase in falls, people experiencing a fall, and injurious falls;[148] the trial of calcitriol showed a reduction in falls and fallers,[144] and the remaining studies showed no statistical difference in falls, people experiencing a fall, or injurious falls. Pooled results showed no statistically significant difference in falls (k=5; n=3,496; IRR, 0.97 [95% CI, 0.79 to 1.20]; I^2=75.8%), people experiencing a fall (k=6; n=6,519; RR, 0.97 [95% CI, 0.88 to 1.08]; I^2= 60.3%) or mortality (k=6; n=7,084; RR, 1.08 [95% CI, 0.83 to 1.40]; I^2=0%) One study showed no difference between vitamin D and control groups in QOL changes at 12 months. The number of people hospitalized or transitioned to institutional care, ADL, and IADL were not reported in any of these studies. Harms were reported variably in four studies and, with one exception, adverse events were no different between the vitamin D and placebo groups.[143, 144, 147, 148] The exception was the single, annual high-dose cholecalciferol (500,000 IU) trial, which revealed a higher rate of falls, people experiencing a fall, and fall-related injuries among the intervention group.[148]

Characteristics of Included Studies

Of the seven included vitamin D trials, four were included in the previous review,[143-146] and three were new.[108, 147, 148] We excluded the four trials that did not recruit a population generalizable to a primary care population[151-154] (e.g., those with vitamin D insufficiency or deficiency) and one poor-quality trial.[155]

Study Characteristics

We identified three fair-quality[143-145] and four good-quality[108, 146-148] RCTs (n= 7,531) with a primary or secondary aim of examining the effectiveness of vitamin D on falls, fall-related injuries, or both at 9 to 60 months of followup (**Table 28**). Two trials were conducted in the United States,[144, 146] two in Australia,[147, 148] and one each in the United Kingdom,[145] Switzerland,[143] and Finland.[108] Trial size ranged from 204 participants[108] to 3,314 participants[145, 148] randomized to the vitamin D and matched control arms.

The outcomes reported in the trials that we included for analysis were falls (k=5; n=3,496), people experiencing a fall (k=6; n=6,519), injurious falls (2 RCTs; n=2,460), mortality (k=6; n=7,084), and QOL (k=1; n=3,314). No studies reported people experiencing an injurious fall, hospitalization, institutionalization, ADL, or IADL. Five studies (n= 3,955) reported harms.[143, 144, 146-148]

Population Characteristics

Five studies recruited participants aged 70 years and older,[108, 143, 145, 147, 148] and two RCTs

recruited participants aged 65 years and older (**Table 29**).[144, 146] Mean age ranged from 71 years[144, 146] to 76.8 years.[145] Five of the seven studies were conducted exclusively with females,[108, 144, 145, 147, 148] and two recruited about the same number of males and females.[143, 146] In the three studies that reported race or ethnicity, the participants were almost exclusively white.[144, 146, 147] Measures of socioeconomic status were not reported.

Five of the seven studies recruited from the community setting.[108, 143, 144, 146, 148] One study recruited participants from general practices,[145] and one RCT recruited from the community and clinics.[147] All seven studies recruited community-dwelling adults.

Four trials recruited patients at average risk of falls where the only risk factor was age.[143, 144, 146, 147] Three trials recruited only patients at high risk (based on varying definitions) for falls.[108, 145, 148] One study defined high risk as a history of falls in the previous 12 months,[108] and the two remaining studies[145, 148] defined high risk as the presence of one or more risk factors, including maternal or family history of hip fracture,[145, 148] self-reported fall,[148] previous fracture,[145, 148] low body weight (<58 kg),[145] or self-reported health that was fair or poor.[145]

Baseline mean serum 25-hydroxyvitamin D levels ranged from 26.4 ng/ml[147] to 31.8 ng/ml.[144] These values were reflective of mean vitamin D levels in adults aged 60 and older based on 2009–2010 data of the National Health and Nutrition Examination Survey (mean 25-hydroxyvitamin D level, 29 ng/ml).[57]

Baseline measures of health or functional status varied. They included history of falls, comorbid conditions, baseline ADL or IADL score, QOL, and self-reported health rating.

Intervention Details

Vitamin D3 was administered orally in all studies with various formulations, including cholecalciferol,[108, 145-148] 1-hydroxycholecalciferol,[143] and calcitriol (**Table 30**).[144] The dosing schedules varied. The cholecalciferol trials used a dose of 700 IU daily,[146] 800 IU daily,[108, 145] 150,000 IU every 3 months,[147] or 500,000 IU annually.[148] The other two RCTs administered 1 μg of 1-hydroxycholecalciferol daily [143] and 0.25 μg of calcitriol twice daily.[144] In two studies, the intervention group received calcium (500 mg/day of calcium citrate malate[146] or 1,000 mg daily of calcium carbonate[145]) in addition to vitamin D.

Vitamin D was administered for 9 months up to 5 years; for two trials, the treatment duration and outcomes followup was 3 years[144, 146] One trial continued therapy for 3 to 5 years and reported outcomes for up to 12 months after treatment was completed.[148] The control groups received a matched placebo in six of the seven trials.[108, 143, 144, 146-148] One open-label study gave participants an educational pamphlet on fall prevention and adequate consumption of calcium and vitamin D.[145]

Study Quality

Five of the seven trials ascertained falls prospectively.[108, 143, 146-148] One of those trials also asked participants about falls every 6 months by interview[146] and another also used medical records.[143]

Two trials measured falls retrospectively by participant recall at 1 month[144] or 6 months.[145] Fractures were ascertained by participant self-report with confirmation by a physician[145] or radiologist.[148] With the exception of the one open-label trial by Porthouse et al,[145] which was not blinded, adequate blinding of outcome assessors was clearly reported. [108, 143, 144, 146-148] Attrition was relatively low (5–15%) in all trials. Intention-to-treat analysis was used in all studies. Adherence to vitamin D therapy was measured by pill count,[108, 144, 146] self-report,[145] serum vitamin D level,[143, 146, 148] or direct observed therapy.[147] Adherence to therapy was approximately 60 percent in two studies,[144, 145] 98 to 100 percent in two other studies,[108, 147] and 82 percent in one study[146]; the other two studies did not report adherence.[143, 148] Trials were designed to have adequate power for outcomes of fracture,[145, 148] bone mineral density,[144, 146] and falls,[147] or they were not reported.[143] One factorial study was underpowered for falls for the arm with vitamin D alone.[108] Three studies received funding from pharmaceutical companies.[143-145]

Falls

Meta-analysis of five RCTs (n=3,496) showed no statistically significant effect on falls at longest followup (9–36 months) (IRR, 0.97 [95% CI, 0.79 to 1.20]; I^2=75.8%) (**Figure 16; Table 31**).[108, 143, 144, 146, 148] This group of trials showed mixed results between the vitamin D and control groups. The RCT (n=213) that used calcitriol showed a statistically significant 37 percent reduction in fall rate in the vitamin D group compared to the control group at 3 years (annual fall rate, 0.27 vs. 0.43; IRR, 0.63 [95% CI, 0.47 to 0.84]).[144] One trial of high-dose annual cholecalciferol treatment (n=2,256) showed a 16 percent increase in falls at 3 years (IRR, 1.16 [95% CI, 1.03 to 1.31]).[148] The three remaining RCTs reporting this outcome showed no statistically significant difference in falls between the vitamin D and control groups (IRR point estimates 0.87 to 1.12).[108, 143, 146] The fall rate of the control group varied widely, from 0.37[143, 146] to 1.18 falls per person-year.[108] Sensitivity analysis removing the high dose annual vitamin D trial showed no statistically significant difference in falls (IRR 0.91 [95% CI, 0.68 to 1.22]).

Injurious Falls

Two trials (n=2,460) reported falls with soft-tissue injury or injurious falls with mixed results (**Figure 3; Table 32**).[108, 148] The annual high-dose (500,000 IU) cholecalciferol study by Sanders et al[148] showed an increase in injurious falls in the vitamin D group (IRR, 1.15 [95% CI, 1.02 to 1.29]), whereas the study by Uusi-Rasi et al[108] showed no difference at 24 months (IRR, 0.84 [95% CI, 0.45 to 1.57]).

Fractures

One trial (n=2,256) administering high-dose (500,000 IU) vitamin D reported fractures. There was no statistically significant difference in fractures between the vitamin D and control groups at 36 months, although the point estimate was above 1 (IRR, 1.25 [95% CI, 0.97 to 1.61]) (**Figure 4; Table 32**).[148]

People Experiencing a Fall

Meta-analysis of six RCTs (n=6,519) showed no statistically significant difference in people

experiencing a fall between the vitamin D and control groups at 9–36 months (RR, 0.97 [95% CI, 0.88 to 1.08]; I^2= 60.3%) (**Figure 17; Table 33**).[143-145, 147, 148, 150] Similar to the mixed results seen for the falls outcome, the calcitriol study (n=213) showed a statistically significant 23 percent reduction in people experiencing a fall in the vitamin D group compared to the control group (RR, 0.77 [95% CI, 0.61 to 0.98])[144, 150] and the annual high-dose (500,000 IU) cholecalciferol study showed an 8 percent increase in people experiencing a fall in the vitamin D group (RR, 1.08 [95% CI, 1.03 to 1.14]).[148] The remaining four RCTs showed no difference in people experiencing a fall between the vitamin D and control groups (RR, 0.84[143] to 1.08[147]). A sensitivity analysis removing the high-dose annual vitamin D trial showed no statistically significant difference in people experiencing a fall (RR 0.94 [95% CI, 0.84 to 1.05]). An additional sensitivity analysis adding trials exclusively recruiting participants with vitamin D insufficiency or deficiency showed a nonstatistically significant reduction in people experiencing a fall with the upper confidence interval including 1 (RR 0.88 [95% CI, 0.78 to 1.00]; I^2=83.2%).

People Experiencing an Injurious Fall

No trials reported this outcome.

People Experiencing a Fracture

Four trials (n=5,436) reported mixed results for people experiencing a fracture (**Figure 7; Table 34**).[145-148] Two trials[145, 146] showed a reduction in people experiencing a fracture; Porthouse et al.[148] showed a nonstatistically significant reduction in people with physician-confirmed hip fractures at 25 months of followup (RR, 0.39 [95% CI, 0.11 to 1.34]) with wide CIs, and Bischoff-Ferrari et al.[146, 149] showed a statistically significant reduction in people with nonvertebral fractures at 36 months (RR, 0.46 [95% CI, 0.23 to 0.90]). The high-dose (500,000 IU annually) cholecalciferol trial showed a nonstatistically significant increase in people with nonvertebral fractures at 36 months (RR, 1.22 [95% CI, 0.95 to 1.57]),[148] and Glendenning et al.[147] reported similar proportions of people experiencing a fracture in both groups (RR, 0.94 [95% CI, 0.40, 2.24]).

Mortality

Six RCTs (n=7,084) reporting mortality at 9 to 36 months of followup showed mixed results.[108, 143-145, 147, 148] Meta-analysis showed no statistically significant difference in deaths between the vitamin D and control groups (RR, 1.08 [95% CI, 0.83 to 1.40); I^2=0%). No individual study reached statistical significance (**Figure 18, Table 35**). Wide CIs were particularly notable in trials with up to two events.

People Transitioning to Institutional Care

No trials reported this outcome.

People Hospitalized

No trials reported this outcome.

QOL

In one study (n=3,314), QOL exhibited similar mean differences in SF-12 mental and physical component scores between the vitamin D and control groups at 12 months compared to baseline (SF-12 mental component adjusted mean difference, 0.03 [95% CI, -0.04 to 0.97] and SF-12 physical component adjusted mean difference, -0.152 [95% CI, -0.10 to 0.7]) (**Table 36**).[145]

ADL

No trials reported this outcome.

Fall Risk Status

Three of the seven trials recruited participants at high risk for falls where the most common definition of increased fall risk was based on history of falls as a single factor or as one of many risk factors. Given the few trials and heterogeneity of dosages and formulations, no conclusions can be made about associations between baseline fall risk and treatment effectiveness.

Harms

Five RCTs (n=3,955) reported harms associated with vitamin D and showed no difference in the frequency of adverse events attributable to treatment (**Table 37**).[143, 144, 146-149] As noted above in the sections on falls and persons experiencing a fall, one trial reported an increase in falls, people experiencing a fall, and fall-related injuries associated with the annual high dose (500,000 IU) of cholecalciferol. The event rates for several of the reported events that did occur were rare (e.g., kidney stones, diabetes). Transient hypercalcemia was reported in two trials[143, 144] and described as mild or clinically asymptomatic; a single case of hypercalciuria was reported in the treatment group in one trial.[146, 149] Most of the conditions are unlikely to be attributable to vitamin D.

Critical Appraisal

These seven vitamin D trials tested various formulations and dosing schedules for community-dwelling older adults at average or high risk of falls who were not specifically selected for vitamin D insufficiency or deficiency. Although most trials had followups lasting more than 12 months, only three of the seven trials were designed to have adequate power to detect differences in falls or fractures in these trials. Given the high statistical heterogeneity in the meta-analyses for falls, people experiencing falls, and mortality, we have limited confidence in interpreting these mixed results.

Single Interventions: Environment

Summary of Results

We identified three trials[117, 156, 157] (four articles[117, 124, 156, 157]) that examined the effect of an environment intervention (i.e., a single home visit to reduce home hazards) on falls in older adults at varying fall risk (n=2,175). The results were mixed: one trial[157] showed a 46 percent

reduction in falls, while two trials showed no effect. None of the trials reporting people experiencing a fall or injurious falls showed differences between the environment intervention group and the control group. One trial reporting changes in QOL and ADL showed no difference between these groups. No trials reported the outcomes of mortality, people hospitalized, people transitioning to institutional care, or harms. All studies were conducted outside of the United States, and the overall conclusions were limited by few studies that were underpowered for fall outcomes.

Characteristics of Included Studies

Of the three included environment trials, one was included in the previous review[156] and two were newly identified.[117, 157] One study from the previous review was excluded because the population was not representative of the general primary care population.[136]

Study Characteristics

We found one good-quality RCT[157] and two fair-quality RCTs[117, 156] that examined the effect of environment interventions on falls (k=3, n=2,175) (**Table 38**). Two of the trials had a primary aim to reduce falls,[117, 156] and the other trial had a secondary aim of falls prevention.[157] Two trials took place in Australia[117, 156] and one took place in the United Kingdom.[157] Trial size ranged from 165 to 1,879 randomly assigned participants. All three trials reported on falls and people experiencing a fall; one of these also reported injurious falls.[117]

Population Characteristics

All three studies recruited community-dwelling adults aged 70 years and older (**Table 39**).[117, 156, 157] One required that all participants had fallen in the year preceding the study[157]; the other two studies reported that 27 percent of their participants had fallen in the previous year[156] or 6 percent within the past month.[117] Mean age ranged from 76 to 79 years. The percentage of females ranged from 52 to 69 percent. The two studies that reported ADLs indicated that participants were still performing most ADLs without limitations (mean score, 18 out of 20[157] or 5.3 out of 6[117]).

Intervention Details

A nurse,[156] home-maintenance staff member,[117] or occupational therapist[157] conducted a one-time assessment of the participant's home to identify environment hazards within the home that could contribute to a fall (**Table 40**). Each study provided some kind of modification to reduce the hazard of falls. Modifications were made during the assessment (if possible)[156, 157] or through a city program (which paid up to $100).[117] For hazards not modified during the assessor's visit or through a city program, the participant was responsible for making changes or hiring someone to complete the work. Only one of the trials had a systematic approach to identifying home hazards and also provided followup phone calls.[157]

Participants in the control group in two of the trials were not given any intervention but could continue to receive usual care.[156, 157] The third trial offered a delayed intervention.[117]

Study Quality

All three trials reported adequate randomization methods, used blinded outcome assessors, collected prospective data on falls, and analyzed data using an intention-to-treat approach. Two of the fair-quality trials had a higher attrition rate (10–15%) than the good-quality study did, but the loss was similar between the intervention and control groups.[117, 156] Participants' adherence to the intervention was variably reported. In one study, 76 percent received help to make the home modifications.[117] In another, 70 percent partially or fully adhered to the recommendations.[157] The third reported that several hazards (e.g., unsafe steps, rugs, or mats; rooms with trailing cords; rooms with an unsafe favorite chair) were significantly reduced.[156] The trials either were not powered to assess the outcomes of falls or did not report power calculations.

Falls

Only one trial of high-risk participants, Pighills et al,[157] reported a statistically significant reduction in the number of falls in the intervention group compared to the control group (IRR, 0.54 [95% CI, 0.36 to 0.83]) (**Figure 19; Table 41**). This trial had a prescriptive protocol for the home assessment and provided followup phone calls as well.[157] The other two trials showed no effect on the rate of falls (IRR, 0.98 [95% CI, 0.81 to 1.19][117] and IRR, 1.02 [95% CI, 0.83 to 1.27][156]).

Injurious Falls

Only one trial captured injurious falls (i.e., a fall that resulted in a cut, scrape, gash, bruise, fracture, head injury, or hospitalization). There were no differences between the intervention and control groups (IRR, 0.97 [95% CI, 0.75 to 1.26])[117] (**Figure 3; Table 42**). The same trial found that the intervention group had a nonstatistically significant higher rate of falls with injuries resulting in health care (IRR, 1.47 [95% CI, 0.81 to 2.67]).

People Experiencing a Fall

All three studies reported that the intervention group had fewer people experiencing a fall than the control group, but the differences were not statistically significant (**Figure 20; Table 43**). RR or OR point estimates ranged from 0.83 to 0.93. One study also looked at people experiencing recurrent falls and found similar nonstatistically significant results (people experiencing two or more falls: RR, 0.94 [95% CI, 0.66 to 1.33]; people experiencing three or more falls: RR, 0.73, [95% CI, 0.42 to 1.27]).[117]

People Experiencing Injurious Falls

None of the studies reported people experiencing injurious falls.

Mortality

No studies reported mortality outcomes.

People Transitioning to Institutional Care

No trials reported this outcome.

People Hospitalized

No studies reported hospitalization.

QOL

Using the EuroQol and SF-12, one study reported on the QOL of participants in the intervention and control groups (**Table 44**). There was no difference from baseline to 12 months between the two groups.[157]

ADL

One study reported ADLs, measured with the Barthel index (**Table 44**). There was no difference from baseline to 12 months between the intervention and control groups.[157]

Fall Risk Status

Only one of these three trials recruited participants at high risk for falls based on history of prior falls, so it is not possible to make conclusions about associations between baseline fall risk and treatment effectiveness.

Harms

No studies reported harms.

Critical Appraisal

These three environment trials of average or high-risk, community-dwelling older adults showed mixed results. The largest of the three trials (more than 1,500 participants) had no effect on fall outcomes,[156] but the smallest trial, which was of good quality and had a designated protocol and provided telephone followup, resulted in a large reduction in falls.[157] These mixed results suggest that larger studies replicating the trial by Pighills et al[157] are needed.

Single Interventions: Medication Management

Summary of Results

Evidence is limited to two underpowered RCTs[158, 159] (3 articles[158-160]) in high-risk older adults, which showed no difference in falls, injurious falls, people experiencing a fall, or mortality with an intervention involving medication management. There were no studies reporting people hospitalized, people transitioning to institutional care, QOL, ADL, or harms. Evidence of the effectiveness and harms of these interventions to reduce falls and fall-related injuries is too

limited for conclusions.

Characteristics of Included Studies

Both trials were newly identified studies.

Study Characteristics

We identified two fair-quality RCTs (n=266) conducted in the United States with a primary aim of examining the effectiveness of medication management on recurrent falls[158, 159] and fall-related injuries (**Table 45**).[158] The fall-related outcomes reported in the trials that we included for analysis were falls, people experiencing a fall, fall-related injuries, and mortality at 6 months[159] and 1 year[158] of followup.

Population Characteristics

Both RCTs recruited participants aged 65 and older (mean age, 75 years) (**Table 46**). The majority of participants were women (73%), were white (92%), and had an education beyond high school (74%).

One trial recruited participants from a central electronic database from a community pharmacy chain,[158] while the second trial recruited participants from a fall-prevention workshop.[159] Both trials recruited participants at high risk for falls (i.e., fell at least once in the prior year,[158, 159] had a fear of falling[159] or took four or more long-term prescription medications,[158] of which one or more was a central nervous system medication (e.g., benzodiazepines, antidepressants, anticonvulsants, sedative-hypnotics, narcotic analgesics, antipsychotics, skeletal muscle relaxants).

All participants were community-dwelling and had no significant cognitive impairment (fewer than three errors on a six-item MMSE-derived screening test[158] or able to provide their own consent[159]). One study reported that 43 percent of participants used a cane or walker and 49 percent had fallen two or more times in the year prior to randomization.[158] The second trial reported that 40 percent had fallen in the prior 6 months; most of the participants assessed their health to be good or better.[159]

Intervention Details

In both trials, the intervention and control groups received an educational fall-prevention brochure (**Table 47**).

The medication management intervention included an algorithm-driven consultation with a pharmacist[159] or pharmacy resident.[158] One trial included a single, 45-minute, face-to-face medication review consultation,[158] while the second trial included one 60-minute, face-to-face medication review consultation and a followup telephone call at 3 months.[159] The pharmacist either contacted the prescriber to approve the medication changes[158] or developed an action plan with prescriber communication only when deemed necessary.[159]

Study Quality

Participants recorded falls by using calendars that were turned in monthly and by participating in telephone interviews every 1[159] to 3 months.[158] One trial specified that personnel who had patient contact or collected data were blinded,[158] while the other trial did not report blinding.[159] One trial conducted analyses controlling for potential confounders (two or more falls in the year prior to randomization, use of a cane or walker, number of high-risk medical conditions, and number of days per week engaged in physical activity),[158] while the other did not.[159] One trial reported no loss to followup,[159] while the other trial reported that 78 percent of the intervention group received the intervention; 28 and 16 percent were lost to followup in the intervention and control groups, respectively, but all randomized patients were analyzed using intention to treat methods. In these two trials, there was wide variation in adherence to medication discontinuation recommendations (16% and 77% of the intervention groups actually discontinued high-risk medications in the two trials.) Both trials were underpowered for any fall-related outcomes.

Falls

One study[158] reported no difference in the rate of falls between the medication management group and the control group (2.2 vs. 2.1 falls per person year; IRR, 1.01 [95% CI, 0.81 to 1.26]) (**Figure 19; Table 41**).

Injurious Falls

The same trial[158] reported no difference in injurious falls between the intervention and control groups at 12 months (IRR, 0.87 [95% CI, 0.62 to 1.24]) (**Figure 3; Table 42**).

Fractures

No trials report this outcome.

People Experiencing a Fall

Both trials reported no difference in people experiencing one or more falls between the medication management group and the control group (RR, 1.02 [95% CI, 0.79 to 1.31] for Blalock et al.,[158] RR, 1.16 [95% CI, 0.55 to 2.41] for Mott et al[159]) (**Figure 20; Table 43**).

People Experiencing an Injurious Fall

No trials reported this outcome.

People Experiencing a Fracture

No trials reported this outcome.

Mortality

There was no difference in mortality between the medication management and control groups in one study.[158] However, the events were rare (3 vs. 2 deaths; RR, 1.50 [95% CI, 0.26 to 8.77]) (**Figure 21, Table 48**).

People Transitioning to Institutional Care

The trials did not report this outcome.

People Hospitalized

The trials did not report this outcome.

QOL

The trials did not report this outcome.

ADL

The trials did not report this outcome.

Fall Risk Status

Both trials recruited participants at high risk for falls based on history of prior falls, fear of falling and/or high-risk medication usage, so it is not possible to make conclusions about associations between baseline fall risk and treatment effectiveness.

Harms

Neither study on medication management reported harms.

Critical Appraisal

The evidence on medication management is limited to two underpowered studies that showed no statistically significant effect on the outcome of falls. The literature is too limited to make any conclusions about the effectiveness or harms of medication management interventions.

Single Interventions: Psychological

Summary of Results

Two trials[161, 162] (five articles[161-165]) of cognitive behavioral interventions targeted community-dwelling older adults at high risk of falling. An 8-week group-based intervention and 16-week individual-based intervention trial showed nonstatistically significant reductions in falls and people experiencing a fall, at 12 and 14 month followup. One trial reported a statistically

significant reduction in people experiencing two or more falls at 14 months of followup. Trial results on injurious falls were mixed. Larger trials adequately powered for fall-related outcomes are needed. Neither study reported fracture, people experiencing an injurious fall, people experiencing a fracture, people hospitalized, or people transitioning to institutional care.

Characteristics of Included Studies

We identified two new studies that used cognitive behavioral interventions for reducing fear of falling.[161, 162]

Study Characteristics

These two fair-quality RCTs (n=929 randomized), conducted in the Netherlands, were aimed to reduce fear of falling and activity avoidance [161] or to address concerns about falls[162] in community-dwelling older adults (**Table 49**). Both trials measured falls, injurious falls, people experiencing a fall, mortality, and IADL changes at 12–14 months of followup.

Population Characteristics

Zijlstra et al[161] recruited community-dwelling older adults with a fear of falling or those who avoided activities due to a fear of falling (**Table 50**). Similarly, Dorresteijn et al recruited community-dwelling older adults who perceived their general health as fair or poor and who had concerns about falling and associated activity avoidance.[162] The mean age was 78 years. Seventy-one percent of participants were female. Approximately half (55%) of the participants lived alone, and more than one-third had fallen more than once in the 6 months before the trial was started in the study by Zijlstra et al.[161] The participants in the study by Dorresteijn et al[162] were more frail, with 61 percent falling in the 6 months prior to the start of the study, 13 percent reporting their general health as poor, 26 percent often or very often concerned about falls, and 23 percent often or very often avoiding activities due to concerns about falls.

Intervention Details

Both studies used a cognitive behavioral intervention designed to reduce fear of falling (**Table 51**). A nursing professional facilitated the intervention in both studies. Zijlstra et al[161] used a group-based approach with eight weekly 2-hour sessions with the purpose of addressing misconceptions, setting realistic goals for safe activity, reducing home hazards, and promoting physical exercise to increase strength and balance. Six of the eight sessions included 15 minutes of low-intensity physical exercise. Every weekly session assigned homework that included physical exercise. A booster session was provided 6 months after the eight weekly sessions were completed. Dorresteijn et al[162] used an individual approach, with seven total sessions (3 home visits, 4 telephone contacts) over 16 weeks aimed to address concerns about falls, thoughts about falling, physical exercise, asserting oneself, overcoming personal barriers; safe behavior, and managing concerns about falls. The session length varied, with in-person visits ranging from 60-75 minutes and telephone contacts of 35 minutes. The control group for both studies received usual care.

Study Quality

Both studies were of fair quality: randomization was adequate, outcome assessors were blinded, and intention to treat analysis was conducted. Data on falls were measured by participants' diaries, which were collected monthly[162] or every 3 months.[161] The power calculation for sample size determination was not reported for the study by Zijlstra et al,[161] and the study by Dorresteijn et al[162] was powered for falls efficacy. There was differential attrition between the intervention and control groups for both studies.

Falls

In both trials, the intervention group had nearly identical results with nonstatistically significant lower rates of falls compared with the control group at 12 to 14 months of followup (adjusted IRR, 0.86 [95% CI, 0.65 to 1.14][161] and adjusted IRR, 0.86 [95% CI, 0.65, 1.13][162]) (**Figure 19; Table 41**).

Injurious Falls

The trial results for injurious falls were mixed. At 12–14 months, one trial showed a nonstatistically significant reduction in fall-related injuries resulting in medical care in the intervention group compared to the control (adjusted IRR, 0.78 [95% CI, 0.45 to 1.34]),[161] but the other trial showed the opposite effect (adjusted IRR, 1.42 [95% CI, 0.96, 2.10])[162] (**Figure 3; Table 42**).

Fracture

Both trials did not report this outcome.

People Experiencing a Fall

There was a statistically significant 28 percent reduction in people experiencing a fall at 14 months in the intervention compared to the control group in one trial (RR, 0.72 [95% CI, 0.58 to 0.90]) however after adjustment these results were not statistically significant (adjusted OR, 0.50 [95% CI, 0.23 to 1.08]).[161] There was a statistically significant reduction in people who fell at least twice in the intervention group compared with the control group (RR, 0.59 [95% CI, 0.43 to 0.81]) and these results remained statistically significant even after adjustment for confounders (adjusted OR, 0.38 [95% CI, 0.17 to 0.84]). The study by Dorresteijn et al[162] reported similar results at 12 months, although none was statistically significant (**Figure 20; Table 43**).

People Experiencing an Injurious Fall

Both trials did not report this outcome.

People Experiencing a Fracture

Both trials did not report this outcome.

Mortality

There was no difference in the number of participants who died between the intervention and control groups in either trial (RR, 0.93 [95% CI, 0.30 to 2.84][161]; RR, 1.01 [95% CI, 0.36 to 2.81][162]) at 12–14 months of followup (**Figure 21, Table 48**). The study by Zijlstra et al[161, 165] also reported mortality at 7 years and found no difference between the intervention and control groups (RR, 0.98 [95% CI, 0.77 to 1.25]) (**Table 48**).

People Transitioning to Institutional Care

Both trials did not report this outcome.

People Hospitalized

Both trials did not report this outcome.

QOL

Both trials did not report this outcome.

ADL and IADL

The study by Dorresteijn et al[162] reported statistically significant improvements in ADL (measured with the Groningen Activity Restriction Scale) for the intervention group versus control group at 12 months followup, but the difference between groups was small (adjusted mean difference, -0.83) (**Table 44**).

The study by Zijlstra et al[161] examined IADL using the Frenchay Activities Index and found no differences between the intervention and control group over 14 months of followup. The study by Dorresteijn et al[162] reported statistically significant improvements in ADL (measured with the Groningen Activity Restriction Scale) for the intervention group versus control group at 12 months followup, but the difference between groups was small (adjusted mean difference, -1.01) (**Table 44**).

The study by Dorresteijn et al[162] reported statistically significant improvements in ADL/IADL (measured with the Groningen Activity Restriction Scale) for the intervention group versus control group at 12 months followup, but the difference between groups was small (adjusted mean difference, -1.81) (**Table 44**).

Fall Risk Status

Both psychological trials recruited participants at high risk for falls based on fear of falling; evidence is too limited to make conclusions about associations between baseline fall risk and treatment effectiveness.

Harms

One trial reported no adverse events or side effects;[161] the other did not report adverse events.[162]

Critical Appraisal

These two trials of a primary care referable group or individual, home-based cognitive behavioral intervention for community-dwelling older adults at high risk of falling were fairly well designed. While results showed a nonstatistically significant reduction in falls and number of people experiencing a fall, both trials' primary aims were to reduce participants' fear of falling, and in one trial, fall outcomes were collected for the purpose of monitoring safety rather than for assessing primary outcomes.[161] These trials were underpowered to detect differences in fall outcomes, so larger trials are necessary to determine if cognitive behavioral intervention has any effect on fall-related outcomes.

Multiple Interventions

Summary of Results

Six fair- to good-quality RCTs[108, 115, 117, 166-168] (10 articles[108, 115, 117, 124, 130, 133, 166-169]) examined the effectiveness of multiple interventions with one to two trials testing each of the following combinations of interventions compared to a control group: exercise+environment, exercise+psychological, exercise+knowledge+fall risk assessment, exercise+vitamin D, and knowledge+environment in older adults of varying risk. There is limited evidence based on three trials designed to have adequate power for falls that knowledge+environment (n=310), exercise+environment+vision (n=272), and exercise+psychological (n=378) interventions reduce falls and/or fallers by 20 to 46 percent. A single underpowered trial (n=453) of exercise+knowledge+falls risk assessment compared to control revealed a nonstatistically significant reduction in falls (IRR, 0.75 [95% CI, 0.52 to 1.09]), but no difference was seen in people experiencing a fall. Two trials of exercise+psychological (n=153) and exercise+vitamin D (n=204) showed no effect on falls (IRRs, 0.94 and 0.99); however, the exercise+vitamin D trial showed a large statistically significant reduction in injurious falls (IRR, 0.38 [95% CI, 0.17 to 0.81]). The evidence on QOL, ADL, IADL, or mortality outcome was limited. No trials reported the outcomes of fracture, people experiencing fracture, people hospitalized, or people transitioning to institutional care.

Characteristics of Included Studies

Of the six included multiple intervention studies, two were included in the previous review,[166, 167] and four were newly identified.[108, 115, 117, 168]

Study Characteristics

We identified three fair-quality[117, 166] and three good-quality[108, 115, 167] RCTs (n=1,770) with a primary or secondary aim of examining the effectiveness of multiple interventions on falls, fall-related injuries, or both (**Table 52**). One trial was conducted in the United States,[167] two in

Australia,[117, 166] two in Germany,[115, 168] and one in Finland.[108] Three RCTs had factorial designs[108, 115, 117] and one was a cluster-randomized trial of general practices.[168] Trial sizes ranged from 153[115] to 453[167] participants (randomly allocated to multiple interventions or matched control groups). Followup time ranged from 12 to 24 months. The outcomes reported in the trials that we included for analysis were falls (k=6; n=1,770), people experiencing a fall (k=4; n=1,413), injurious falls (k=5, n=1,460), people experiencing a fall-related injury (k=1, n=378), mortality (k=3; n=1,035), QOL (k=1; n=258), and harms (k=3, n=810). No studies reported on hospitalization, institutionalization, ADL, or IADL.

Population Characteristics

Four of the six studies recruited participants aged 70 years and older;[108, 115, 117, 166] two of these studies had upper age limits (80 years[108] or 90 years[115]) (**Table 53**). Two RCTs recruited participants aged 65 and older.[167, 168] Mean age ranged from 74.0 years[108] to 78.4 years.[166] One study recruited women exclusively,[108] while in the other five studies women comprised nearly half [115] to up to three-fourths of the participants.[166-168] Only the U.S. study reported on race or ethnicity; nearly all were white (95%).[167] Measures of socioeconomic status were reported in only the study by Freiberger et al[115] (35.4 percent with low educational attainment and 25.7 percent with low income). All but one study[168] excluded patients with cognitive impairment.

All six studies recruited community-dwelling adults. Four of the studies recruited a general population of participants from a community[166, 167] or used population-based registries.[108, 117] The remaining studies recruited participants from a health insurance company database[115] or clinic.[168]

Two trials recruited participants at average risk of falling where the only risk factor for falls was the participant's age.[117, 167] Four trials recruited patients at high risk for falls, as defined as either a history of falls (in the previous 6 or 12 months),[108, 115, 166, 168] a fear of falling,[115, 166, 168], low physical function (TUG test or Chair Stand Test >10 seconds) or balance deficits.[168]

The measures of health or functional status at baseline in the studies varied. The measures included a history of falls, comorbid conditions, number of medications, baseline ADL or IADL score, quality of life, living alone, and self-reported health rating.

Intervention Details

The trial by Clemson et al[166] (knowledge+environment assessment) offered educational sessions (2-hour sessions each week for 7 weeks), an educational session reviewing safety hazards in the home, a home visit and 1.5 hour booster session 3 months after the last session (**Table 54**). The trial by Fitzharris et al[117] (exercise+environment+vision intervention) included supervised group exercise classes (1-hour weekly session for 15 weeks), a home visit to modify hazards, and vision screening with appropriate referral. The trial by Freiberger et al[115] (exercise+psychological) included progressive supervised group exercises or a multicomponent cognitive behavioral program that addressed the thoughts and concerns of elderly people about falls and the hazards of falls (1-hour sessions twice per week for 16 weeks). This trial also provided cognitive training by using exercises to improve participants' ability to concentrate, process information faster, and improve short-term memory. The second exercise+psychological

trial was conducted by Siegrist et al[168] and included a progressive supervised group exercise program with strength, power, balance, and gait training, a self-management program with perception and functional training, and a cognitive behavioral program aimed to increase self-efficacy (1-hour weekly sessions for 16 weeks) and a 12-week home exercise program. The trial by Shumway-Cook et al[167] (exercise+knowledge+falls risk assessment) involved a total of 156 progressive group exercise sessions (1-hour sessions 3 times per week), nurse-led educational classes (1-hour monthly classes for 6 months), and an assessment of the participant's risk of falling that was mailed to his or her PCP. The factorial design trial by Uusi-Rasi et al[108] (exercise+vitamin D) offered 800 IU daily of cholecalciferol plus 78 weekly or twice weekly group exercise classes offered over 104 weeks.

For four of the RCTs that used multiple exercise components,[108, 115, 117, 167] group exercise sessions were supervised by exercise instructors, physical therapists, or fall-prevention instructors. The interventions in all five trials lasted between 7 weeks[166] and 104 weeks.[108] All five RCTs included some exercise for gait and balance as well as for strength and resistance. One study specifically mentioned flexibility training[167]; however, stretching was a part of other study protocols as well.[108, 115] The trial by Clemson et al[166] had the least intensive exercise component (educational sessions with brief exercise practice and review).

The intensity and duration of the supervised group exercise classes varied, as detailed above. The total number of exercise sessions offered in the trials ranged from 7[166] to 156[167] sessions over 15[117] to 104 weeks.[108] Four RCTs also also made recommendations for home training programs.[108, 115, 117, 168]

Control groups received usual care.[108, 115, 117, 166-168] One study provided brochures on preventing falls.[167] In another study the control group received two social visits.[166] In the single study with the vitamin D intervention, the control group received placebo in addition to usual care.[108]

Study Quality

In all six RCTs, study participants used diaries to record the outcomes of falls prospectively. Blinding of the assessors for these outcomes was clearly reported in four of the studies.[108, 115, 117, 166] Four of the five RCTs had similar baseline characteristics between the intervention groups.Two of the five RCTs reported statistically significant baseline differences between the intervention and control groups[166, 168] (higher baseline rate hip fracture in the control group in one study[117] and higher TUG, CST, falls efficacy scale scores and higher proportion needing walking aids in control group in another study[168]). Despite being controlled for some of thesedifferences in the analyses, these trials may overestimate any benefit from the intervention. All studies used intention-to-treat analysis. Overall attrition at 12 to 24 months was low for these trials (completion rates >90%,[115, 166, 167] 88%,[117] 72%,[115] or 79%[168]). Participants' attendance at the exercise sessions was reported in different ways but was relatively high in the four studies that reported compliance for the multiple intervention group: 84 percent (at least 75 percent of the 16-week twice-weekly sessions[115]), 82 percent (attended more than 10 out of 16 training sessions[168]), mean of 72 percent (twice per week or weekly 24-month exercise sessions[108]), and median of 58 percent (12-month, thrice-weekly exercise classes[167]). In the study by Clemson et al,[166] 90 percent attended at least five of the seven educational sessions. Three of the studies

adjusted for confounders in the results for fall outcomes.[108, 115, 168] Three studies were designed to have adequate power for a falls outcome.[117, 166, 168] Three studies were underpowered for a falls outcome: one had had a low recruitment rate,[167] one was powered for TUG scores,[115]and the last was a factorial design not powered specifically for a fall outcome in the multiple interventions arm.[108]

Falls

Six multiple intervention trials (n=1,770) reported a falls outcome.[108, 115, 117, 166-168] The rate of falls in the control groups ranged from 0.51 to 2.4 per person-year in the individual studies. The three RCTs designed to have adequate power for falls (exercise+environment+vision,[117] knowledge+environment,[166] and exercise+psychological[168]) showed statistically significant reductions in falls in the multiple intervention group (IRR, 0.80 [95% CI, 0.65 to 0.98][117]; IRR, 0.68 [95% CI, 0.57 to 0.83][166]; IRR, 0.54 [95% CI, 0.35 to 0.84][168]). Unlike the other studies in this group, the trial by Clemson et al[166] did not have a distinct dedicated supervised exercise program; instead, it provided eight weekly 2-hour educational sessions in which some exercise education and practice was a part of three of the sessions. One underpowered exercise+knowledge+falls risk assessment RCT[167] showed a nonstatistically significant trend that favored the intervention group with an IRR in the same range as the studies by Fitzharris et al[117] and Clemson et al,[166] with an IRR of 0.75 (95% CI, 0.52 to 1.09).[167] The one RCT of exercise+vitamin D, which had the most intensive and longest duration of the exercise intervention, showed no difference in falls (IRR, 0.99 [95% CI, 0.72 to 1.39])[108] (**Figure 19; Table 41**).

Injurious Falls

Five studies (n=1,460) reported injurious falls at 12 to 24 months.[108, 115, 117, 167, 168] One study of exercise+vitamin D showed a 62 percent reduction in injurious falls (i.e., falls resulting in medical care) at 24 months (RR, 0.38 [95% CI, 0.17 to 0.81])[108]; interestingly, this exercise+vitamin D trial showed no effect on overall falls (IRR, 0.99 [95% CI, 0.72 to 1.39]). Three studies (exercise+knowledge+falls risk assessment,[157] exercise+environment+vision,[105] and exercise+psychological[168] showed similar nonstatistically significant reductions in injurious falls but with different definitions (i.e., minor or major injuries or those requiring hospitalization,[117] falls resulting in medical care,[167] or not defined[168]) (IRR, 0.72, [147] 0.79,[168] and 0.80[105] respectively). The remaining trial of exercise+psychological intervention showed no effect on injurious falls.[115] (**Figure 3; Table 42**).

Fractures

No trials reported this outcome.

People Experiencing a Fall

Four multiple intervention RCTs (n=1,413) demonstrated mixed results regarding the number of people experiencing a fall.[117, 166-168] The prevalence of people in the control group who fell was similar in the three studies (49.4%,[168]58.2%,[146] 63.5%,[105] 57.3%[147]). The trial by Fitzharris et

al[117] (n=272) (exercise+environment+vision) reported a 33 percent statistically significant reduction in people experiencing a fall at 18 months of followup (RR, 0.67 [95% CI, 0.51 to 0.88]). The other three RCTs showed no difference at 12 to 14 months of followup (n=310; RR, 0.90 [95% CI, 0.73 to 1.10], [146] n=453; adjusted RR, 0.96 [95% CI, 0.82 to 1.13], [147] and n=378; RR 0.85 [95% CI, 0.68, 1.06]). The two studies, which reported the number of people who had had two or more falls, revealed a beneficial trend favoring the multiple intervention group (RR, 0.74[166] and 0.70[117]), but they were not statistically significant (**Figure 20; Table 43**).

People Experiencing an Injurious Fall

One exercise+psychological trial (n=378) reported a reduction of people experiencing an injurious fall in the intervention group compared to the control group (RR, 0.75 [95% CI, 0.56 to 1.00])[168] (**Table 55**).

People Experiencing a Fracture

No trials reporting this outcome.

Mortality

Three studies (n=1,035) reported mortality outcomes at 12 to 24 months (**Figure 21, Table 48**).[108, 167] The individual studies reported RRs of 0.67 (95% CI, 0.11 to 3.97) for the exercise+knowledge+fall-risk assessment trial[147]; 0.25 (95% CI, 0.01 to 5.48) for the exercise+vitamin D trial, [115] and 0.56 (95% CI, 0.23 to 1.39) for the exercise+psychological trial.[168] The wide CIs reflected a relatively uncommon outcome with 10 or fewer events in each group.

People Transitioning to Institutional Care

No trials reported this outcome.

People Hospitalized

No trials reported this outcome.

QOL

Only one study (n=258) reported on SF-36 physical and mental health components.[166] No statistically significant mean differences between the multiple intervention group and the control group were found (SF-36 physical component mean difference, 0.70 [95% CI, -2.94 to 1.88]; SF-36 mental health component mean difference 0.53 [95% CI, -2.95 to 1.88]) (**Table 44**).[166]

ADLs

No trials reported this outcome.

Fall Risk Status

Most of these multiple trials (4 of 6) recruited participants at high risk for falls based on history of prior falls, fear of falling, or functional tests of balance/gait; evidence is too limited to make conclusions about associations between baseline fall risk and treatment effectiveness.

Harms

Three trials (n=810) reported either no adverse events[115, 167] or no severe adverse events[108] associated with the intervention. However, it is unclear how the adverse events were collected or measured.[108, 115, 167]

Critical Appraisal

Due to the various combinations of intervention types, these fair- to good-quality trials of community-dwelling older adults do not provide a coherent body of evidence; thus, pooling the results is inappropriate. Three trials showed statistically significant reductions in the rate of falls (and one of these showed a reduction in people experiencing a fall as well) despite the differences in the intervention combinations (knowledge+environment, exercise+environment+vision, exercise+psychological).[117, 166, 168]

Chapter 4. Discussion

Overall Summary of the Evidence

In this review, we identified 62 trials (n=35,058) examining seven types of multifactorial, single, or multiple interventions designed to reduce falls, people experiencing a fall, and/or fall-related injuries in average and high-risk older adults. We analyzed 11 fall-related outcomes; the most commonly reported outcomes were falls and people experiencing a fall. Thirty-one of the trials were powered to detect clinically meaningful differences in falls or people experiencing a fall. The largest bodies of literature within this review evaluated multifactorial and exercise interventions with 26 and 21 trials, respectively. Our findings suggest that there is a fall-related benefit (i.e., reduction in falls and/or people experiencing a fall) associated with both multifactorial and exercise interventions, but evidence is most consistent across multiple fall-related outcomes for the exercise trials. For all other interventions, we were unable to make firm conclusions about their effects on included outcomes due to insufficient data or mixed results.

A summary of each intervention type appears below and in **Tables 56** and **57**. An evidence map provides a visual synopsis of our main findings (**Figure 22**).

Multifactorial Interventions

Our meta-analyses, which examined 26 multifactorial trials, showed a 21 percent reduction in the incidence rate of falls with substantial heterogeneity (k=17; n=9,737; IRR, 0.79 [95% CI, 0.68 to 0.91]; p=0.001; I^2=87.2%) but showed no effect on people experiencing a fall (k=24; n=12,490; RR, 0.95 [0.89 to 1.01]; p=0.000; I^2=56.4%), people experiencing an injurious fall (k=16; n=9,445; RR, 0.94 [95% CI, 0.85 to 1.03]; I^2=34.3%), or mortality (k=23; n=9,721; RR, 0.96 [95% CI, 0.79 to 1.17]; p=0.659; I^2=0%). In addition to the clinical heterogeneity inherent in the nature of the customized multifactorial interventions, some of the statistical heterogeneity may also be related to differences in recruitment setting (i.e., patients recruited after a fall from emergency settings may realize greater fall reductions from multifactorial interventions than those recruited from other settings). For all other fall-related outcomes, an insufficient number of studies was available for pooling (e.g., the outcome was reported in <50% of the 26 trials). For outcomes including injurious falls, fracture, persons with a fracture, ADL, IADL, QOL, people hospitalized, and people transitioning to institutional care, the existing studies were underpowered and revealed no statistically significant effect of the multifactorial intervention.

Exercise

Our meta-analyses examining 21 exercise trials revealed a nonsignificant 13 percent reduction in falls (k=14; n=4,663; IRR, 0.87 [95% CI, 0.75 to 1.00]; I^2=57.3%), an 11 percent reduction in people experiencing a fall (k=15; n=4,926; RR, 0.89 [95% CI, 0.81 to 0.97]; I^2=43.9%), a 19 percent reduction in injurious falls (k=10, n=4,622; IRR, 0.81 [95% CI, 0.73 to 0.90]; I^2=0.0%), and a reduction in people experiencing an injurious fall, with individual estimates ranging from 0.61 to 0.90 (k=5, n=2,776). We observed no effect on mortality (k=11; n=4,263; RR, 0.93 [95%

CI, 0.71 to 1.22]; I^2=0%). Unlike the multifactorial intervention results, which only showed statistically significant reductions in incidence of falls, the exercise intervention evidence base showed a more consistent pattern of effectiveness across multiple fall-related outcomes (falls, people experiencing a fall, injurious falls, and people experiencing an injurious fall) despite fewer trials and fewer total participants. For the remaining outcomes (e.g., hospitalization, institutionalization, QOL, IADL), there was an insufficient number of exercise trials to pool (1–3 trials for each outcome), and none of the underpowered trials had an effect on these outcomes.

Vitamin D

Seven heterogeneous studies of different vitamin D formulations, dosing schedules, and varying baseline risk in community-dwelling older adults (not selected for vitamin D insufficiency or deficiency) reported mixed results for falls (k=5; n=3,496), people experiencing a fall (k=6; n=6,519), and mortality (k=6; n=7,084). While we presented vitamin D meta-analyses showing no overall effect on these outcomes, we are aware that the number of trials available is at the lower end of what would be considered a sufficient number of trials for pooling, and the wide variation in the formulation and dosages may contribute to the statistical heterogeneity obscuring important differences related to formulation or dosage. A single study showed no difference in QOL at 12 months. No studies reported on hospitalizations, institutionalizations, ADLs, or IADLs. Sensitivity analyses performed removing the high-dose vitamin D trial showed no statistically significant difference in falls or people experiencing a fall. Our main analysis excluded trials solely recruiting populations with low vitamin D levels because our clinical question was whether or not universal supplementation of primary care older populations would influence fall-related outcomes. However, adding trials with participants with insufficient or deficient vitamin D levels in a sensitivity analysis showed a nonstatistically significant reduction in people experiencing a fall with the upper confidence interval including 1 (RR, 0.88 [95% CI, 0.78 to 1.00]).

Environment

Three environment trials (n=540) showed mixed results. One small trial showed a 46 percent reduction in falls; the other two trials showed no difference in falls. Three trials showed no difference in people experiencing a fall. One trial showed no difference in injurious falls,[117] and another showed no difference in QOL or ADL outcomes.[157]

Medication Management

Evidence is limited to two underpowered RCTs (n=266). There was no difference in falls, people experiencing a fall, injuries or mortality seen in high-risk older adults receiving medication management interventions.

Psychological

Two trials (n=2,886) of psychological interventions showed nonstatistically significant

reductions in falls and people experiencing a fall. Trial results on injurious falls were mixed, and there was no difference in mortality.

Multiple Interventions

Six trials that provided more than one intervention component to all participants used a variety of combinations of components. Five trials used exercise plus one or more other interventions. Overall, the studies did not provide sufficient evidence to allow us to conclude whether there was a benefit from combining individual intervention types.

Heterogeneity

For the exercise and multifactorial intervention trials, we explored heterogeneity by the setting of the trial recruitment, study quality, duration, and country; the duration of the intervention, total hours, and time per week; and mean age of participant, participant's risk status, and rate of the control group for falls or people experiencing a fall. For the multifactorial trials, we found no patterns that suggested that any of these variables altered the effectiveness of treatment, with the exception of the recruitment setting. For the recruitment setting, trials that recruited participants after a fall from an emergency setting had a greater reduction in the fall rate (but not the number of people experiencing a fall) and meta-regression showed that both clinic ($p=0.030$) and multiple ($p=0.023$) recruitment settings were statistically different than the emergency setting (**Appendix E**). Notably, while there was no linear correlation seen between control group fall rates and intervention effectiveness, this association between recruitment setting and effect size may reflect the fact that trials recruiting from emergency settings have generally higher-risk populations. For exercise interventions, our initial exploratory analysis, which should be interpreted with caution, suggested that group-based exercise compared to individual-based exercise, multiple exercise components versus single exercise component, and interventions including strength or resistance exercises compared to those without those components were more likely to be associated with a greater reduction in both falls and people experiencing a fall.[170]

Harms

Theoretically, increasing physical activity could lead to more frequent falls and injuries, but the trial literature is too limited to confirm this idea. Some of the exercise intervention trials and multifactorial interventions with exercise components have reported largely minor adverse effects associated with exercise, including muscle soreness; injurious falls occurring during exercise sessions were rare. The vitamin D trial with the highest dosage (500,000 IU annually of cholecalciferol) was associated with a statistically significant increase in falls, people experiencing a fall, and injurious falls as well as a nonstatistically significant increase in fractures, but this trial has not been replicated.[148] Other dosing regimens do not appear to be consistently associated with increased harms.

Comparison With Other Systematic Reviews (Michael 2010 and Gillespie 2012)

Michael 2010 Review (USPSTF)

Our review represents an update to the 2010 systematic review for the USPSTF by Michael et al.[53, 54] Major differences between this review and that one include the use of studies published since the earlier review's end search date of February 2010 and the addition of number of falls and injurious falls as outcomes (we calculated IRRs for trials based on the number of falls and followup time when IRRs were not reported by the study authors). Another major difference was our exclusion of trials that solely recruited populations with specific medical diagnoses (e.g., exclusion of vitamin D trials that recruited participants with vitamin D deficiency or insufficiency). Moreover, we excluded certain types of interventions we considered to be most applicable to the frailest older adults in institutional settings (e.g., hip protectors, nutritional interventions) or interventions that could be implemented for reasons other than preventing falls (e.g., treatment of visual defects).

Despite the differences between our review and the prior review, our conclusions regarding the effect of interventions on preventing falls are similar, with the exception of vitamin D, where excluding populations that had vitamin D deficiency or insufficiency resulted in fewer included trials and the results indicated a more mixed picture with meta-analyses showing no overall effect. On the basis of the results of our findings and in terms of the vitamin D literature, it is unclear if the use of this vitamin by the general population of older adults plays a role in reducing falls. Other researchers have reported conflicting results regarding vitamin D's effect on falls.[171, 172] Some systematic reviews that included trials that recruited institutionalized participants and those with vitamin D deficiency or insufficiency reported a pooled reduction in falls, but the dose and target population remain uncertain.[173-175] Still others have concluded from the broader literature on vitamin D (including vitamin D-deficient or -insufficient populations) that no benefit is achieved with vitamin D, with or without calcium, in reducing falls among older adults[176] and that new studies are unlikely to change this conclusion.[177]

Gillespie 2012 Review (Cochrane)

Our review methods differ in several ways from the oft-cited 2012 Cochrane review by Gillespie et al.[55] Our criteria excluded cataract surgery, comparative effectiveness trials, trials with less than 6 months of followup, and trials that recruited participants who were not representative of general, unselected primary care populations (e.g., participants with osteoporosis, vitamin D deficiency or insufficiency, visual impairment.) In addition, the minimum age we selected was 65 years, while Gillespie selected 60 years for the minimum age; this did not make a substantive difference in our included studies. Finally, we included fall-related injuries as an outcome (Gillespie reported only fall-related fracture). Despite differences in the inclusion criteria, statistical methods, and intervention categorizations for meta-analysis, our conclusions regarding the effectiveness of exercise, multifactorial, and vitamin D interventions on falls and/or people experiencing a fall are similar to those of Gillespie et al[55] and others.[172, 178-180] Subanalyses by Gillespie et al demonstrated that vitamin D was effective in reducing falls or people experiencing

a fall in four trials (n=804) of populations selected for lower vitamin D levels.[55] Gillespie et al demonstrated that tai chi-based exercise interventions were effective in reducing falls (n=1,563, k=5) and the number of people experiencing falls (n=1,625, k=6). We saw no difference in effectiveness for tai chi-based exercise interventions in the current review. Gillespie included five tai chi exercise trials that were not included in our current review; these interventions were excluded because of study aim,[181] follow-up of less than 6 months,[140, 182] quality,[182] or comparative effectiveness.[138, 183] In general, the five tai chi exercise studies included in Gillespie and excluded from our current review had large positive effects, and a couple were statistically significant.

Fall and Injury Outcomes

As mentioned above, most trials provided data on either falls or people experiencing a fall. We calculated fall rates for many of the trials for inclusion in our meta-analyses; the remaining outcomes were less commonly reported in the trials. While it remains uncertain whether falls or people experiencing a fall represent a more clinically meaningful outcome, we present both in this review because the number of trials and participants was similar for these outcomes (falls: k=52, n=26,319; people experiencing a fall: k=54, n=26,560). Since each fall could result in injury, an intervention that reduces the number of falls could provide an important public health benefit by reducing the number of injuries and thus overall morbidity. On the other hand, reducing the number of people experiencing a fall may represent an important outcome to individuals seeking to prevent any fall and subsequent injury, activity limitation, and functional decline. Our qualitative within-trial comparisons between falls and people experiencing a fall showed no apparent association between statistically significant reductions in one of these outcomes (falls) and the other (people experiencing a fall). Nor was there an association between the rate of falls or percentage of people experiencing a fall in the control group and the effect of interventions on falls and people experiencing a fall.

For effective interventions, trials would ideally show that interventions lead to fewer falls and fewer people experiencing a fall as well as fall-induced injuries. We attempted to increase our power to analyze the effect of interventions on injuries by creating a composite category of "injurious falls" (defined as a trial-reported injurious fall, fall-induced injury, or fall with injury resulting in medical attention), although we recognized that the severity of injuries may vary widely even among falls that lead to visits to an emergency department. With the exception of exercise interventions, for which we found a reduction in injurious falls in the pooled analysis and a reduction in people experiencing an injurious fall based on our qualitative analysis and consistent with the findings of another review,[178] the available evidence on injurious falls or persons with injurious falls for the remaining interventions is either too limited to make conclusions or the available evidence suggests no effect. Concluding that interventions other than exercise have no effect on injuries would be premature given that so few of the trials were designed to have adequate power for preventing injury (or fracture).[83, 85, 110, 145, 148] The uncertainty of the effect of all nonexercise interventions on injuries remains.

A fracture may represent a serious injury that can be diagnosed more objectively than a fall or person experiencing a fall can (hence, fracture reporting in other systematic reviews[53-55] instead

of the general category of injury). Preventing mortality associated specifically with hip fractures remains a clinically important goal for interventions in preventing falls. Only one-fourth of the trials included in our review (14 of 58) reported fracture outcomes (9 multifactorial trials,[66, 70, 73, 83-87, 90] 2 vitamin D trials,[145, 148] and 3 exercise trials[109, 112, 120] reported fracture events or people with fracture). Even fewer (4 trials) reported hip fractures (1 exercise,[120] 1 vitamin D,[145] and 2 multifactorial trials)[70, 90] reported hip fracture or persons with hip fracture). Other systematic reviewers who have pooled fractures in exercise trials have shown an approximately 60 percent reduction in fracture with exercise interventions (Gillespie et al[55]: k=6, RR, 0.34 [95% CI, 0.18 to 0.63], el-Khoury et al[178]: k=6, RR, 0.39 [95% CI, 0.22 to 0.66]). We did not pool the trials reporting fractures; the few available trials showed inconsistent and imprecise results (**Figure 4; Figure 7**), so we have low certainty of fall-prevention intervention effects on fractures.

The effect of interventions to prevent falls on functional status or QOL remains uncertain. The few trials reporting QOL, ADL, or IADL showed no benefit, but these studies used different scales, and few trials were powered for these outcomes. Larger trials might be able to explore interventions to prevent falls associated with QOL, but it is unlikely that measures of ADL or IADL would have sufficient specificity in this population for measuring functional status. The issues with ADL and IADL scales include floor and ceiling effects, insensitivity to change, and a lack of evidence that supports a minimal clinically important difference among community-dwelling older adults.[184, 185] The most severe outcome of mortality would not be expected to be affected by these interventions to reduce falls in older adults because competing causes of mortality are more common than falls. In addition, these relatively short-term studies (most trials lasted 12 months) of older adults had relatively few mortality events, so null findings on mortality were expected.

Implementation Issues

Selection of High-Risk Patients for Interventions to Prevent Falls

While a number of primary care tools are available for use in assessing the risk of falls among older adults, the efficacy of these tools is uncertain. The literature on fall-risk assessment tools is both complex and limited: few prospective or retrospective studies use different cut points for any given tool, LRs are inconsistent for a given tool across the available studies, and rarely is there a consistent LR high enough to move the post-test probability to a clinically important threshold. Systematic reviews of the TUG test and other clinical screening tests for the risk of falls suggest that evidence of the adequacy of these screening instruments for predicting falls is insufficient.[33, 186] A 2016 systematic review of fall-risk assessment tools concluded that no single test or measure included in the review (56 measures including history questions, self-report measures, and performance-based measures) was an accurate diagnostic tool.[187] Given the multifactorial etiology of falls, there may be value in combining measures to accurately predict future falls; however, such combinations have not been validated in large studies. In addition, the interventions included in this review rarely used these tools to assess participants' eligibility or inclusion into a study. We did not find any evidence that interventions targeted to populations at high risk of falls (other than recruitment from emergency settings in the multifactorial studies) were more successful than interventions targeted at populations at average risk of falls. Thus,

within our included literature, we were not able to evaluate evidence addressing feasible approaches for clinicians to identify older adults who would most benefit from exercise or multifactorial interventions.

The CDC STEADI toolkit includes an algorithm for annual fall-risk assessment beginning with three questions (history of falls, unsteadiness, and worries about falling); in those with a positive response to any of these questions, the algorithm suggests a TUG test (with an optional 30-Second Chair Stand[188] and Four-Stage Balance Test).[29] However, systematic reviews of the TUG test and other clinical screening tests for the risk of falls suggest that evidence of the adequacy of these screening instruments for predicting falls is insufficient.[33, 186]

In the included studies, 65 percent of the RCTs were conducted in populations at high risk of falls (40 of 62 RCTs). Medication management and psychological interventions selected only high-risk populations. More than half of the multifactorial (73%, 19 of 26), multiple (67%, 4 of 6), and exercise (57%, 12 of 21) trials selected high-risk populations. Vitamin D and environment interventions were more likely to include populations at average risk of falls. Only one of the included studies adopted the CDC recommendations for risk assessment to identify a population at high risk for falling.[168] The most common approach taken in the included studies to identify a person at high risk of falls was to collect the patient's history of falls (k=16).[67, 70-72, 75, 76, 78, 79, 85-87, 90, 108, 115, 157, 159, 166] The remaining RCTs conducted with high-risk populations evaluated two or more risk factors (e.g., history of a fall, difficulty with mobility, use of health care) and included participants with any of these risk factors.

Implementation of Effective Interventions

There are some important considerations in applying our findings to the U.S. health care system for the multifactorial and exercise interventions. The interventions offered in the included exercise trials are different from typical physical therapy referrals available in the U.S. clinical setting in their design (the majority were not customized based on individual risk assessment and diagnoses) and delivery (exercises delivered by exercise instructor or other health professional and group based) but similar in their focus on common components (balance, gait, strength). Most of these exercise programs are similar to what may be available in the community, rather than clinical, setting. In the multifactorial trials, the individual treatment interventions including physician specialty referrals, physical therapy/exercise, and environment interventions are largely reflective of what patients could receive piecemeal, although rarely in such a comprehensive fashion in the current U.S. health care delivery system. The exercise/PT interventions included in the multifactorial trials are similar to what patients receive in the U.S. clinical setting in their design (physical therapist designed and individually developed program based on functional assessment and diagnoses), delivery (physical therapist delivered most of the interventions—some individually and some group), and components (balance, gait, strength).

Limitations of the Literature

Although we used the ProFaNE taxonomy to systematically categorize intervention types, components, personnel, participants, settings, and outcomes, the heterogeneity in the designs and

implementation strategies within even a single intervention type was marked. Meta-analysis reporting a single point estimate may present false precision in a field where the complexity of the causes of falls, patient functional status and comorbidities, and environmental influences would be expected to lead to subgroup differences. Exercise showed the most consistent benefits across multiple fall-related outcomes (i.e., falls, people experiencing a fall, injurious falls, people experiencing an injurious fall), even though the exercise trials varied widely by the type and number of exercise components, the setting, and the intensity and duration. Among multifactorial interventions, which were designed to customize interventions to patients dealing with the complexity of falls, the protocols were rarely described in enough detail for replication. Nonetheless, clinicians and guideline developers need a best-evidence approach to preventing falls on the basis of available trial data. Aside from an annual dose of 500,000 IU of vitamin D, which may be associated with harms related to falls, uncertainty remains about the role of vitamin D in preventing falls. Different target populations, formulations, and dosages may have different effects on falls.[189] One ongoing trial, the Study To Understand Fall Reduction and Vitamin D in You (STURDY), will randomly allocate 1,200 patients to one of four doses of vitamin D (200, 1,000, 2,000, or 4,000 IU per day) as a means to prevent falls among adults aged 70 and older who are at high risk of falls.[190] The literature examining multiple interventions included only one or two trials of any given combination of interventions. The literature of other single interventions (i.e., environment, psychology, medication management) was similarly limited.

Limitations of Our Approach

We excluded trials that specifically recruited participants with neurologic diagnoses (e.g., dementia, Parkinson's disease, stroke) because those populations may require specialized approaches to preventing falls. We also excluded other specific diagnoses, such as vitamin D insufficiency and osteoporosis, so our conclusions may not be applicable to those populations. Our inclusion criteria more generally represented unselected community-dwelling older adults seen in primary care. We included trials only when the primary or secondary aim was to prevent falls among older adults, both to select interventions with biologic plausibility of reducing falls and for pragmatic purposes. We limited our search to English-language literature following USPSTF methodology.[58] We excluded comparative effectiveness trials and as such, for the exercise trials, we excluded those with active exercise controls (e.g., stretching, walking). We conservatively pooled trials that represented at least 50 percent of the studies for a given intervention so did not perform meta-analysis for many outcomes. Our protocol prioritized hard health outcomes consistent with the USPSTF methodology and therefore did not include functional outcomes, such as changes in balance, endurance, or walking speed. While we recognize that falls efficacy scales and fear of falling are commonly reported in trials, we excluded these outcomes in favor of those focused on falls, people experiencing a fall, and injuries due to a fall. We also did not examine other non-fall-related outcomes that may be associated with these interventions (e.g., the effect of exercise on cardiovascular outcomes or vitamin D on other health outcomes). For vitamin D, this review captures a small fraction of the large body of evidence of vitamin D's effect on numerous outcomes including cardiovascular and cancer outcomes in populations with and without vitamin D deficiency.[191-193]

Future Research

Large-scale RCTs are needed that replicate the multifactorial and exercise trials with detailed published protocols. Ideally, these trials would use recommended clinical risk-assessment tools (e.g., STEADI screening protocol) to target interventions to high-risk patients. One such trial, the Strategies to Reduce Injuries and Develop Confidence in Elders (STRIDE) study (jointly funded by the Patient-Centered Outcome Research Institute and the National Institute on Aging of the National Institutes of Health) is a large-scale (n=6,000), pragmatic cluster-randomized trial of a multifactorial intervention in community-dwelling older adults at risk of falls who are being recruited from 86 U.S. primary care practices. This trial will report falls, fall-related injuries, and physical function. The scheduled completion date is July 2019.[194] Other ongoing research trials are listed in **Appendix F**.

Only fifty percent of community-dwelling older adults adhere to fall-prevention interventions at 1 year.[195] Thus, exploring barriers to the implementation of effective exercise interventions would be critical to increasing exercise among elderly adults.[196, 197] Likewise, in considering how to implement effective exercise interventions, it remains uncertain whether altering personnel, components, and/or intensity of exercise may influence outcomes. Additionally, while our review did not address comparative effectiveness, it would be helpful to focus future research on whether the addition of another intervention to an effective intervention (e.g., exercise) is more beneficial. Finally, to provide adequate evidence on potential harms, all research needs to more consistently monitor adverse effects in both the control and intervention groups.

Conclusion

The largest bodies of literature evaluated multifactorial and exercise interventions, with 26 and 21 trials, respectively. Our findings suggest that there is a fall-related benefit associated with both multifactorial and exercise interventions, but evidence is most consistent across multiple fall-related outcomes for the exercise trials. The current fall-prevention evidence base demonstrates that exercise is associated with fewer falls, people experiencing a fall, injurious falls, and people experiencing an injurious fall in average and high-risk community-dwelling older adults. Multifactorial interventions, which include risk-based, customized referrals and treatments, appear to reduce falls but not people experiencing a fall or injuries, and while there are numerous multifactorial trials designed with somewhat similar strategies, the studies are clinically and statistically heterogeneous. No specific effective exercise or multifactorial protocol has been replicated in larger population trials. Vitamin D, environment, and medication management interventions have either single trials showing no statistically significant effect or a few trials reporting mixed results. Single trials of cognitive behavioral, knowledge+environment, and exercise+environment+vision interventions showed moderate effectiveness in reducing falls, people experiencing a fall, or both.

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Figure 1. Analytic Framework

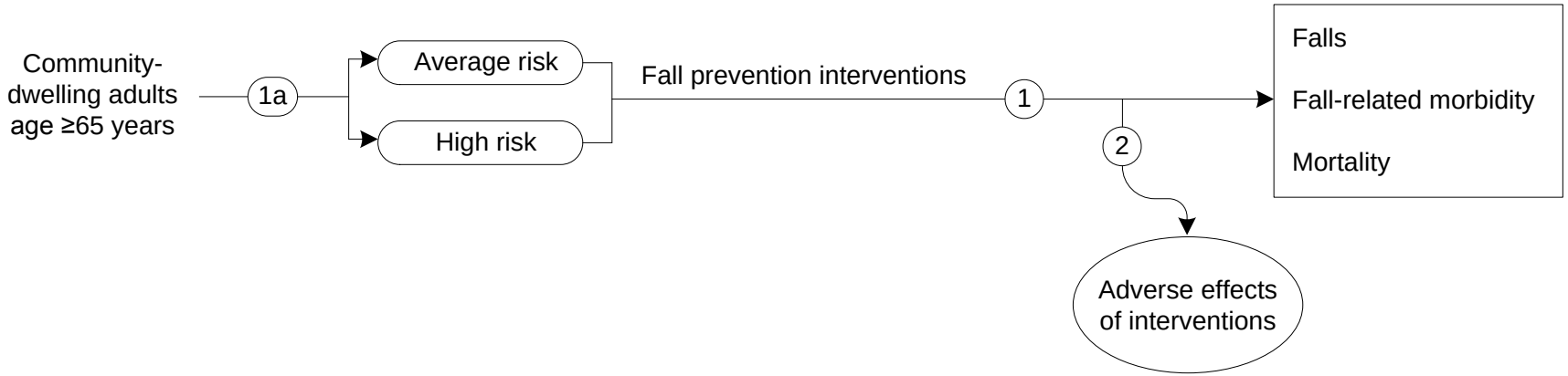
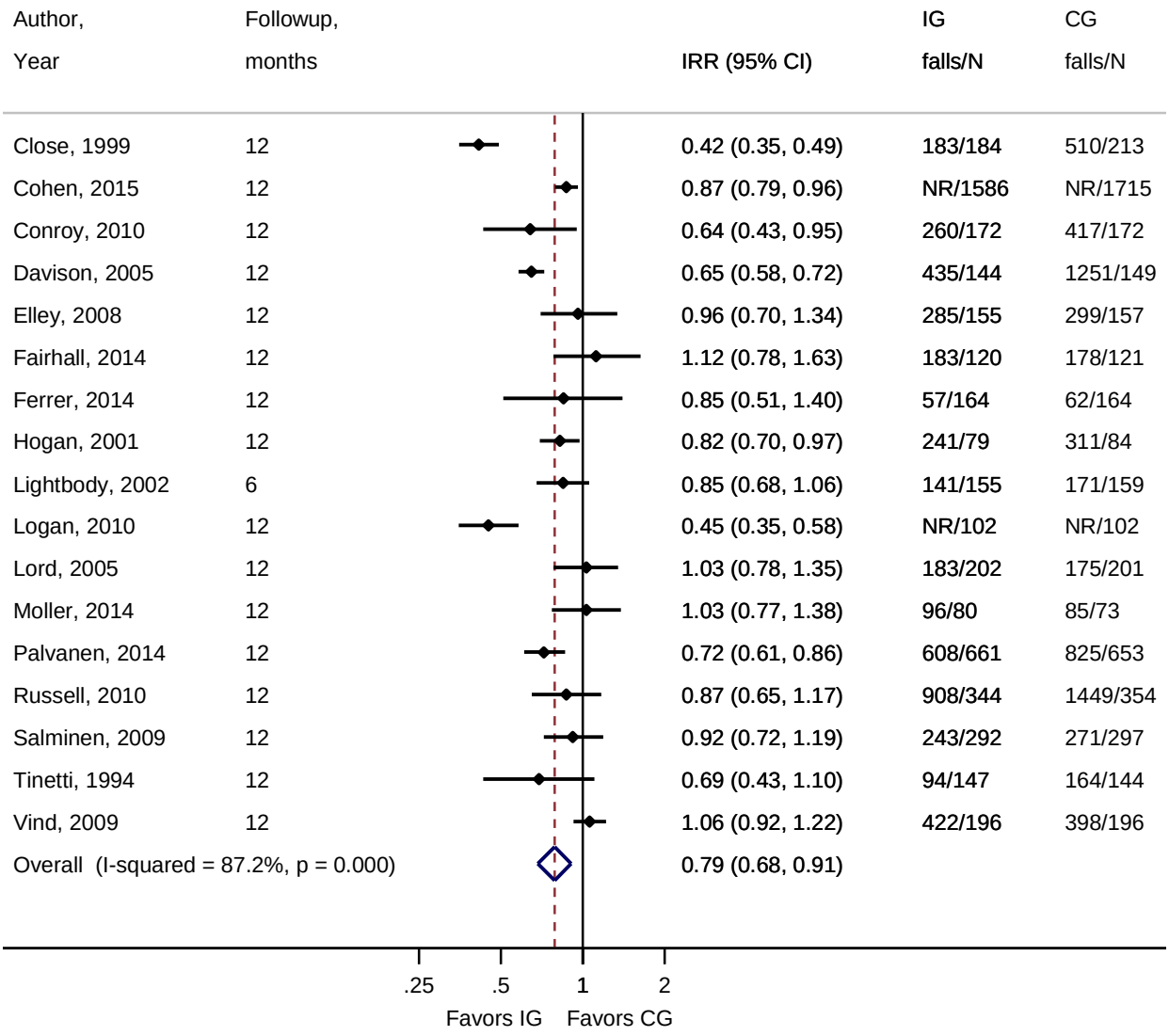
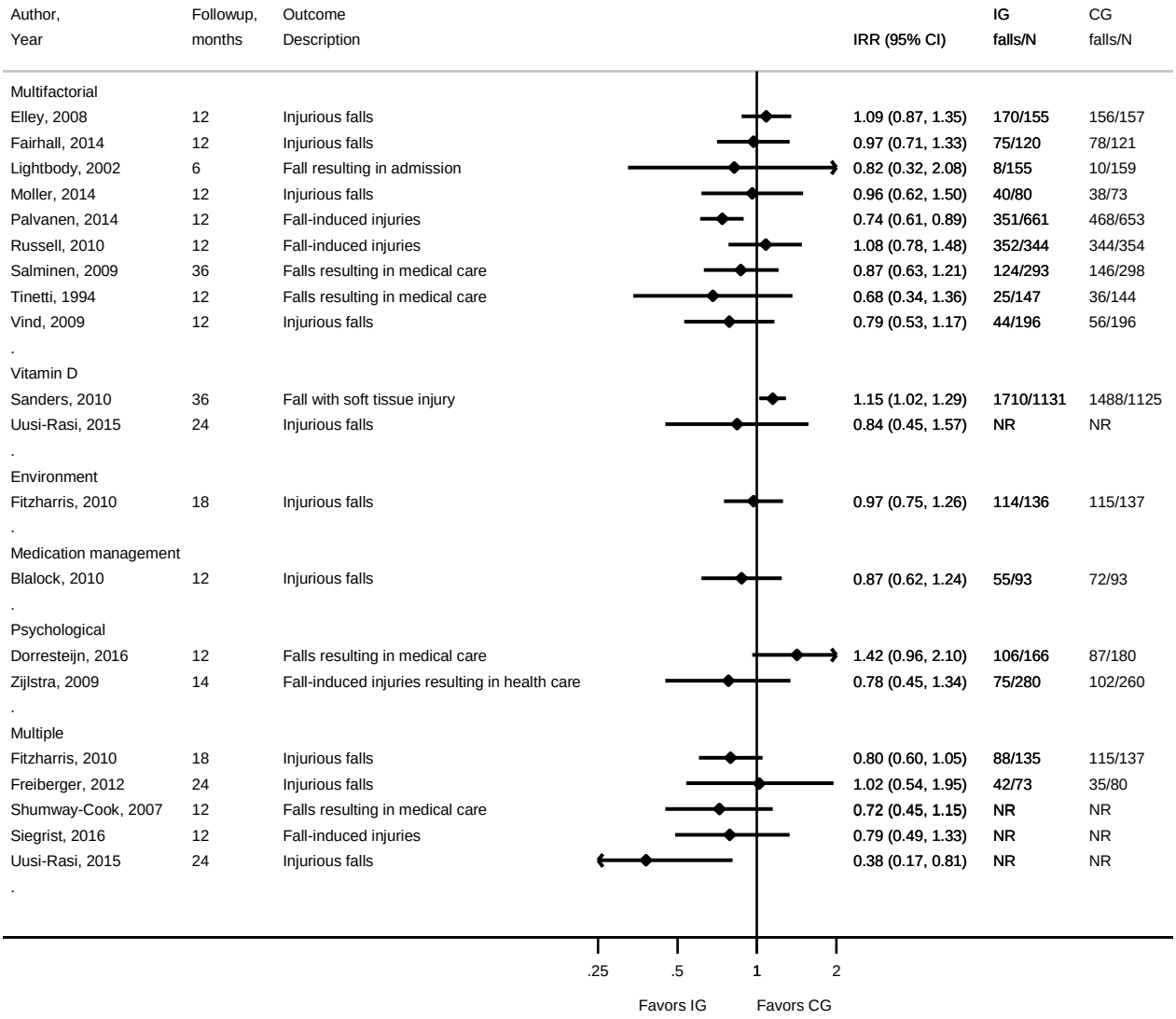


Figure 2. Pooled analysis of multifactorial intervention randomized controlled trials for falls at longest followup (6–12 months)



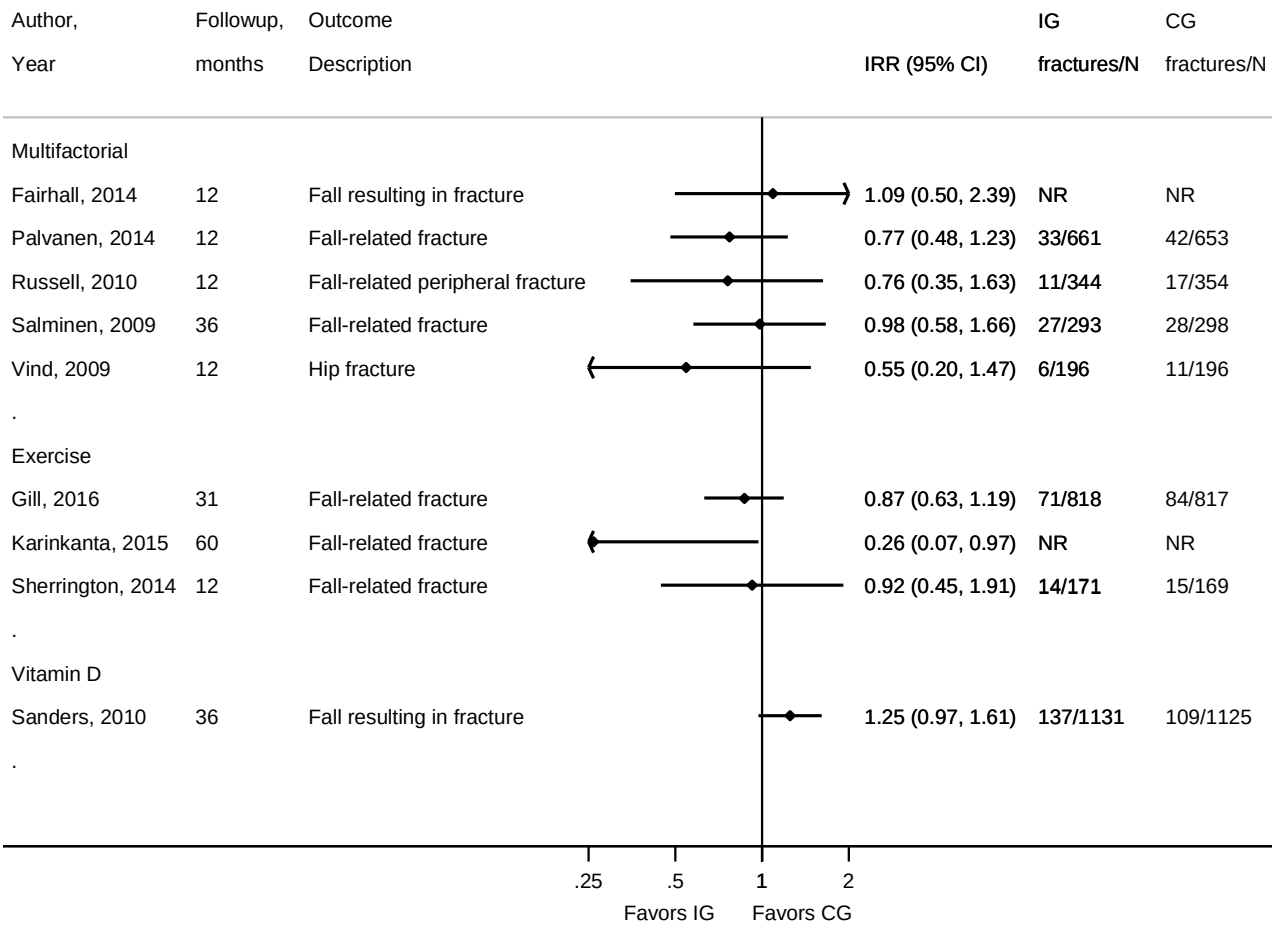
Abbreviations: CG = control group; CI = confidence interval; IG = intervention group; IRR = incidence rate ratio

Figure 3. Forest plot of randomized controlled trials for injurious falls at longest followup (6–36 months)



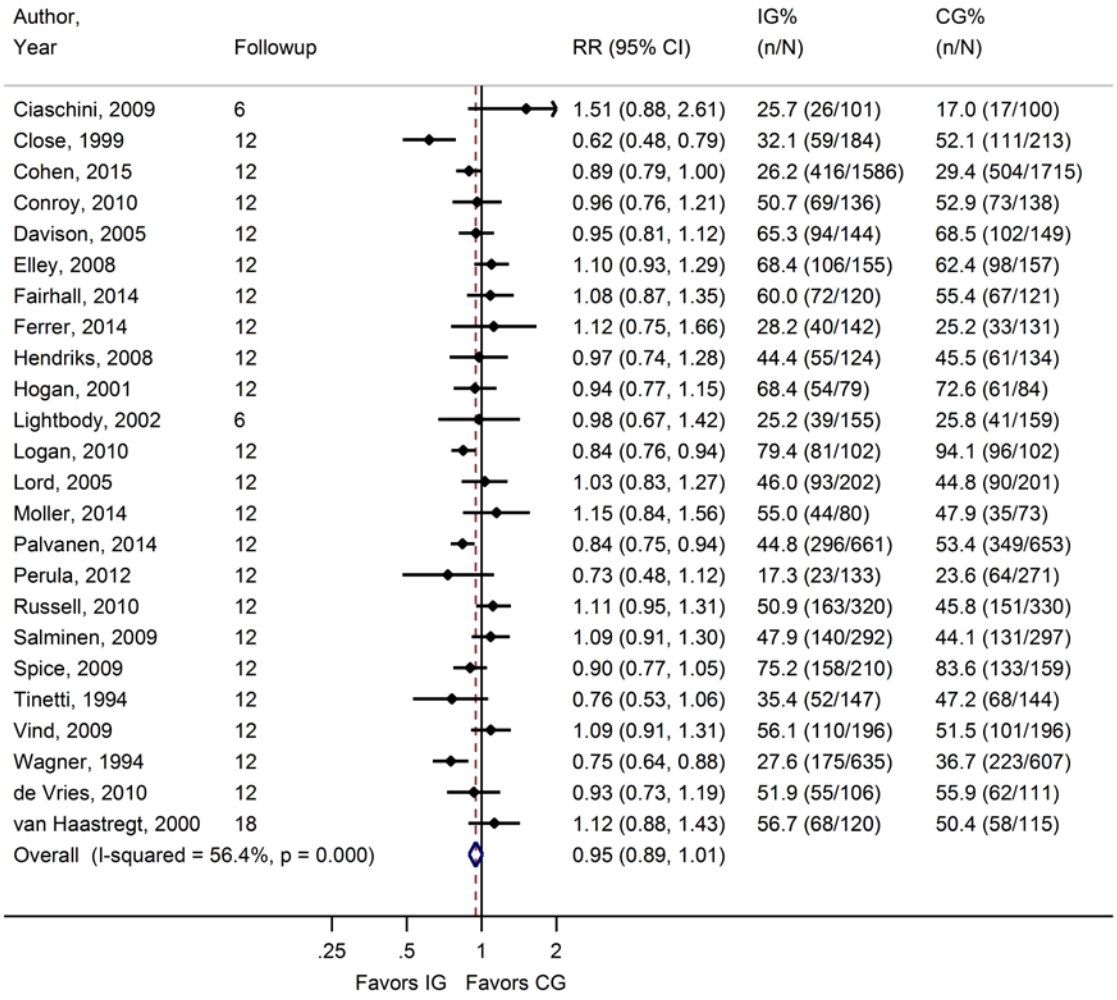
Abbreviations: CG = control group; CI = confidence interval; IG = intervention group; IRR = incidence rate ratio

Figure 4. Forest plot of randomized controlled trials for fractures at longest followup (12–60 months)



Abbreviations: CG = control group; CI = confidence interval; IG = intervention group; IRR = incidence rate ratio

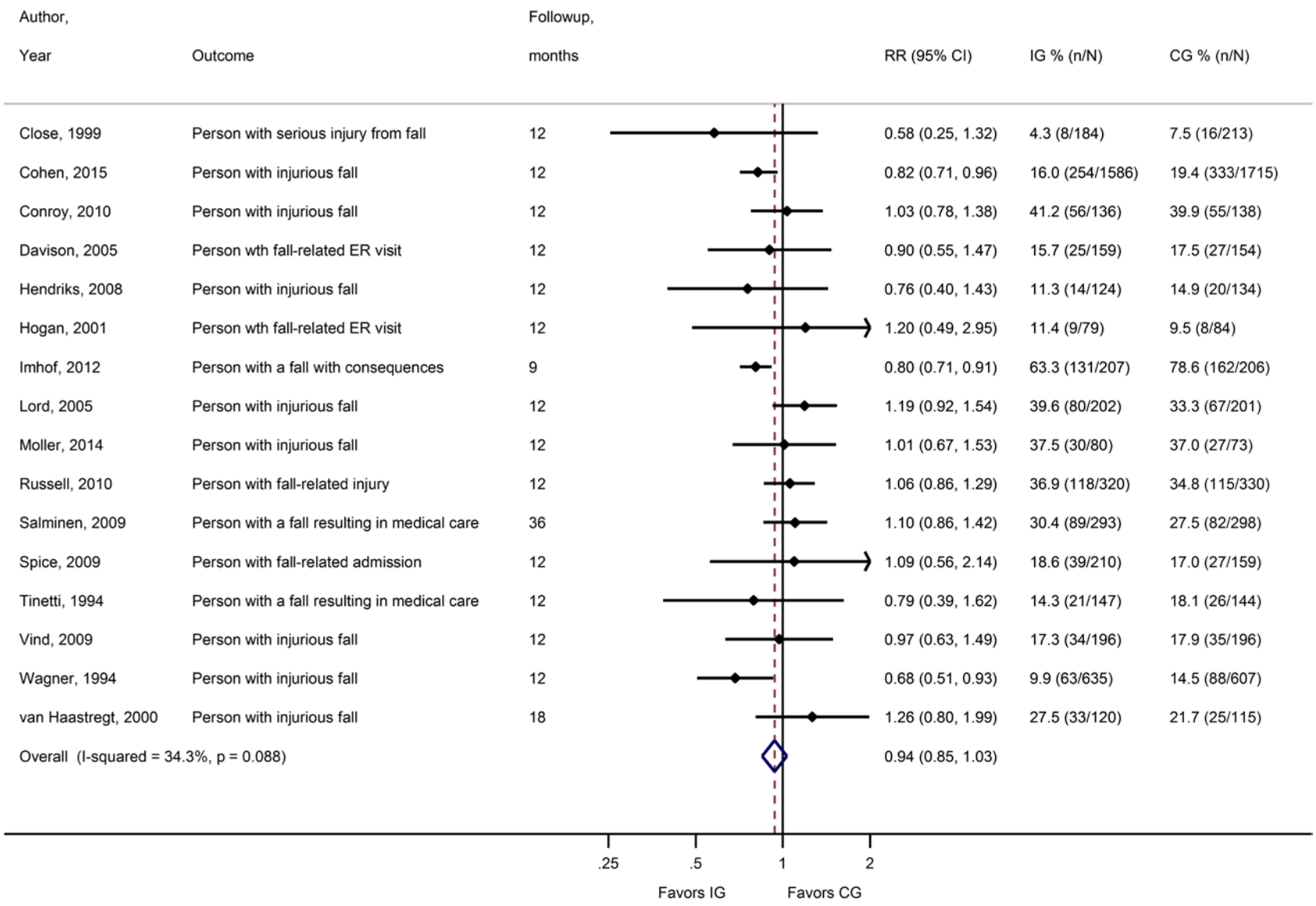
Figure 5. Pooled analysis of multifactorial intervention randomized controlled trials for people experiencing a fall at longest followup (6–12 months)



Abbreviations: CG = control group; CI = confidence interval; IG = intervention group; RR = relative risk

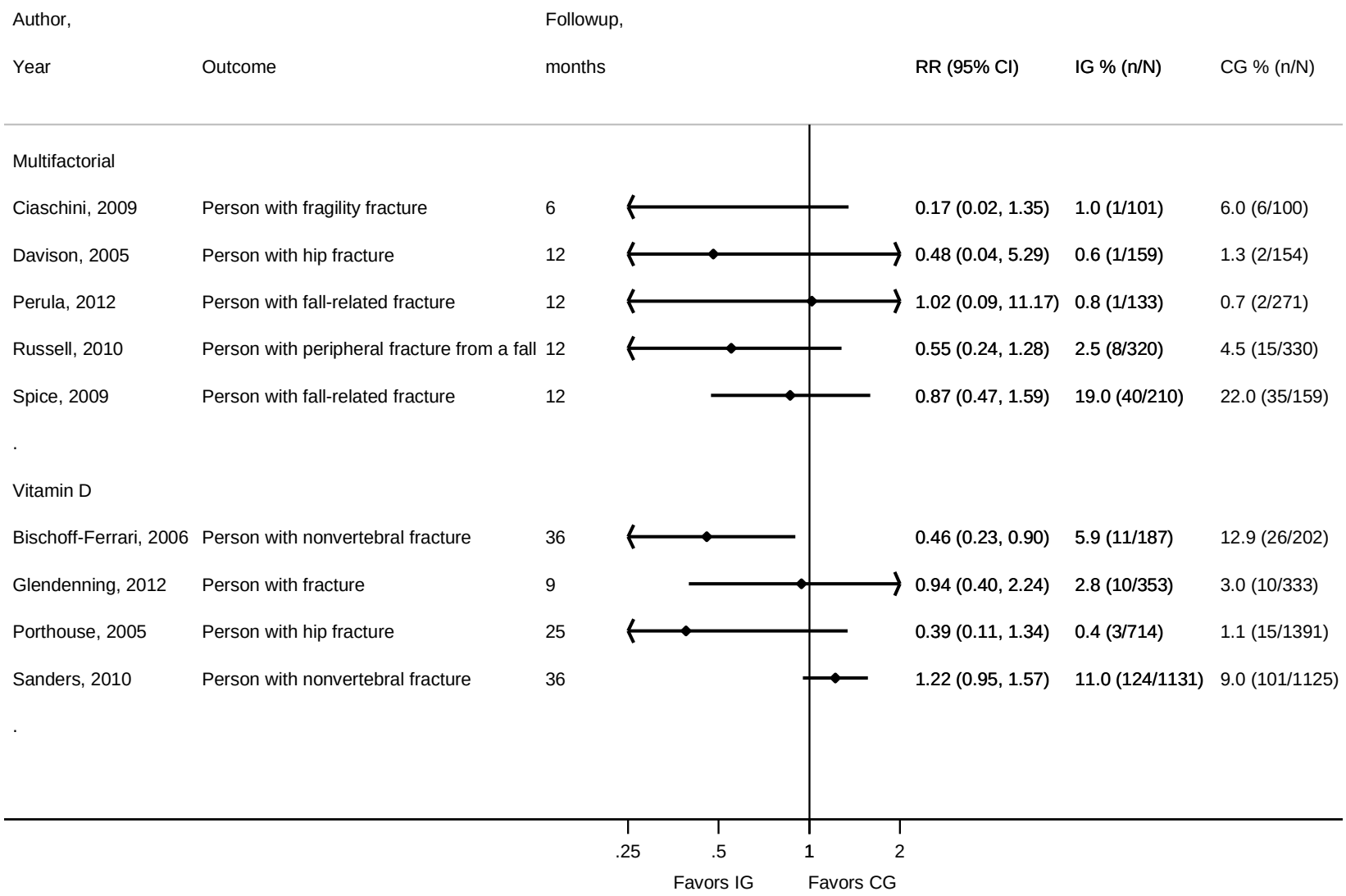
NOTE: Tinetti, 1994: Author reported RR adjusted for clustering in the current analysis.

Figure 6. Pooled analysis of multifactorial intervention randomized controlled trials for people experiencing an injurious fall at longest followup (12-36 months)



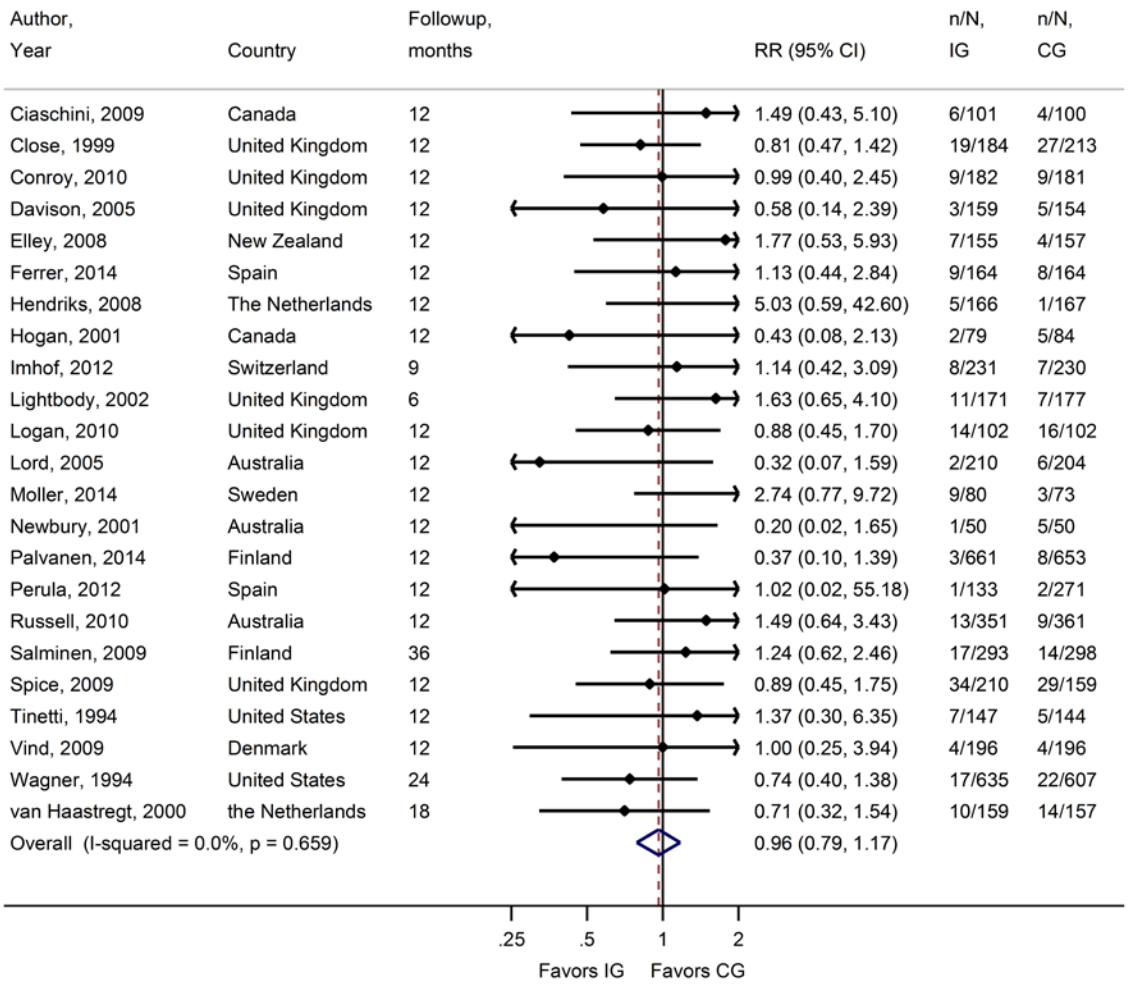
Abbreviations: CG = control group; CI = confidence interval; IG = intervention group; RR = relative risk

Figure 7. Forest plot of randomized controlled trials for people experiencing a fracture at longest followup (6–36 months)



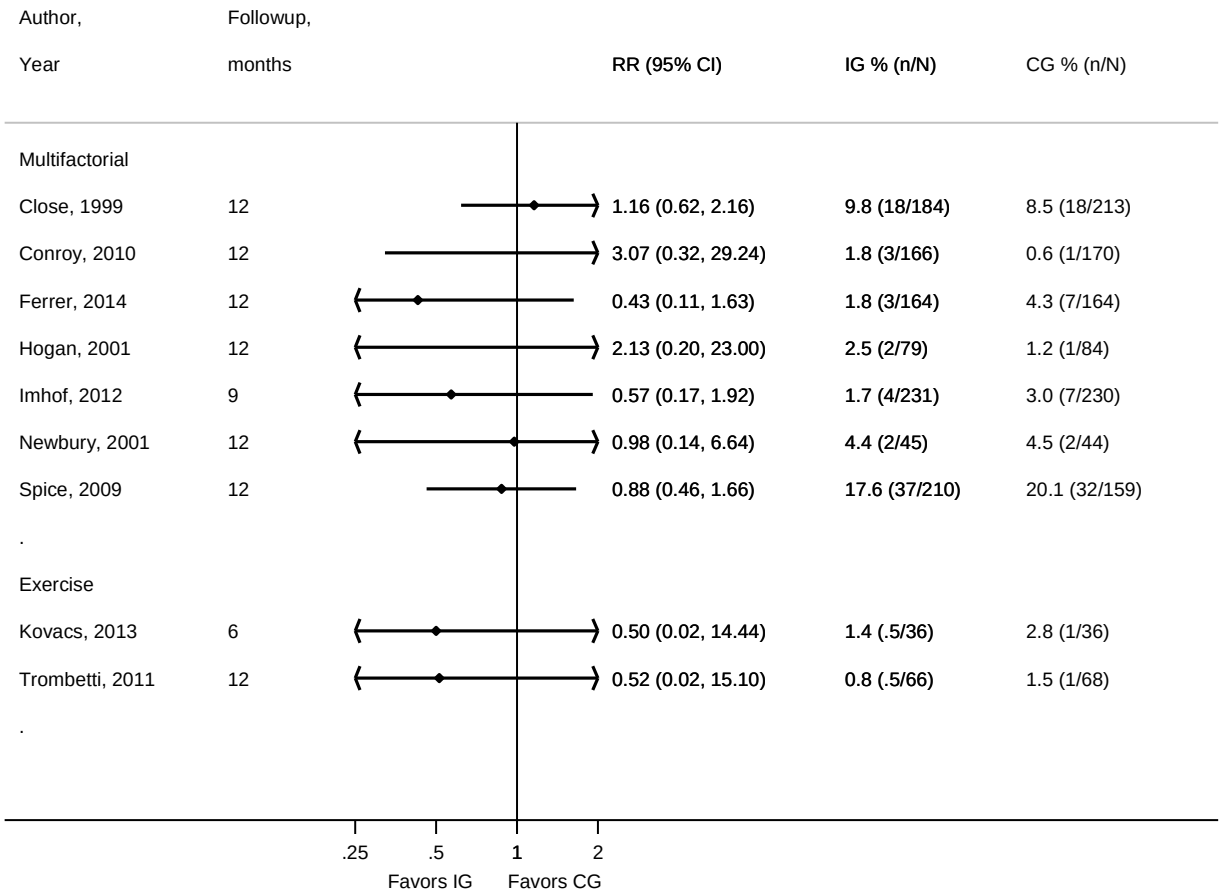
Abbreviations: CG = control group; CI = confidence interval; IG = intervention group; RR = relative risk

Figure 8. Pooled analysis of multifactorial intervention randomized controlled trials for mortality at longest followup (6–36 months)



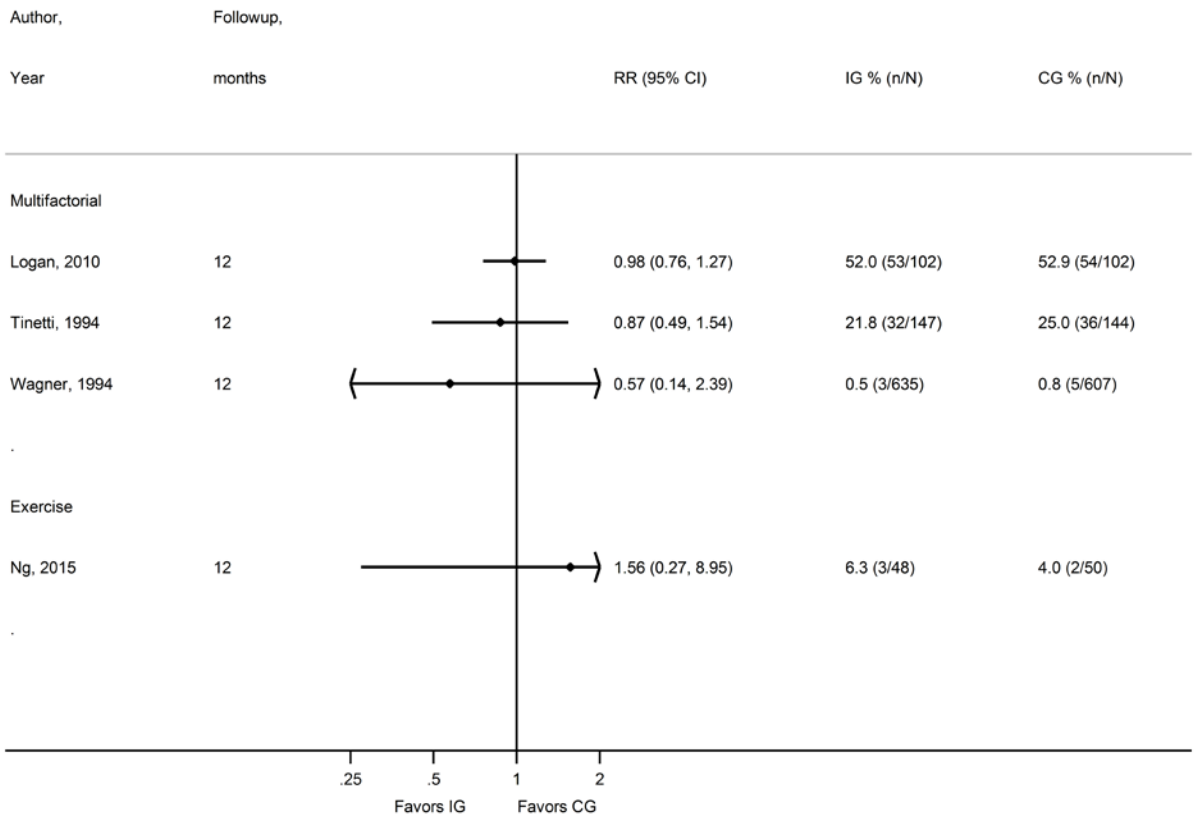
Abbreviations: CG = control group; CI = confidence interval; IG = intervention group; RR = relative risk

Figure 9. Forest plot of randomized controlled trials for people transitioning to institutional care at longest followup (6–12 months)



Abbreviations: CG = control group; CI = confidence interval; IG = intervention group; RR = relative risk

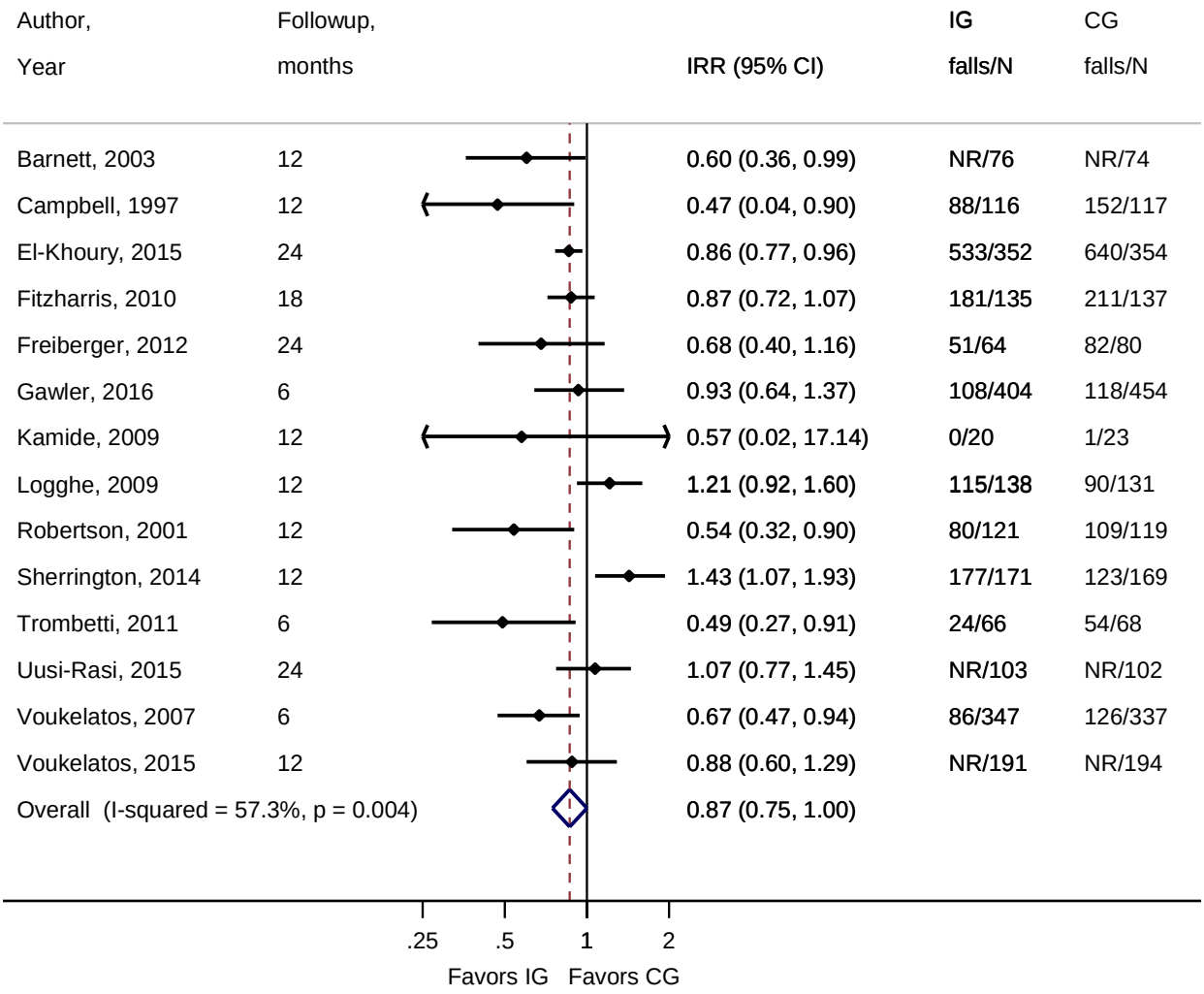
Figure 10. Forest plot of randomized controlled trials for people hospitalized at longest followup (12 months)



Abbreviations: CG = control group; CI = confidence interval; IG = intervention group; RR = relative risk

Note: One multifactorial intervention study reported an odds ratio only: 0.61 (95% CI, 0.35 to 1.05)[67]

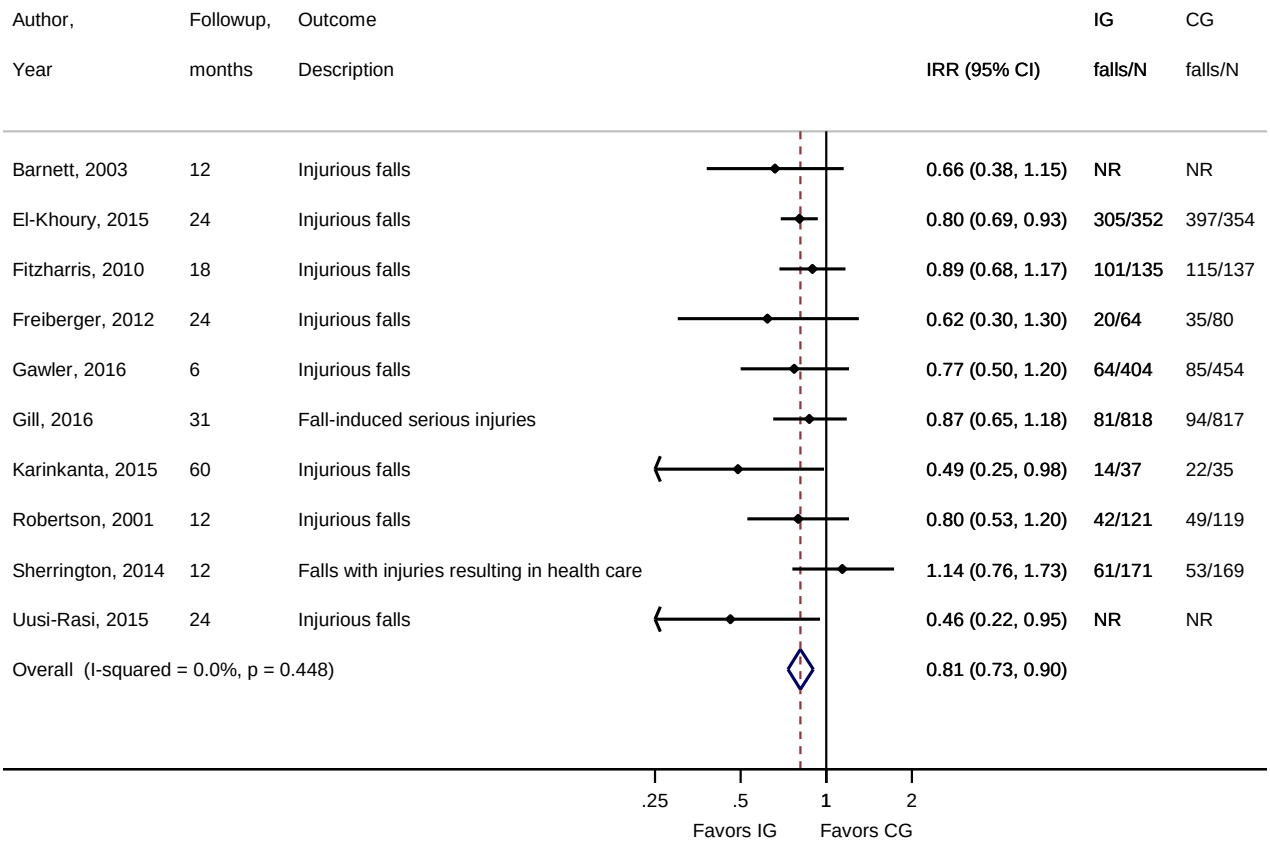
Figure 11. Pooled analysis of exercise intervention randomized controlled trials for falls at longest followup (6–24 months)



Abbreviations: CG = control group; CI = confidence interval; IG = intervention group; IRR = incidence rate ratio

NOTES: For studies with no events, we applied a continuity correction of 0.5 to allow for statistical calculations. Luukinen, 2007 not is included in meta-analysis; original research report provided a relative risk but did not report events or confidence intervals.

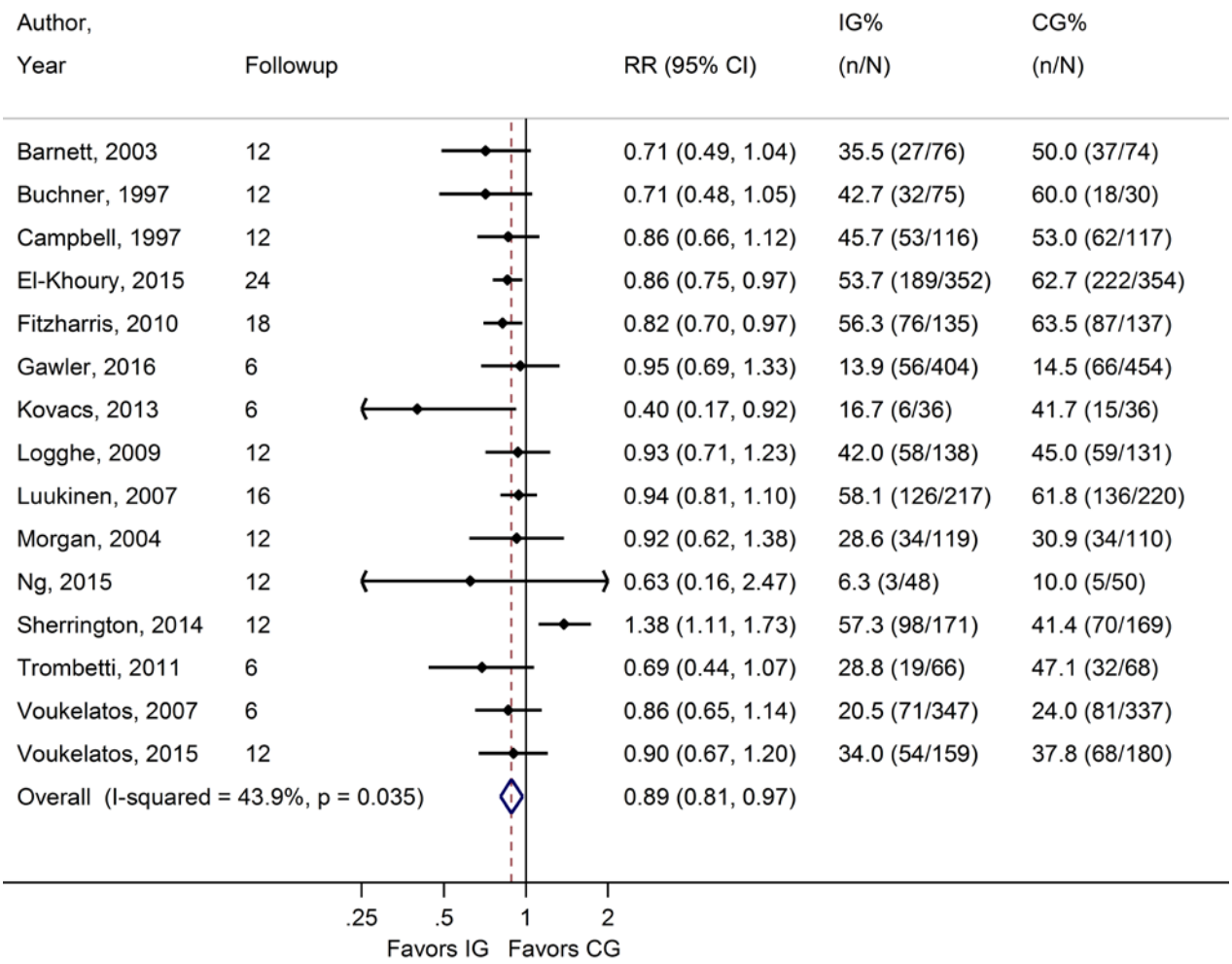
Figure 12. Pooled analysis of exercise intervention randomized controlled trials for injurious falls at longest followup (6–60 months)



Abbreviations: CG = control group; CI = confidence interval; IG = intervention group; IRR = incidence rate ratio

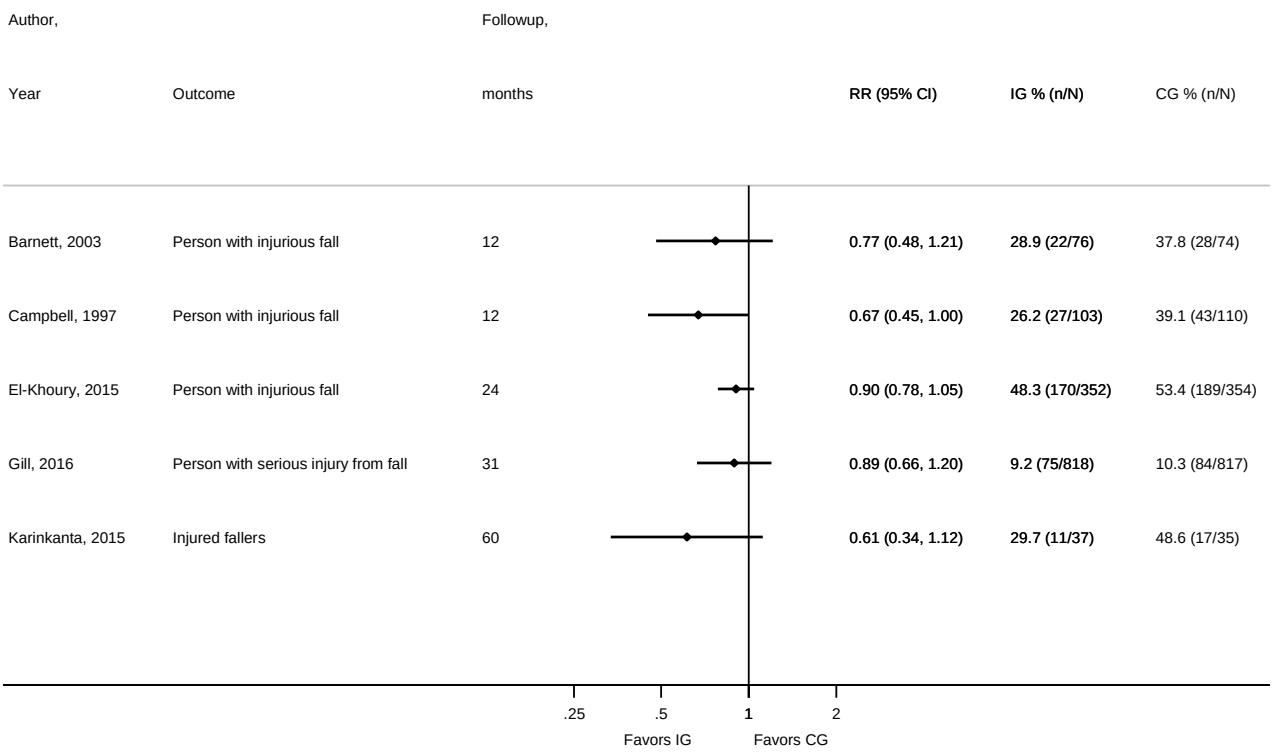
NOTE: Luukinen, 2007 is not included in meta-analysis; original research report provided a relative risk but did not report events or confidence intervals.

Figure 13. Pooled analysis of exercise intervention randomized controlled trials for people experiencing a fall at longest followup (6–24 months)



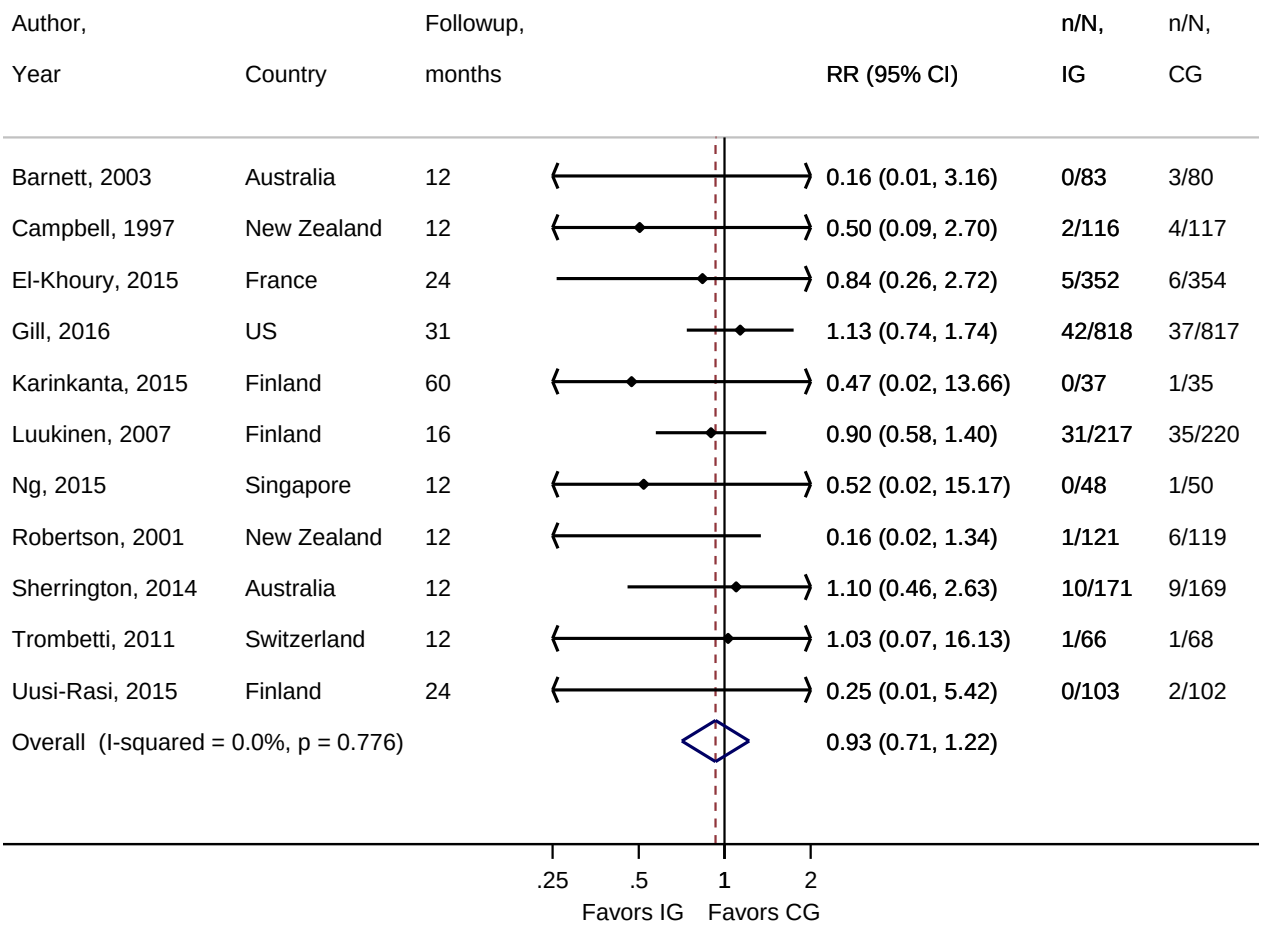
Abbreviations: CG = control group; CI = confidence interval; IG = intervention group; RR = relative risk

Figure 14. Forest plot of exercise intervention randomized controlled trials for people experiencing an injurious fall at longest followup (12–60 months)



Abbreviations: CG = control group; CI = confidence interval; IG = intervention group; RR = relative risk

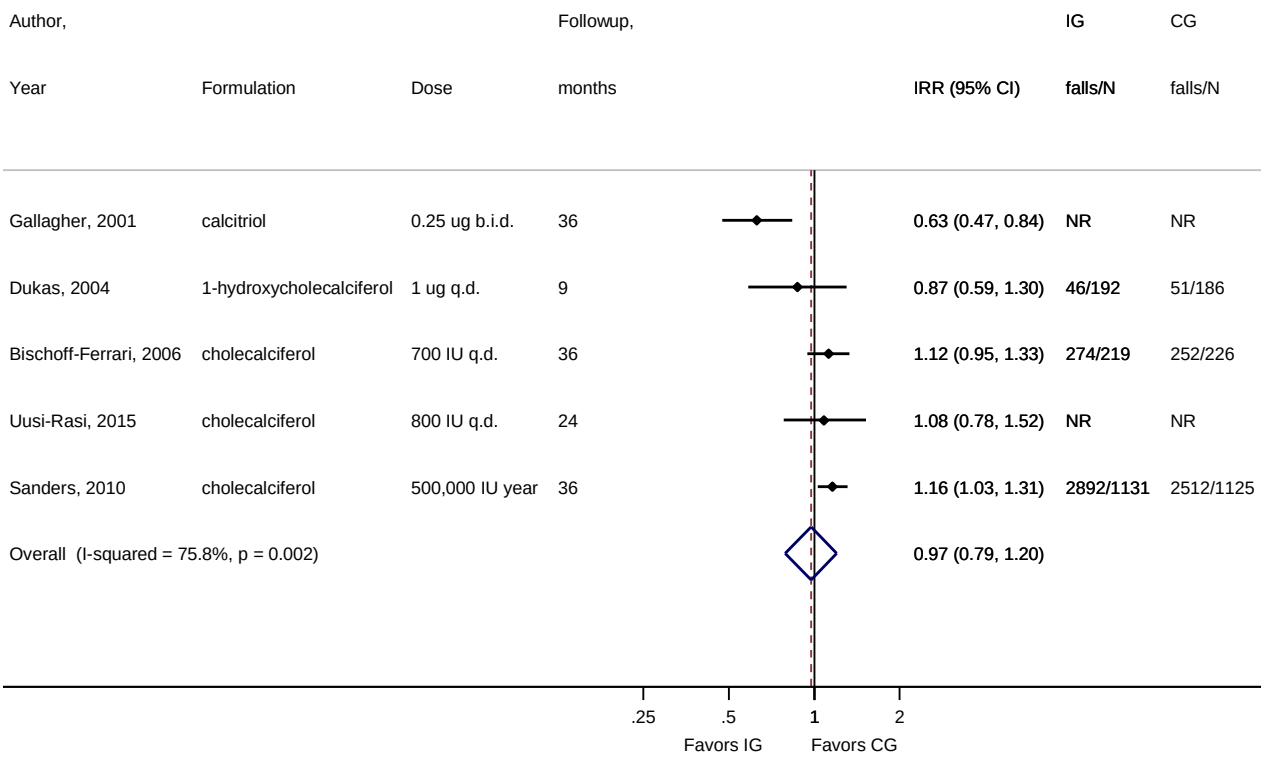
Figure 15. Pooled analysis of exercise intervention randomized controlled trials for mortality at longest followup (12–60 months)



Abbreviations: CG = control group; CI = confidence interval; IG = intervention group; RR = relative risk

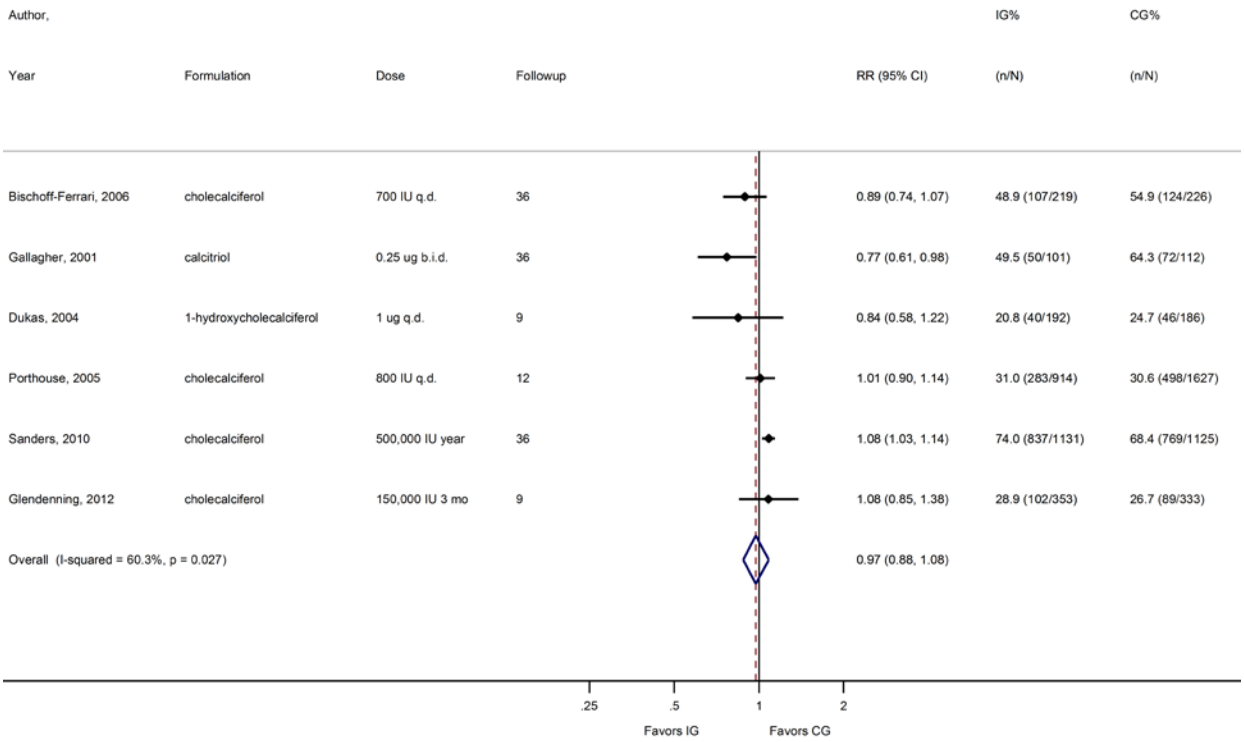
NOTE: For studies with no events, we applied a continuity correction of 0.5 to allow for statistical calculations.

Figure 16. Pooled analysis of vitamin D intervention randomized controlled trials for falls at longest followup (9–36 months)



Abbreviations: b.i.d. = twice a day; CG = control group; CI = confidence interval; IG = intervention group; IU = international unit; IRR = incidence rate ratio; q.d. = once a day; ug = micrograms

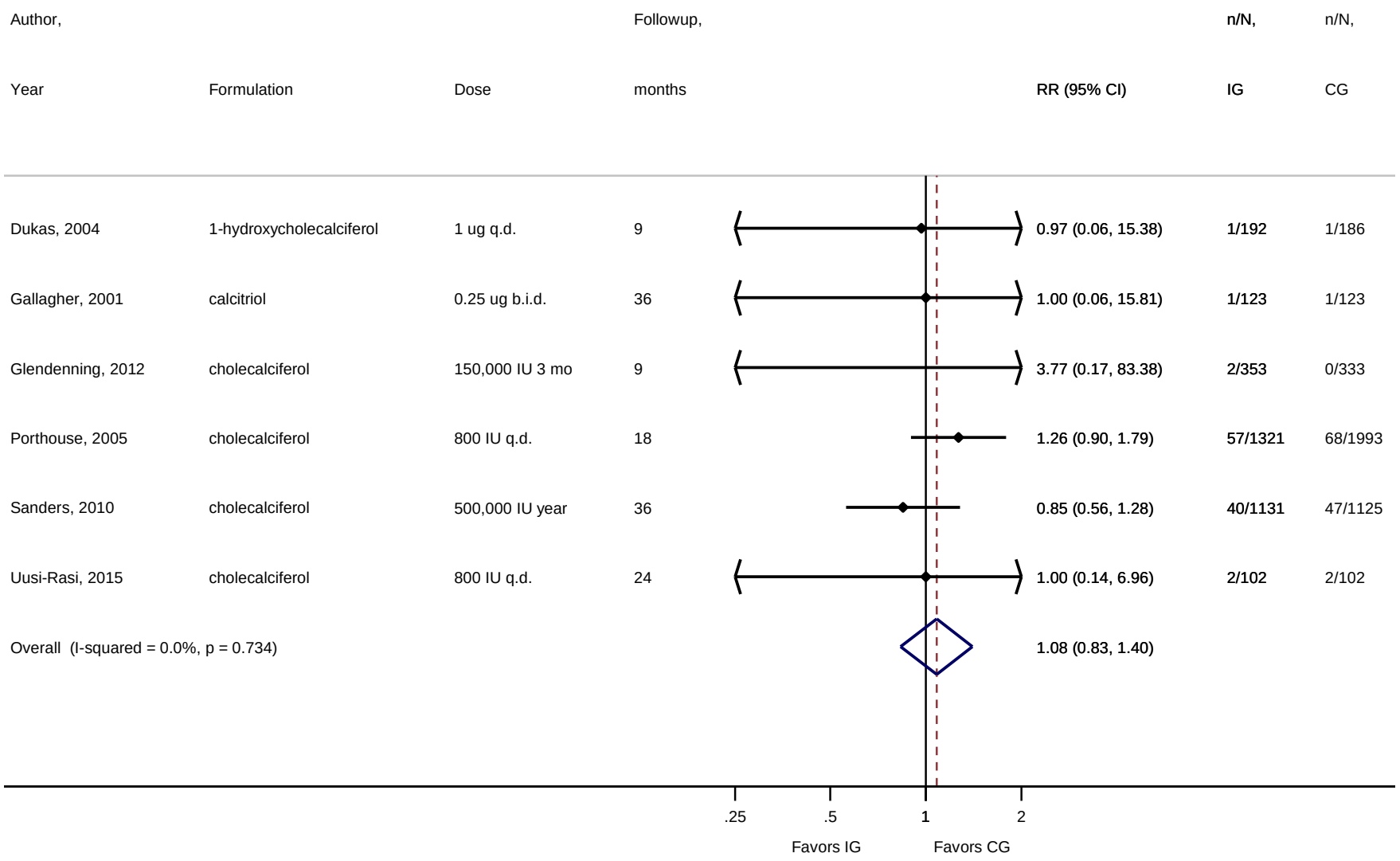
Figure 17. Pooled analysis of vitamin D intervention randomized controlled trials for people experiencing a fall at longest followup (9–36 months)



Abbreviations: b.i.d. = twice a day; CG = control group; CI = confidence interval; IG = intervention group; IU = international unit; q.d. = once a day; RR = relative risk; ug = micrograms

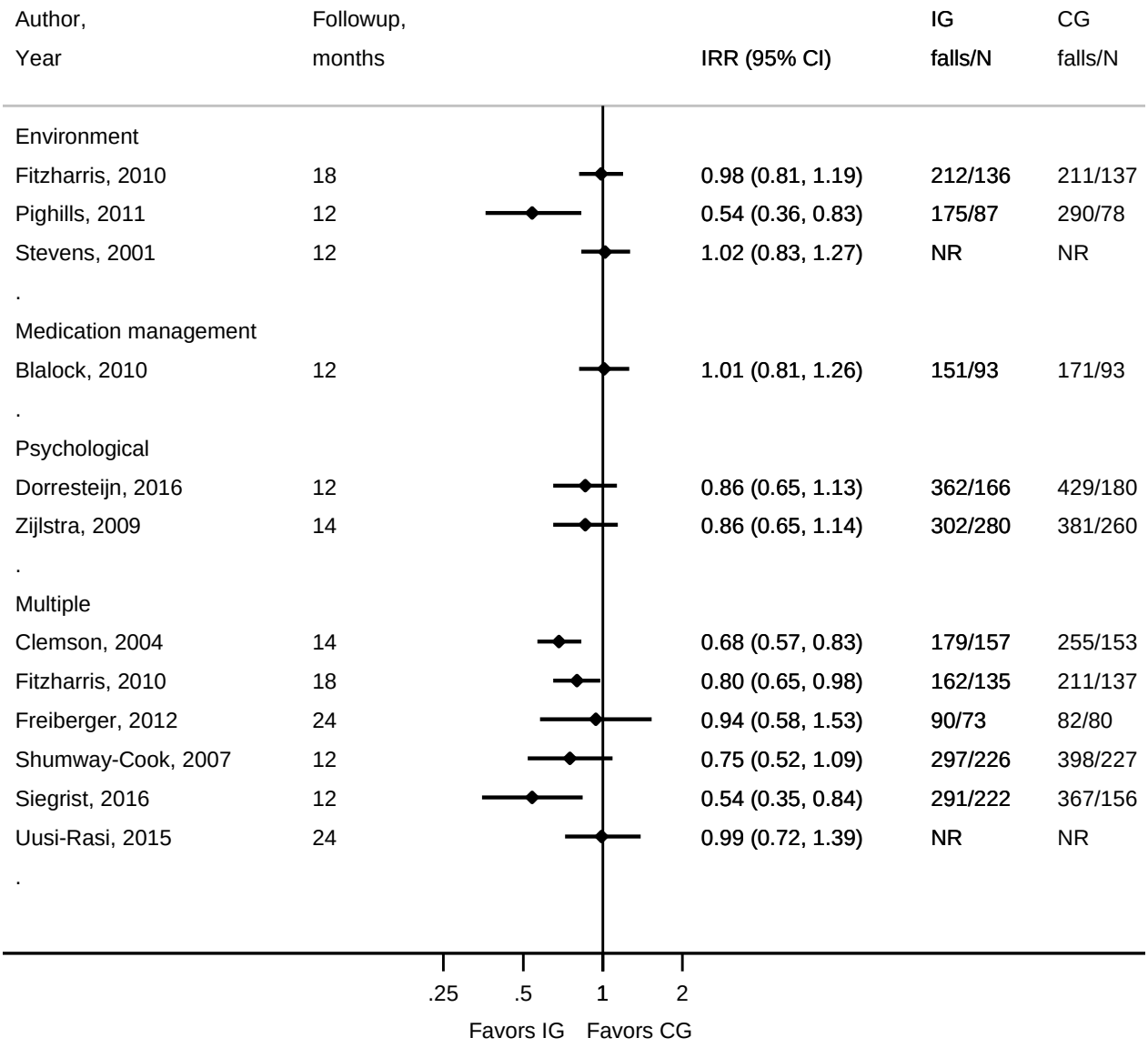
NOTE: Porthouse, 2005 authors provided data beyond what was reported in the original publication.

Figure 18. Pooled analysis of vitamin D intervention randomized controlled trials for mortality at longest followup (9–36 months)



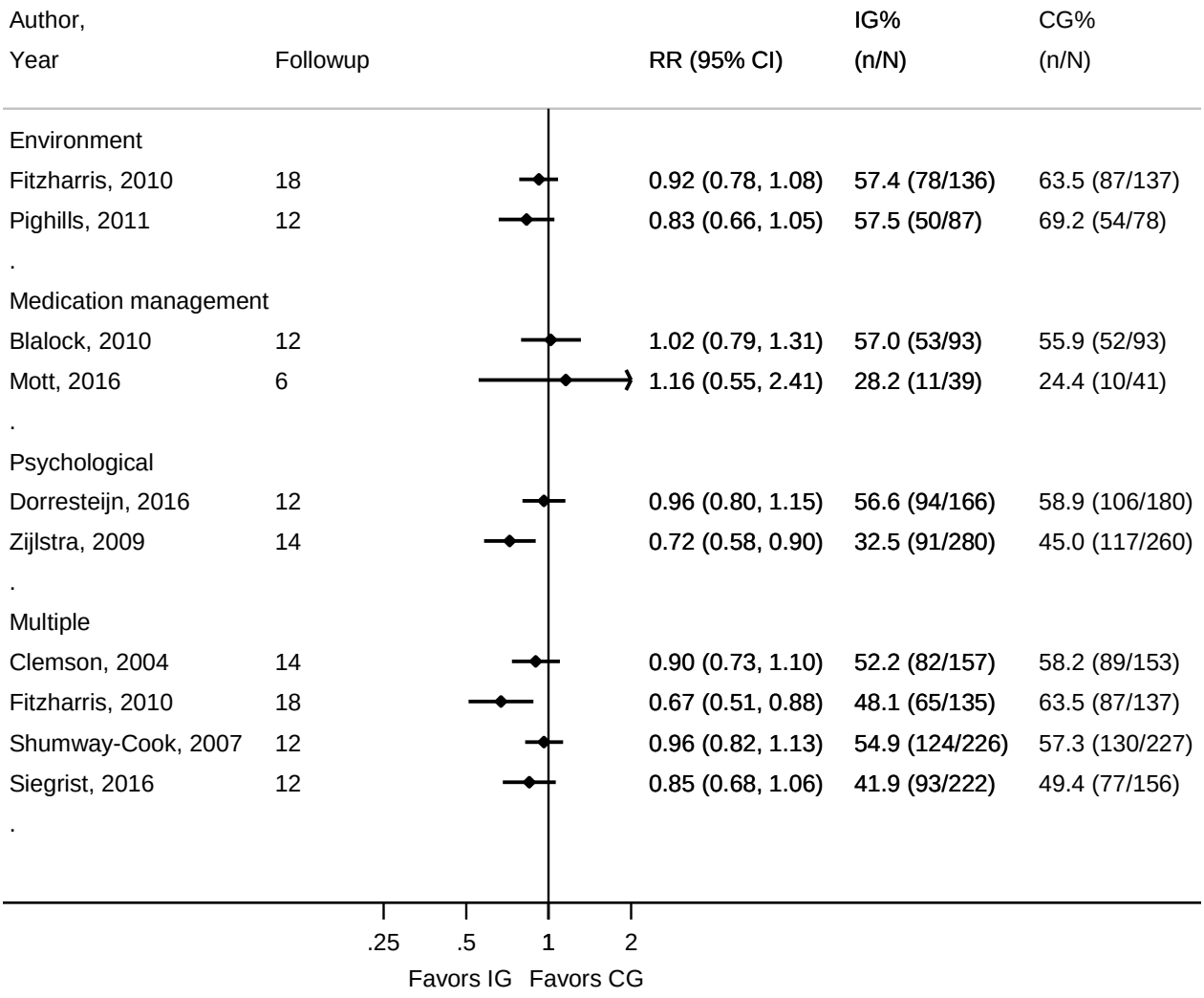
Abbreviations: b.i.d. = twice a day; CG = control group; CI = confidence interval; IG = intervention group; IU = international unit; q.d. = once a day; RR = relative risk; ug = micrograms

Figure 19. Forest plot of other interventions randomized controlled trials for falls at longest followup (12–24 months)



Abbreviations: CG = control group; CI = confidence interval; IG = intervention group; IRR = incidence rate ratio

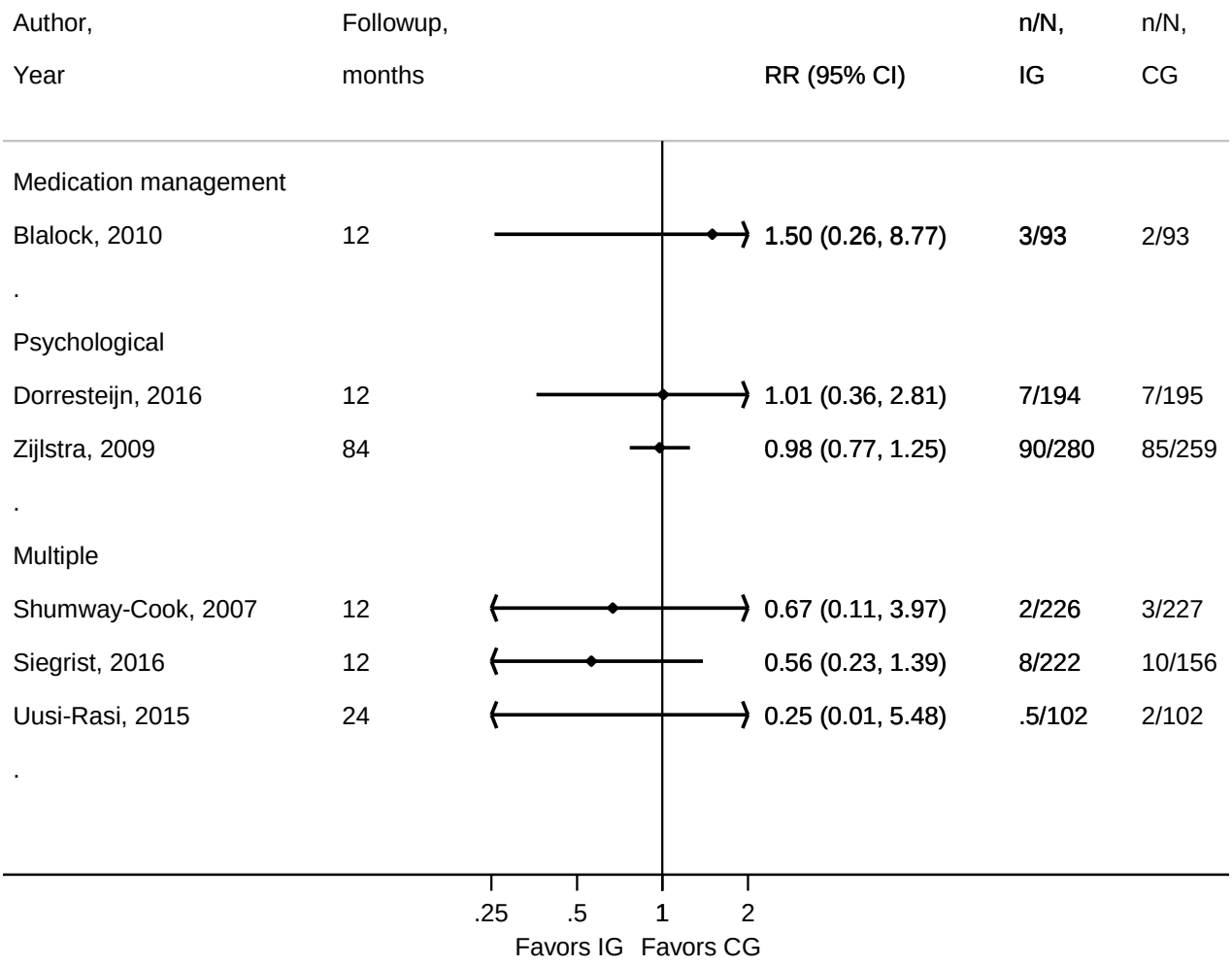
Figure 20. Forest plot of other intervention randomized controlled trials for people experiencing a fall at longest followup (12–18 months)



Abbreviations: CG = control group; CI = confidence interval; IG = intervention group; RR = relative risk

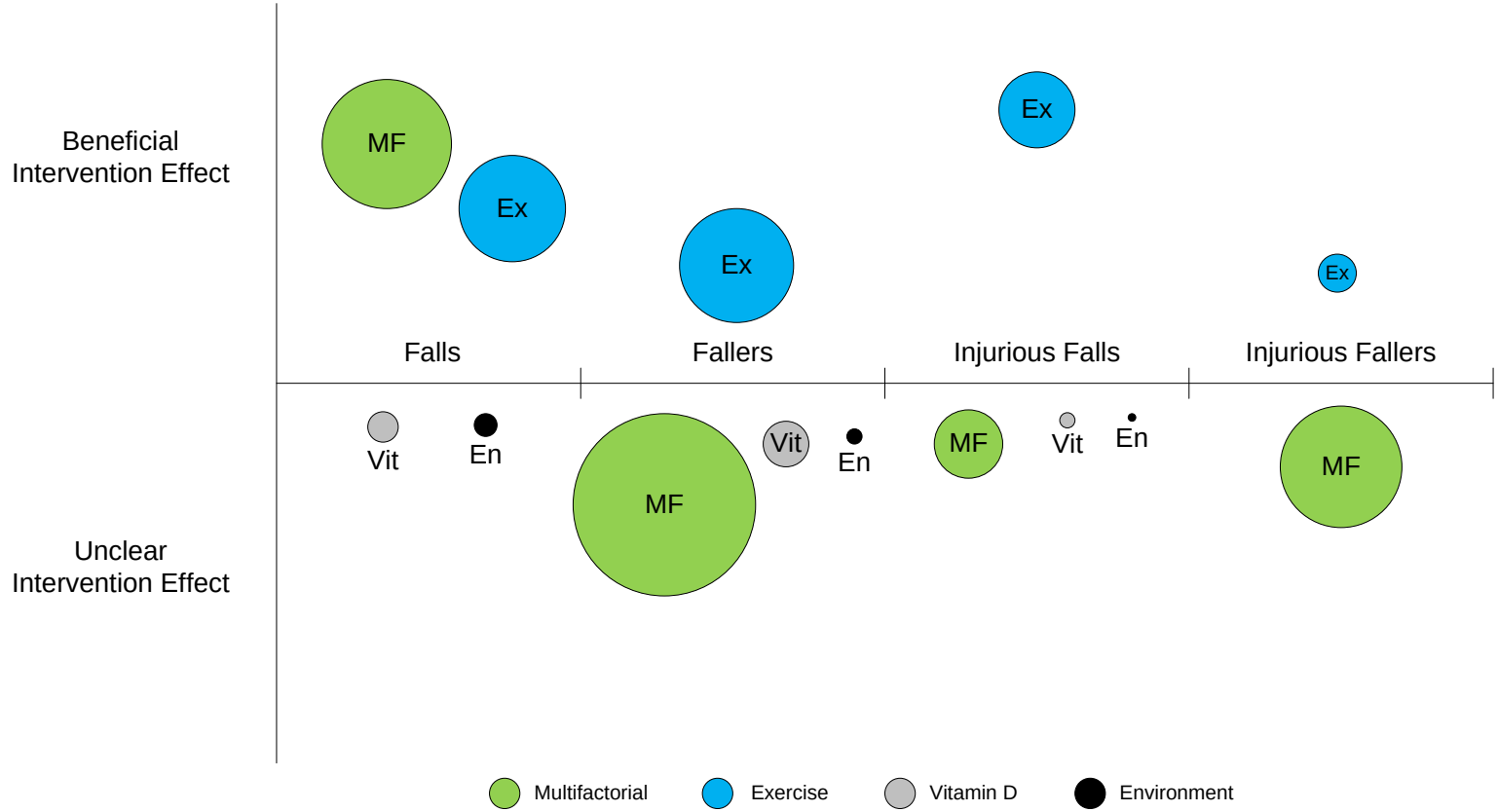
NOTE: Under Environment, Stevens, 2001 is not included in meta-analysis; authors provided OR but did not report number of people who had fallen.

Figure 21. Forest plot of other intervention randomized controlled trials for mortality at longest followup (12–24 months)



Abbreviations: CG = control group; CI = confidence interval; IG = intervention group; RR = relative risk

Figure 22. Evidence map of the largest intervention types and main outcomes



Note: Circle size corresponds to number of participants analyzed

Abbreviations: En = environment; Ex = exercise; MF = multifactorial; Vit = vitamin D

Table 1. Examples of fall-risk assessment tools feasible for primary care

Measure	Description
Questionnaires	
CDC STEADI three initial screening questions	A fall in the past year; feeling of unsteadiness when standing or walking; worry about falling.
Patient administered: Stay Independent[198]	Patient-administered questionnaire and scored questions on risk factors for falling (e.g., fall in previous 6 months, trouble stepping onto a curb, lost feeling in feet, depression).
Physical Function Measures	
Timed Up and Go	The time it takes for a subject to rise from an arm chair, walk 3 meters, and return to the chair and sit.
Gait speed	Speed used to walk a pre-specified distance in the clinic.
Short Physical Performance Battery	Summary measure that incorporates time to complete 5 chair stands, balance testing, and time to walk 8 feet.
30-Second Chair Stand	Number of times a patient can stand from a chair without using their arms in 30 seconds.
4-Stage Balance Test	Four standing positions (feet side by side; feet with the instep of one foot touching the toe of the other; one foot in front of the other; one foot) that should be held for at least 10 seconds.
Performance Oriented Mobility Assessment (POMA)[199]	Task-oriented test measuring patient gait and balance abilities. Balance tests measure nine maneuvers from sitting position. Gait tests include seven measures that time and observe the patient's abilities.
Combination	
QuickScreen[200]	Assessment of previous falls, drug use, vision, peripheral sensation, lower limb strength, balance, and coordination.

Table 2. Study characteristics, for multifactorial interventions, by author

Author, Year	Quality	Aim	Country	Target Population	Recruitment Setting	Inclusion/Exclusion Criteria
Ciaschini, 2009[66]	Fair	To evaluate the impact of a multifaceted community-based program aimed at optimizing evidence-based management of patients at risk for fall-related fractures	Canada	Community-dwelling persons aged 55 years or older, able to give informed consent and identified as at risk for fall-related fractures	Hospital, ED, clinic, or self-referred	Inclusion: Community-dwelling; aged 55 years or older; able to give informed consent; identified as at risk for fall-related fractures according to one of the following criteria: Attended the hospital ED with a fall and found to be at a high risk for falls as defined by a Timed Up and Go result of more than 14 seconds; were self-referred or referred by a health care provider because of a perceived high risk of fracture, and were identified at a high risk for falls defined by a Timed Up and Go result of more than 14 seconds; attended the hospital Fracture Clinic for a nonpathological fracture of the vertebrae, hip or wrist or had a BMD in the past year with a t-score of ≤ −2.0. Exclusion: NR
Close, 1999[67]	Fair	To assess the benefit of a structured interdisciplinary assessment of people who have fallen in terms of further falls	UK	Aged 65 years and older, living in the community, and presenting to an accident and emergency department with a fall	ED	Inclusion: Aged 65 years and above; living in the local community; attended the accident and ED with a primary diagnosis of a fall Exclusion: Cognitive impairment (a score on the abbreviated mental test of less than 7) and no regular caregiver; did not live locally; spoke little or no English
Cohen, 2015[68]	Fair	To test the effectiveness of a multifactorial fall-prevention intervention among a community-dwelling population of people ages 75 and older who had private long-term care insurance but who were not receiving claims payments for long-term services and support	USA	Community-dwelling older adults ages 75 years or older who had private long-term care insurance but who were not receiving claims payments for long-term services and support	Long-term care insurers	Inclusion: Community-dwelling; aged 75 years or older; had private long-term care insurance for at least 5 years but were not receiving claims payments for long-term services and support Exclusion: NR

Table 2. Study characteristics, for multifactorial interventions, by author

Author, Year	Quality	Aim	Country	Target Population	Recruitment Setting	Inclusion/Exclusion Criteria
Conroy, 2010[69]	Good	To determine the clinical effectiveness of a day hospital-delivered multifactorial fall-prevention program for community-dwelling older people at high risk of future falls identified through a screening process	UK	Older people aged 70 years or older	Clinic	Inclusion: Aged 70 years or older; identified from eight general practices; previous fall or two or more of the following fall risk factors: one or more falls in the previous year, taking more than four prescribed medications, previous stroke, Parkinson's disease, inability to stand from a chair without using arms to push up, symptoms of dizziness on standing, use of a mobility aid, or being housebound Exclusion: Living in a care home; in receipt of end of life care; already attending a fall-prevention program; unwilling or unable to attend a fall-prevention program; unable to provide informed consent or assent; had other interventions
Davison, 2005[70]	Fair	To determine the effectiveness of multifactorial intervention to prevent falls in cognitively intact older persons with recurrent falls	UK	Cognitively intact men and women aged over 65 years presenting to Accident & Emergency (A&E) department with a fall or fall-related injury	ED	Inclusion: Aged 65 years or older; presenting to A&E with a fall or fall-related injury; at least one additional fall in the preceding year Exclusion: Cognitively impaired (MMSE<24); >1 previous episode of syncope; immobile; lived >15 miles from A&E; registered blind; aphasic; clear medical explanation for their fall (i.e., acute myocardial infarction, stroke, or epilepsy); enrolled in another study
de Vries, 2010[71]	Fair	To evaluate the effectiveness of a multifactorial intervention in older persons with a high risk of recurrent falls	The Netherlands	Persons 65 years or older who consulted the emergency department or their family physician after a fall	ED, Clinic	Inclusion: Living independently or in an assisted living facility; living in the vicinity of the hospital; experienced a fall Exclusion: Inability to sign informed consent; a Mini-Mental State Examination score of less than 24; inability to provide a fall history; experiencing a fall due to a traffic or occupational accident; living in a nursing home; experiencing a fall more than 3 months before randomization; acute disease requiring long-term rehabilitation, such as a hip fracture or stroke

Table 2. Study characteristics, for multifactorial interventions, by author

Author, Year	Quality	Aim	Country	Target Population	Recruitment Setting	Inclusion/Exclusion Criteria
Elley, 2008[72]	Fair	To assess the effectiveness of a community-based falls-and-fracture nurse coordinator and multifactorial intervention in reducing falls in older people	New Zealand	Community-living people aged 75 years and older who had fallen in the previous year	Clinic	Inclusion: Aged 75 and older (≥55 and older for Maori); fallen in the previous 12 months Exclusion: Unable to understand study information and consent processes; unstable or progressive medical condition; severe physical disability; dementia
Fairhall, 2014[73]	Good	To assess the effect of a frailty intervention on risk factors for falls and fall rates in frail older people	Australia	Community-dwelling adults aged 70 years or older without severe cognitive impairment who met the Cardiovascular Health Study frailty definition	Clinic	Inclusion: 70 years or older; frail (met specified cut-offs for three or more of the Cardiovascular Health Study frailty criteria: slow gait, weak grip, exhaustion, low energy expenditure and weight loss); did not live in a residential aged-care facility; Mini-Mental State Examination score >18; life expectancy of at least 12 months (a modified Implicit Illness Severity Scale score ≤3) Exclusion: NR
Ferrer, 2014[74]	Fair	To assess the effectiveness of a multifactorial intervention to reduce falls among the oldest-old people, including individuals with cognitive impairment or comorbidities	Spain	Community-dwelling adults born in 1924	Clinic	Inclusion: Community-dwelling; born in 1924; registered at one of seven primary health care centers Exclusion: Institutionalized
Hendriks, 2008[75]	Fair	To assess whether a pragmatic multidisciplinary fall-prevention program was more effective than usual care in preventing new falls and functional decline in elderly people	The Netherlands	Community-dwelling people aged 65 years and over who were seen in an emergency department after a fall	ED	Inclusion: Community-dwelling; aged 65 and older; attended the emergency department of the University Hospital Maastricht for the consequences of a fall Exclusion: Unable to speak Dutch; cognitively impaired (score <4 on the Abbreviated Mental Test); admitted for more than 4 weeks to a hospital or another institution; permanently wheelchair-dependent or bedridden

Table 2. Study characteristics, for multifactorial interventions, by author

Author, Year	Quality	Aim	Country	Target Population	Recruitment Setting	Inclusion/Exclusion Criteria
Hogan, 2001[76]	Fair	To determine whether a standardized, multidimensional, in-home assessment of elderly people who had fallen, coupled with a subject-specific care plan, would reduce the likelihood of further falls compared with usual care	Canada	Community-dwelling persons aged 65 years or older who had fallen within the previous 3 months	NR	Inclusion: Community-dwelling; aged 65 years or older; fallen within the previous 3 months (qualifying fall could not have occurred during vigorous or high-risk activities, while in an active treatment hospital, or because of syncope or an acute stroke) Exclusion: NR
Imhof, 2012[77]	Fair	To evaluate the effects of an advanced practice nurse in-home health consultation program on quality of life, health indicators (falls, acute events), and healthcare utilization	Switzerland	Community-dwelling adults aged 80 years and older	Hospital, clinic, community-based, Home care organizations	Inclusion: German-speaking; community-dwelling; aged 80 and older; cognitively able to understand and consent to the study Exclusion: At the end of life; major psychiatric diagnosis; severe cognitive impairment (as measured using the Clinical Dementia Rating Scale)
Lightbody, 2002[78]	Fair	To evaluate a nurse-led management plan and care pathway for older people discharged from an Accident and Emergency Department after a fall	UK	Patients aged 65 or over attending the Accident and Emergency department with a primary diagnosis of a fall	ED	Inclusion: Aged 65 or over; attended the Accident and Emergency department with a primary diagnosis of a fall Exclusion: Admitted to hospital as a result of the index fall; lived in institutional care; refused or were unable to consent; resided outside the catchment area
Logan, 2010[79]	Good	To evaluate whether a service to prevent falls in the community would help reduce the rate of falls in older people who call an emergency ambulance when they fall but are not taken to hospital	UK	Adults aged 60 years or older living at home or in residential care who had fallen and called an emergency ambulance but were not taken to the hospital	Ambulance service records	Inclusion: Aged 60 years or older; living at home or in a care home in one of four primary care trust areas in Nottinghamshire, United Kingdom; contacted the East Midlands Ambulance Service through the emergency telephone system because of a fall, but had not been taken to a hospital Exclusion: Unable to give consent; too ill to participate (e.g., terminally ill); already in a fall-prevention rehabilitation program

Table 2. Study characteristics, for multifactorial interventions, by author

Author, Year	Quality	Aim	Country	Target Population	Recruitment Setting	Inclusion/Exclusion Criteria
Lord, 2005[80]	Good	To determine whether an individualized fall-prevention program comprising exercise, visual, and counseling interventions can reduce physiological fall risk and falls in older people	Australia	Community-dwelling adults aged 75 years or older	Health insurance company membership database	Inclusion: Community-dwelling; aged 75 years or older Exclusion: Minimal English language skills; blind; Parkinson's disease; Short Portable Mental Status Questionnaire score <7
Moller, 2014[81]	Fair	To investigate the effects of a home-based 1-year case management intervention in older people with functional dependency and repeated contact with the health care services on self-reported falls and self-reported injurious fall	Sweden	Persons aged 65 years or older living in the study municipality	Clinic, municipal home care organization, self-referral	Inclusion: Aged 65 years or older; living in the study municipality; in need of help with at least two activities of daily living; admitted to hospital at least twice; had at least four outpatient contacts during the previous 12 months; able to communicate verbally; no cognitive impairments (MMSE ≥25) Exclusion: NR
Newbury, 2001[82]	Fair	To measure the outcomes of a health assessment, conducted by a nurse, of people aged 75 years and older living independently in their own homes	Australia	Persons aged 75 years and older and living independently in the community	Clinic	Inclusion: Persons aged 75 years and older; living independently in the community Exclusion: NR
Palvanen, 2014[83]	Fair	To assess the effectiveness of the multifactorial Chaos Clinic Falls Prevention Program on rate of falls and related injuries of home-dwelling older adults	Finland	Home-dwelling people aged 70 years or older	Clinic, community-based	Inclusion: Home-dwelling; aged 70 years or older; at least one of the following independent risk factors for falls and injuries: problems in mobility and everyday function, three or more falls during the last 12 months, a previous fracture after the age 50, an osteoporotic fracture (hip fracture) in a close relative (mother or father), osteoporosis (diagnosed or a strong clinical suspicion such as thoracic kyphosis), low body weight (BMI < 19), and sickness or illness essentially increasing the risk for osteoporosis, falls and fractures Exclusion: Inability to give informed consent; disabilities or illnesses preventing physical activity and

Table 2. Study characteristics, for multifactorial interventions, by author

Author, Year	Quality	Aim	Country	Target Population	Recruitment Setting	Inclusion/Exclusion Criteria
						training; inability to move; terminal illness (predicted lifetime less than 12 months)
Perula, 2012[84]	Fair	To determine the effectiveness of a multifactorial intervention program to prevent falls among older adults as compared with a brief intervention	Spain	Community-dwelling adults aged 70 years or older	Clinic	Inclusion: Community-dwelling; aged 70 years or older; ability to walk independently; could provide informed consent Exclusion: Institutionalized; immobilized or bedridden; terminal disease or severe psychiatric illness; contraindications to physical exercise
Russell, 2010[85]	Fair	To investigate the effect of a referral-based targeted multifactorial fall-prevention intervention on the occurrence of recurrent falls and injuries in older people presenting to an emergency department after a fall and discharged directly home from the ED	Australia	Community-dwelling adults aged 60 years and older presenting to an ED after a fall and discharged directly home	ED	Inclusion: Community-dwelling; aged 60 years and older; presenting to an ED after a fall and discharged directly home Exclusion: Persons unable to follow simple instructions and unable to walk independently indoors (with or without a walking aid); cognitive impairment was initially an exclusion criterion but to ensure adequate participant numbers and generalizability, participants with cognitive impairment were later included if they had a caregiver who consented to participation
Salminen, 2009[86]	Good	To evaluate the effects of a multifactorial fall prevention program on falls and to identify the subgroups that benefit the most	Finland	Community-dwelling adults aged 65 years or older who had fallen at least once during the previous 12 months	Hospital, clinic, community-based, or pharmacies and written invitations delivered by health professionals	Inclusion: Community-dwelling; aged 65 years or older; fallen at least once during the previous 12 months; MMSE score 17 or greater; able to walk 10 meters independently with or without walking aids; living at home or in sheltered housing units provided for elderly people who require occasional support and assistance from a resident staffer but who do not require full residential care Exclusion: NR

Table 2. Study characteristics, for multifactorial interventions, by author

Author, Year	Quality	Aim	Country	Target Population	Recruitment Setting	Inclusion/Exclusion Criteria
Spice, 2009[87]	Fair	To determine the effectiveness of two interventions, one based in primary care and the other in secondary care, at preventing further falls in recurrent fallers	UK	Community-dwelling adults aged 65 years or older who had two or more falls in the previous year and did not present to an emergency department with the index fall	Clinic	Inclusion: Community-dwelling; aged 65 years or older; two or more falls in the previous year; did not present to an emergency department with the index fall Exclusion: Life expectancy less than 1 year; planned to move from the area within one year; abbreviated mental test score of less than 7; non-English speakers with no available interpreter; nursing home residents
Tinetti, 1994[88]	Good	To assess the effectiveness of the multifactorial targeted risk-abatement strategy in reducing the risk of falls among elderly persons in the community	USA	Community-dwelling adults aged 70 years or older	HMO	Inclusion: Community-dwelling; aged 70 years or older; able to ambulate independently; not currently enrolled in another study on aging; score of at least 20 on the MMSE; not participating in vigorous sports or walking for exercise within the month before enrollment; had at least one risk factor for falling (postural hypotension; use of sedatives; use of at least four prescription medications; impairment in arm or leg strength or range of motion, balance, ability to move safely from bed to chair or to the bathtub or toilet (transfer skills), or gait Exclusion: NR
van Haastregt, 2000[89]	Fair	To evaluate whether a program of multifactorial home visits reduces falls and impairments in mobility in elderly people living in the community	The Netherlands	Community-dwelling adults aged 70 years or older with moderate impairments in mobility or a history of recent falls	Clinic	Inclusion: Community-dwelling adults; aged 70 years or older; moderate impairments in mobility, two or more falls in the previous 6 months, or have scored 3 or more on the mobility control scale of the short version of the sickness impact profile Exclusion: Bedridden; fully dependent on a wheelchair; terminally ill; on the waiting list for admission to a nursing home; receiving home care from a community nurse on a regular basis

Table 2. Study characteristics, for multifactorial interventions, by author

Author, Year	Quality	Aim	Country	Target Population	Recruitment Setting	Inclusion/Exclusion Criteria
Vind, 2009[90]	Good	To evaluate the effect of multifactorial fall prevention in community-dwelling people aged 65 and older	Denmark	Older adults who had visited the emergency department or had been hospitalized due to a fall	Hospital, ED	Inclusion: Aged 65 years and older; been treated in the emergency department or admitted to Glostrup University Hospital because of a fall Exclusion: Falls caused by external force or alcohol intoxication; persons not living locally; institutionalized; unable to walk; terminally ill; having impaired communication; or being described as suffering from dementia in hospital notes or by staff; planned geriatric intervention
Wagner, 1994[91]	Fair	To test a multicomponent intervention program to prevent disability and falls in older adults	USA	Ambulatory older adults aged 65 years or older	HMO	Inclusion: Ambulatory; aged 65 years or older; independent in activities of daily living Exclusion: Seriously ill; institutionalized; living outside the catchment area

Abbreviations: A&E = accident and emergency (department of hospital); BMD = bone mineral density; BMI = body mass index; ED = emergency department; HMO = health maintenance organization; MMSE = Mini-Mental State Examination; NR = not reported; NS = not specified; UK = United Kingdom; USA = United States of America

Table 3. Population characteristics, for multifactorial interventions, by author

Author, Year	N randomized	Mean age	Females, %	SES	White, %	Definition of fall risk*	At risk of falling,* %	Baseline health or functional status
Ciaschini, 2009[66]	201 IG: 101 CG: 100	71.9	94	NR	NR	Attended ED with a fall and TUG of more than 14 seconds; or referred because at high risk of fracture and TUG of more than 14 seconds; or attended hospital fracture clinic for a non-pathological fracture of the vertebrae, hip, or wrist or had a BMD in the past year with a t-score of ≤ -2.0	100 (at risk for fall-related fractures)	History of falls within the past year: 41.3% Fear of falling: 35.8% Taking four-plus medications: 56.2% Rise from chair with assist: 52.7% Unsteady gait: 37.3% Experiences dizziness: 49.3% Impaired vision: 15.4% Confusion: 7.5% Thin/fragile bones: 33.4% Stopped walking when talking: 22.4%
Close, 1999[67]	397 IG: 184 CG: 213	78.2	67.5	NR	NR	Attended the ED with a primary diagnosis of a fall	100	Fall in previous year: 65% Recurrent faller: 28% Barthel index: 18.8 Lives alone: 61%
Cohen, 2015[68]	5310 (1919 to other group) IG: 2839 CG: 2471	81	58	50% (% with incomes <$50,000)	NR	NR	NR	1+ falls in previous 6 months: 19% No limitations in ADL: 91% No limitations in IADL: 84%
Conroy, 2010[69]	364 IG: 183 CG: 181	78.8	59.9	NR	NR	A previous fall or two or more of the other fall risk factors (described below) were used to identify those at high risk of a future fall Risk factors: One or more falls in the previous year, taking more than four prescribed medications, previous stroke,	100	At least one fall in previous 12 months: 58% Taking more than 4 medications: 53%

Table 3. Population characteristics, for multifactorial interventions, by author

Author, Year	N randomized	Mean age	Females, %	SES	White, %	Definition of fall risk*	At risk of falling,* %	Baseline health or functional status
						Parkinson's disease, inability to stand from a chair without using arms to push up, symptoms of dizziness on standing, use of a mobility aid and being housebound.		
Davison, 2005[70]	313 IG: 159 CG: 154	77	72	15 (mean age left school)	NR	Presenting to the A&E with a fall or fall-related injury	100	Median number of falls in previous 12 months: 3
de Vries, 2010[71]	217 IG: 106 CG: 111	79.8	70.5	58.5% (edu >=11 yrs)	NR	Consulted the emergency department of the VU University Medical Center or their family physician after a fall	100	Barthel Index score, median: 19.0 Lawton IADL score, median: 7.0 Number of falls in preceding year, median: 2 Assisted living: 4%
Elley, 2008[72]	312 IG: 155 CG: 157	80.8	68.9	NR		Fall or trip in the previous 12 months (from inclusion)	100	# of falls in previous year, median: two
Fairhall, 2014[73]	241 IG: 120 CG: 121	83.3	67.6	NR	NR	Met specified cut-offs for three or more of the CHS frailty criteria: slow gait, weak grip, exhaustion, low energy expenditure and weight loss (from inclusion).	100	100% met the cutoffs for three or more of the CHS frailty criteria Lives alone: 46%, walking speed, SPPB
Ferrer, 2014[74]	328 IG: 164 CG: 164	85	61.6	18.9 (formal education >6 yrs)	NR	Oldest-old age group, 85 years (from inclusion)	100	Lived alone: 31% Barthel index, median (range 0-100, higher scores indicate better functioning): 95.0

Table 3. Population characteristics, for multifactorial interventions, by author

Author, Year	N randomized	Mean age	Females, %	SES	White, %	Definition of fall risk*	At risk of falling,* %	Baseline health or functional status
Hendriks, 2008[75]	333 IG: 166 CG: 167	74.8	68.5	28.2% (≤ primary school edu)	NR	Attended the ED of the University Hospital Maastricht for the consequences of a fall (from inclusion).	100	Living alone: 43% At least one fall in previous 12 months: 100% Frenchay Activity Index, mean: 23.5
Hogan, 2001[76]	163 IG: 79 CG: 84	77.6	71.8	NR	NR	Fallen within the previous 3 months without resulting in a lower-extremity fracture (from inclusion).	100	Mean Functional Autonomy Measurement System (includes ADL, IADL, mobility, communication, mental function, range 0 to -87, where -87 indicates lower functioning): -6.9
Imof, 2012[77]	461 IG: 231 CG: 230	85	72.7	27.8% (edu <10 yrs)	100	NA	NR	Living alone: 67% ADL (OARS), mean: 24.5 Self-rated health good/excellent: 61% Falls within last 12 months: 40% support
Lightbody, 2002[78]	348 IG: 171 CG: 177	75 (median for both groups)	74.4	NR	NR	Attending the A&E department with a primary diagnosis of fall	100	Falls in previous 12 months: 42% Mean ADL (Barthel): 19
Logan, 2010[79]	204 IG: 102 CG: 102	82 (median)	64.7	NR	NR	Fallen and contacted an ambulance service through the emergency telephone system but had not been taken to a hospital	100	Living alone: 61% Median ADL (Barthel, 0-20): 15 Mean ADL: 14.6
Lord, 2005[80]	414 (206 to other group) IG: 210 CG: 204	80.2	68	NR	NR	NA	NR	Previous falls, mean: 0.79 Fear of falling (moderate or more): 32%

Table 3. Population characteristics, for multifactorial interventions, by author

Author, Year	N randomized	Mean age	Females, %	SES	White, %	Definition of fall risk*	At risk of falling,* %	Baseline health or functional status
Moller, 2014[81]	153 IG: 80 CG: 73	81.5	66.7	NR	NR	Need help with at least 2 activities of daily living, admitted to hospital at least twice or have had at least 4 outpatient contacts during the previous 12 month (from inclusion).	100	100% needed help with at least 2 ADLs Fall in previous 3 months: 25% Median IADL: 2 Downton Fall Risk Index 3+: 79%
Newbury, 2001[82]	100 IG: 50 CG: 50	NR (IG median: 78.5; CG median: 80)	63	NR	NR	NA	NR	NR
Palvanen, 2014[83]	1314 IG: 661 CG: 653	77.6	86	NR	NR	At least one of the following: problems in mobility and everyday function, 3 or more falls during the last 12 months, a previous fracture after the age 50, an osteoporotic fracture (hip fracture) in a close relative (mother or father), osteoporosis (diagnosed or a strong clinical suspicion such as thoracic kyphosis), low body weight (BMI<19), and sickness or illness essentially increasing the risk for osteoporosis, falls, and fractures (from inclusion).	100	Fall within previous 6 months: 36%

Table 3. Population characteristics, for multifactorial interventions, by author

Author, Year	N randomized	Mean age	Females, %	SES	White, %	Definition of fall risk*	At risk of falling,* %	Baseline health or functional status
Perula, 2012[84]	404 IG: 133 CG: 271	76.4	53.2	60.9% (social class V – lowest)	NR	NA	NR	Fell in previous year: 31% Afraid to fall: 57%
Russell, 2010[85]	712 IG: 351 CG: 361	75.4	70.2	NR	NR	Presented to an ED after a fall and were discharged directly home (from inclusion).	100	Living alone: 38% Sustained 1+ falls in previous 12 months: 51% Assistance required to perform activities of daily living: No assistance: 56% Supervision: 1.4% Some assistance: 36% Completely dependent: 6.9%
Salminen, 2009[86]	591 IG: 293 CG: 298	72.5-73 (median for both groups)	84.2	1.5% (<basic edu)	NR	Fallen at least once in the previous 12 months.	100	Living alone: 53% Median ADL: 31-32 (range 8-40 where 40 indicates better functioning)
Spice, 2009[87]	375 (141 to other group) IG: 213 CG: 162	82	73.4	NR	NR	Two or more falls in the preceding year	100	Median Barthel Index: 18 (range 0-20, 20 indicates higher functioning)
Tinetti, 1994[88]	301 IG: 153 CG: 148	77.9	69.1	30.6% (edu beyond HS)	"high proportion"	At least one of the following risk factors for falling: postural hypotension; use of sedatives; use of four-plus prescription medications; and impairment in arm or leg strength or range of motion, balance, ability to move safely from bed to chair or to the bathtub or toilet (transfer skills), or gait (from inclusion)	100	Fall in past year: 43%

Table 3. Population characteristics, for multifactorial interventions, by author

Author, Year	N randomized	Mean age	Females, %	SES	White, %	Definition of fall risk*	At risk of falling,* %	Baseline health or functional status
van Haastregt, 2000[89]	316 IG: 159 CG: 157	77.2	66	51% (elementary school edu or less)	NR	Reported two or more falls in the previous six months or scored 3 or more on the mobility control scale of the short version of the Sickness Impact Profile	100	Living alone: 50% At least one fall: 37% More than one fall: 19% Mean mobility control: 5.5 (range 0-12, 0 is favorable) Mean daily activity: 32.4 (range 13-52, 52 is favorable) Mean fear of falling: 18.0 (range 10-40, 10 is favorable) Median perceived health: 2 (range 1-5, 5 is favorable)
Vind, 2009[90]	392 IG: 196 CG: 196	74.4	73.8	NR	NR	Visited the emergency department or had been hospitalized due to a fall (from inclusion)	100	Mean Barthel score (0-100): 98.2 Mean Frenchay Activities Index (0-45): 29.0 Lived alone: 51%
Wagner, 1994[91]	1242 (317 to other group) IG: 635 CG: 607	72.5	60	34% (<$15,000 income); 26% (college graduate)	94	NA	NR	Falls in last 12 months: 34%

Abbreviations: A&E = accident and emergency (department of hospital); ADL = activities of daily living; AMT = Abbreviated Mental Test; CG = control group; CHS = Cardiovascular Health Study; GDS = Geriatric Depression Scale; ED = emergency department; edu = education; IADL = instrumental activities of daily living; IG = intervention group; MMSE = Mini-Mental State Examination; NA = not applicable; NR = not reported; NS = not specified; OARS = Older Americans Resources Services; PADL = personal activities of daily living; PD = Parkinson's Disease; SES = socioeconomic status; SPPB = short physical performance battery; TUG = Timed Up-and-Go ; QoL = quality of life
* As defined by study authors

Table 4. Intervention details, for multifactorial interventions, by author

Author, Year	IG Description	CG Description	Research team personnel delivering assessment
Ciaschini, 2009[66]	A research nurse assessed participants allocated to the intervention group in their home and completed the Berg Balance Scale, the InterRAIScreener, a medication review and an assessment for orthostatic hypotension. The InterRai Screener is used to assess the elderly individual to identify those who merit further assessment in order to prevent or stabilize early functional or health decline. A complete list of patient medications was compiled from two sources: (i) the patient's pharmacy records and (ii) home visits conducted by the study nurses. Medications associated with an increased risk of falls were identified, and primary care providers were asked to assess this list of flagged medications. The criteria for appropriate referral for physiotherapy and occupational therapy services were based on the results of the InterRAI Screener and the Berg Balance Score. Physiotherapy interventions were tailored to each patient and included strengthening exercises, gait and balance training and referral to activities such as T'ai Chi classes. Occupational therapy interventions were also tailored to each patient and included home environmental assessment and cognitive testing. All therapists completed standard reporting forms indicating their recommended interventions and barriers to patient compliance with these recommendations. Patients received personalized counseling from the research nurse about fall prevention, including a written summary of the suggested management plan. They also received educational materials including a checklist for fall prevention.	All members of the usual care group received usual health care during the first 6 months and then were eligible to receive the intervention for a subsequent 6 months.	Nursing professionals
Close, 1999[67]	A comprehensive general examination was undertaken, but also focused on a more detailed assessment of visual acuity, balance, cognition, affect, and prescribing practice. Postural hypotension was defined as a symptomatic decrease in systolic blood pressure of 20 mm Hg or more, as the patient rose from lying to standing. Visual acuity was assessed with a Snellen chart, and the patient was defined as having impaired vision if the acuity was 6/12 or worse in either eye, being partially sighted if corrected vision in both eyes was 6/24 or worse, or being blind if acuity was 6/60 or worse in both eyes. Poor binocular vision was defined as a disparity in acuity between eyes of two lines or more on the Snellen chart. Balance was tested by asking the patient to stand on one leg; impaired balance was defined as an inability to stand on one leg for more than 10 seconds. Folstein mini mental state examination was used to assess cognition (a score of ≤26 was taken as evidence of cognitive impairment) and the modified geriatric depression scale 27 to assess affect (a score of ≥6 indicated possible underlying depression). Carotid sinus studies were undertaken if the cause of the fall was unclear or clinical suspicion was high. On completion of the assessment and in conjunction with the baseline data, a primary cause for the index fall was assigned, and identified risk factors were modified if possible. If further investigation, assessment, or follow-up was thought to be necessary a referral was made to the relevant service and the examination findings and the recommended course of action were detailed. If multidisciplinary input was thought to be appropriate, a referral was made to the day hospital. Drug modification was achieved by direct contact with the general practitioner.	No assessment	Medical doctors, occupational therapists

Table 4. Intervention details, for multifactorial interventions, by author

Author, Year	IG Description	CG Description	Research team personnel delivering assessment
	There was no further medical input from the physician after the assessment. A single home visit was undertaken by an occupational therapist after the medical assessment. Function was assessed with the Barthel index and supplemented for descriptive purposes only by a modified version of the functional independence and functional assessment measures. Environmental hazards were identified and documented with a checklist designed by the Health and Safety Executive, UK. The falls handicap inventory was used as an indirect marker of the psychological consequences of the fall. 18 questions on health, function, and emotion produce a maximum score of 72. On completion of the assessment, advice and education was given about safety within the home, and modifications such as removal of loose rugs were made with the patient's consent. Minor equipment was supplied directly by the occupational therapist, and patients who required handrails, other technical aids, adaptions, or additional support were referred to social or hospital services in the usual way.		
Cohen, 2015[68]	Clinical assessment: A registered nurse performed an in-home assessment collecting information on health, fall history, home environment, and medications. Tests of gait and balance included the Up and Go Test, the Four Test Balance Scale, and the Chair Stand test. Coaching and education were also provided at the time of the assessment. Customized recommendations and education: Using the data collected during the assessment, an action plan was created by a separate nurse and mailed to the participant. Customized recommendations and education: The action plan documented the specific fall risk factors and provided personalized and general recommendations for minimizing fall risk. Participants also received a fall prevention and wellness toolkit. The toolkit contained an exercise DVD and education book entitled Go4Life which focuses on endurance, flexibility, balance, and strength; a LIFT Wellness Pedometer, an Exercise Progress Chart and a monthly Fall journal and pamphlet with suggestions for minimizing falls in the home. The individual's primary care physician received the specific results of all tests along with a guide explaining how to interpret results and their implications, a summary of fall experiences, a complete list of all medications, results of blood pressure tests, information on environmental hazards, and additional clinical notes from the assessment. Also identified were medications found on the Beers criteria list that put an individual at an increased fall risk. The document provided an easy-to-navigate summary as well as an educational tool to the PCP on the specific fall-related issues faced by their patient. Coaching call: Within 2 weeks of the action plan delivery, the nurse who created the action plan conducted a follow-up call with the participant and reviewed the assessment findings and recommendations. During the call, additional coaching and education occurred, and participants were strongly encouraged to set an appointment for followup with their PCP about the action plan. Quarterly newsletter: A newsletter was mailed to participants quarterly for a period of 1 year. It provided additional coaching and education about fall prevention and support for implementing action plan recommendations.	Initial baseline assessment by telephone and interviewed at 3-month intervals over a year.	Nursing professionals

Table 4. Intervention details, for multifactorial interventions, by author

Author, Year	IG Description	CG Description	Research team personnel delivering assessment
Conroy, 2010[69]	Participants in the intervention arm were invited to attend a fall-prevention program based in a geriatric day hospital closest to their home. The fall-pprevention program consisted of a medical review, physiotherapy, and occupational therapy treatments. The fall-prevention program was that used in routine local clinical practice and no additional resources or interventions beyond routine clinical practice were employed in the intervention arm. In all three settings, the medical assessment was carried out by, or under the direction of, a consultant geriatrician. It included a clinical history, physical examination including an orthostatic blood pressure measurement, laboratory tests where indicated, 12-lead ECG and where appropriate a neurovascular assessment. Medical interventions varied according to medical diagnoses made and could include a medication review, bone health assessment, referral to an optician or ophthalmologist or to other specialists. The physiotherapy assessment included assessment of gait, balance, mobility and muscle strength, and the intervention included provision of strength and balance training, tailored to individuals' needs. The occupational therapy assessment included an interview to investigate home hazards and, when required, a home assessment was also performed. Occupational therapy interventions could include the provision of assistive technology and home adaptations. Finally, participants received a nursing review and an educational program focusing on healthy aging.	Usual care; no further intervention was offered to participants in the control arm, who had access to all usual services, including referral to a community or hospital-based fall-prevention program if indicated.	Medical doctors, nursing professionals, physical therapists, occupational therapists
Davison, 2005[70]	Medical and fall history and full clinical examination were performed including assessment of medications and vision. A comprehensive cardiovascular assessment was performed in all intervention subjects to assess for orthostatic hypotension, carotid sinus hypersensitivity and vasovagal hypersensitivity. Laboratory blood tests and electrocardiogram were performed. Interventions for identified abnormalities followed recognized treatment recommendations. Gait and balance were assessed by modified Performance Orientated Mobility Score, along with feet, footwear and assistive devices, with standardized intervention for abnormal scores. Occupational therapy assessment utilized a checklist for home environmental hazards (User Safety and Environmental Risk).	The control group did not undergo medical or therapy assessment.	NR
de Vries, 2010[71]	The multidisciplinary intervention started with a visit to the geriatric outpatient clinic. A multifactorial fall-risk assessment was conducted that aimed to identify modifiable fall risk factors. The assessment of fall risk factors and design of the treatment plan were based on the Dutch Institute for Health Care Improvement guideline. The assessment consisted of a general medical and drug history, fall and mobility history, and physical examination results. According to the guideline, special emphasis was placed on signs and symptoms of potentially modifiable fall and fracture risk factors, such as postural hypotension, visual impairment, parkinsonism, osteoporosis, osteoarthritis, gait disorders, psychotropic and cardiovascular drug use, and environmental hazards. When indicated, additional diagnostic tests were performed (e.g., laboratory tests or imaging). The multifactorial treatment could consist of several therapies and recommendations. In participants who used cardiovascular or psychotropic drugs, treatment withdrawal was recommended when no current medical or psychiatric	The control group received usual care. In the Netherlands, usual care after a fall mainly consists of treatment of the consequences of a fall.	Nursing professionals, other modern health professionals

Table 4. Intervention details, for multifactorial interventions, by author

Author, Year	IG Description	CG Description	Research team personnel delivering assessment
	condition warranted continuation of the drugs. Special emphasis was placed on the importance of discontinuation of benzodiazepines. When the 25-hydroxyvitamin D3 level was <20 ng/mL, treatment with a combination of calcium carbonate, 500 mg, and cholecalciferol, 400 IU, was initiated. Postural hypotension was treated primarily with compression stockings for the lower legs and discontinuation of vasodilating medication. Every participant with a gait disorder was referred to one of two designated physical therapists for home-based training for improvement of balance and strength. A home visit aimed at home hazard reduction by an occupational therapist was offered to every participant with a gait disorder. Referral to an ophthalmologist was initiated when the corrected visual acuity was less than 0.5 (20/40) OU on the Snellen chart. Referral to other medical specialists was initiated when deemed necessary (e.g., referral to a cardiologist for participants with new or uncontrolled arrhythmias). The family physician of each participant was contacted by telephone immediately after the examination to discuss referrals to medical specialists, medication changes and followup.		
Elley, 2008[72]	A falls-and-fracture nurse coordinator with substantial gerontological experience was trained by the clinical investigators and at an established community-based fall-prevention program in Australia (2 days). She visited intervention participants at home and used a standardized health assessment and an evidence-based algorithm to assess risk of falls and refer participants to their family physician, an optometrist, podiatrist, physical therapist, or occupational therapist and to receive a home-based exercise program to address identified risks: 1. Health assessment: history of circumstances of the fall, medications, previous cardiovascular or neurological illness, continence, vision, postural blood pressure, balance and gait, cardiovascular screen (syncope, arrhythmia). 2. Home hazards assessment: an audit for environmental safety. 3. Bone health assessment: a brief osteoporosis risk screen, recommendation for family physician assessment to consider vitamin D and calcium supplementation, dual energy X-ray absorptiometry (DEXA) measurement of bone density, and bisphosphonates where indicated. 4. The Otago Exercise Programme: delivered by a trained health practitioner or physical therapist for 1 year during home visits at Weeks 1, 2, 4, and 8 and after 6 months. Participants were given monthly calendars to fill in and return to researchers recording daily adherence to exercises and a walking plan. Exclusion criteria for the Otago Exercise Programme were a Timed Up and Go Test score longer than 30 seconds or marked neurological impairment. The falls-and-fracture nurse coordinator could refer those excluded to a community physical therapist who tailored an alternative exercise program. After completion of the assessment, the nurse made the referrals and followed up to ensure that contact was made with the Otago Exercise Programme exercise instructor. The nurse instigated a referral to the regional occupational therapy service if a need for	Control group participants received usual care and were offered two social visits from an accredited provider for older people, a nursing student, or a medical student. All study participants received a pamphlet produced by the New Zealand Accident Compensation Corporation about prevention of falls in older adults, which is current recommended practice after a fall. All family physicians in the area were invited to an evening educational session about fall prevention, osteoporosis, and fracture prevention as part of regular regional continuing education. This ensured that the physicians had basic background when referrals were made to them for identified fall risk factors.	Nursing professionals

Table 4. Intervention details, for multifactorial interventions, by author

Author, Year	IG Description	CG Description	Research team personnel delivering assessment
	modification was detected using the standard home assessment. The nurse conducted small alterations such as lightbulb replacement, nonslip bath mats, and coordinating family or community volunteers to paint the edge of outdoor steps with white paint to improve visibility. The intervention assessment was usually undertaken at one visit. The nurse telephoned 2 to 4 weeks later to ensure that referral consultations had taken place. All study participants received a pamphlet produced by the New Zealand Accident Compensation Corporation about prevention of falls in older adults, which is current recommended practice after a fall. All family physicians in the area were invited to an evening educational session about fall prevention, osteoporosis, and fracture prevention as part of regular regional continuing education. This ensured that the physicians had basic background when referrals were made to them for identified fall risk factors.		
Fairhall, 2014[73]	12-month multifactorial intervention was delivered by an interdisciplinary team comprising two physical therapists, a geriatrician, rehabilitation physician, dietitian, and nurse, and was coordinated via regular case conferences and case management. It was tailored to each participant based on baseline CHS frailty criteria and issues identified during comprehensive geriatric evaluation. Ten physiotherapy visits in the 12-month study period focused on exercise. A home program of balance and lower limb strength training was performed in standing, tailored to the individuals' physical impairments and prescribed for 20–30 minutes three to five times per week for 1 year. Full details of the weight-bearing exercise for Better Balance program are available at www.webb.org.au. The physical therapists assessed the home environment, provided safety advice, recommended mobility aids and organized simple modifications to enhance safety. Medical management included medication review and management of chronic health conditions. Participants with significant urinary incontinence were referred to a continence clinic. Participants who met the weight-loss CHS frailty criterion (unintentional weight loss exceeding 4.5 kg in the past year) underwent nutritional assessment and management. Participants were referred to an occupational therapist for home safety interventions when the environment presented a high fall risk. The intervention and control groups received the usual care available to older residents of the Hornsby Ku-ring-gai area from community services and their general practitioner, such as medical management of health conditions, delivery of care requirements, and allied health involvement.	Received usual care available to older residents of the Hornsby Ku-ring-gai area from community services and their general practitioner, such as medical management of health conditions, delivery of care requirements, and allied health involvement.	Medical doctors, nursing professionals, physical therapists, dietician
Ferrer, 2014[74]	Subjects in the intervention group were assessed for their risk of falling and a treatment plan was devised based on their existing medical care and service networks in the community. The intervention used a specific algorithm that identified nine areas of potentially modifiable risk factors for falls, including psychotropic and cardiovascular drug use, auditory acuity, visual acuity, balance and gait disorders, risk of malnutrition, disability, cognitive impairment, social risk, and home safety. A health care professional	Participants in the control group received usual health care.	Medical doctors, nursing professionals

Table 4. Intervention details, for multifactorial interventions, by author

Author, Year	IG Description	CG Description	Research team personnel delivering assessment
	(doctor or nurse from the health center with specialized training in geriatrics) visited participants in the intervention group after their baseline interview to give recommendations according to the algorithm. For cognitively impaired participants, caregivers were required to be an integral part of the program and ensure that the intervention was implemented. Participants were advised to contact their primary physician to review the results, recommendations, and referrals. Each participant's family physician was mailed after the examination to discuss referrals to medical specialists, changes in medication, and follow-up. The algorithm evaluated long-term prescriptions, with special emphasis on significant polypharmacy (five or more prescriptions), progressive discontinuation of benzodiazepines, and nutritional or vitamin supplementation. Subjects were referred to an ophthalmologist if their worst corrected monocular near vision was less than 0.5/1 decimals on the Jaeger chart. If there was visual field impairment, the patient was advised to alter their lighting at home to improve visibility (high ambient light level, conventional wall-plug night-light). Participants with gait disorders were referred to physical therapists for assessment and balance and strength training. There was a focus on progressive balance exercises over 3 months. Information given was reinforced with printed sheets of standard exercises adapted to this age group. The algorithm also generated recommendations for treatment of auditory impairment when the participant was unable to hear a whispered voice at approximately 0.6 m, for risk of malnutrition, and for functional or cognitive decline when deemed necessary. During the second year, two specific interventions were also offered as another set of recommendations, ie, rehabilitation and nutritional assessment. Rehabilitation assessment included subjects with one or more falls and no or minor cognitive impairment (Mini-Mental State Examination (19/35). These subjects received four 90-minute sessions with a physical therapistsover the course of 6 months coordinated by a specialist in rehabilitation at the referral hospital. Subjects at nutritional risk (Mini-Nutritional Assessment score <=23.5/30) had three individual one-hour sessions with a dietician from the referral hospital, who developed plans for individualized nutrition. The nutritionist monitored nutritional intervention at the health care center at 3, 6, and 12 months. At the end of each session, the participants received printed information for use at home.		
Hendriks, 2008[75]	The fall-prevention program consisted of structured medical and OT assessment to assess and address potential risk factors for new falls. The medical assessments were performed at the Maastricht University Hospital and comprised a comprehensive general examination (anamnesis and fall history, cardiovascular, respiratory, abdominal system, and neurological system) and a more-detailed assessment of vision, sense of hearing, locomotor apparatus, feet and footwear, peripheral nervous system, balance and mobility (Romberg and Get Up and Go Test), anthropometry, cognition (Mini-Mental State Examination), affect (Geriatric Depression Scale), blood tests if indicated, and medication use. After the medical assessment, an occupational therapist visited the participants at	Currently, no standard approach to fall risk assessment is available for fallers presenting to the ED and being discharged to home. In usual care in the Netherlands, hospital physicians, specialists, and GPs do not systematically record or address medical	Medical doctors, occupational therapists

Table 4. Intervention details, for multifactorial interventions, by author

Author, Year	IG Description	CG Description	Research team personnel delivering assessment
	home for a structured functional and environmental assessment. Daily functioning was assessed using the 15-item Frenchay Activity Index (FAI) and an OT checklist. Environmental hazards were identified and registered using a home-safety checklist. In addition, the Falls Handicap Inventory (FHI) was used to assess handicaps associated with repeated falls. The participants received recommendations with regard to behavioral change, functional needs, and safety within the home environment. Technical aids and adaptations or additional support were directly referred to and delivered by social and community services. To increase adherence, participants were sent a letter with the recommendations and referrals from the occupational therapist by way of reminder. A copy of this letter was sent to the participants' GPs. The medical assessment was scheduled to take place in the first month after baseline. Subsequently, the home assessment was scheduled within 1 month after the medical assessment. Afterward, a summary of the results and recommendations for further referral were sent to the participants' GP. Therefore, it was scheduled to take at approximately 2.5 months (with a maximum 3.5 months) after baseline measurement for all recommendations to reach the participants and be implemented.	risks and other risk factors for falls, such as environmental hazards in the home and patients' risk behavior. Moreover, when people present to the ED or the GP Cooperative, no systematic attention is usually given to the specific consequences of injurious falls for the daily functioning of individual patients in their unique situation.	
Hogan, 2001[76]	Visited at home by an assessor. Initial visits took 1-2 hours. Upon completion of this initial assessment, all assessors met to discuss the results and agree on an individualized plan designed to decrease the subject's risk of falling. This took about 20 minutes per subject. Recommendations were then communicated in writing to the subject, the attending physician and the source of referral (if different). Although advice would be given by the assessors about how to act on the recommendations, the suggestions were not implemented by the assessors other than referring certain subjects to the exercise class. Subjects were referred to an exercise class designed for elderly people who had fallen, if they had performed poorly on the balance and gait measures, were not attending an exercise program, and agreed to the referral. This was provided in a geriatric day hospital. Subjects participated on average three times in the exercise class. Subjects were also give instruction in an exercise program that they were advised to follow at home.	Home visit from a recreational therapist who performed a leisure assessment. After a brief explanation of the study and what was expected of participants, subjects were asked about their past leisure involvement (e.g., memberships in clubs, hobbies, cultural interests, family pets), personal interests, what motivated them to take part in leisure activities, present activity level and support systems. The visit was similar in duration to the assessment performed on the intervention group. A letter was sent to each subject's attending physician informing him or her of the study and summarizing the baseline information obtained by the RA.	Medical doctors, nursing professionals, physical therapists, occupational therapists

Table 4. Intervention details, for multifactorial interventions, by author

Author, Year	IG Description	CG Description	Research team personnel delivering assessment
Imhof, 2012[77]	Persons in the control and intervention groups received healthcare services as usual provided by community health nurses (23%) and physicians (97%) and covered by the participants' mandatory health insurance. Persons randomized to the intervention group took part in a complimentary 9-month in-home HCP delivered by one of four APNs. The APNs were all registered nurses with a master's degree in Nursing Science. The nurses were prepared for a generalist practice with a role that was similar to that of a clinical nurse specialist. The four nurses had an average of 22 years of work experience in home care and gerontological nursing. A collaborating doctor specialized in geriatrics trained them for the intervention program in comprehensive geriatric assessment. To ensure continuity, the same APN who conducted the pre-randomization assessment delivered the intervention. Three measures were taken to establish consistency among the four intervention nurses. First, APNs were trained for the intervention in a 5-day training program. The consultation followed a standardized sequence of decisions that considered the health problems that the nurse identified and the concerns of the participant. Second, the project team obtained and carefully reviewed a detailed intervention protocol. Discrepancies in documentation or standardization were discussed among the intervention nurses, and decisions for further procedures were made. Third, the intervention nurses participated in regular clinical briefing sessions. The intervention included four home visits (mean length 46 ±6 minutes) after 4, 12, 24, and 36 weeks, and three telephone calls (mean length 17 ±4 minutes) after 8, 18, and 30 weeks. Total intervention time per participant averaged 4 hours. The HCP was developed based on the principles of health promotion, empowerment, partnership, and family-centeredness, as described in behavioral change theories. Interventions were customized to the participants' needs. Intervention nurses used evidence-based guidelines regarding prevalent health concerns such as mobility, vision and hearing, pain, nutrition, cognitive abilities, and bladder control, along with questions of social support and case management, to address the health problems they had identified and the concerns on which participants had chosen to focus. At the end of each visit, participants developed an action plan with concrete activities or strategies to address their health or family concerns. This action plan was evaluated during the following visit or telephone call and served as a basis for further interventions. During the intervention time with participants, nurses engaged in assessment of health and family situation; education and counseling regarding specific health concerns, daily management of symptom or illness, and organization of family or professional care; performing activities that the participant was unable to perform alone; skills training; and evaluation of previous nurse activities and activities that participants had decided to do.	Persons in the control and intervention groups received healthcare services as usual provided by community health nurses (23%) and physicians (97%) and covered by the participants' mandatory health insurance.	Nursing professionals

Table 4. Intervention details, for multifactorial interventions, by author

Author, Year	IG Description	CG Description	Research team personnel delivering assessment
Lightbody, 2002[78]	Following some basic training, therapists and clinicians agreed about the nurse's initial assessment and criteria for onward referral, as some areas require specialist assessment, e.g. provision of aids and adaptations. The intervention group was assessed for risk factors for falls at home by the falls nurse 2–4 weeks following the Index fall (current fall). Medication, ECG, blood pressure, cognition, visual acuity, hearing, vestibular dysfunction, balance, mobility, feet, and footwear were assessed using adapted versions of the falls checklist and ''s'' test. The environmental assessment identified inadequate lighting, tripping hazards, and unsuitable furniture. Patients were given advice and education about safety in the home, and simple modifications were made with consent (e.g., mat removal). Risk factors requiring further action were referred to relatives, community therapy services, social services, and/or the primary care team. Direct referrals were not made to hospital outpatients or day hospital.	Usual care	Nursing professionals
Logan, 2010[79]	The intervention was provided by four community fall teams, which included occupational therapists, physical therapists, and nurses. An individualized multifactorial intervention program was undertaken. This followed the UK clinical fall guidelines in which participants and therapists set treatment goals. Intervention was primarily delivered in participants' homes, but participants were also offered group sessions in community centers. The interventions at home included training in strength and balance for at least six sessions led by the physical therapist; an assessment of hazards in the home and modifications to the environment, including provision of equipment such as chair raisers, minor adaptations such as grab handles, and advice, such as removal of items from the floor and improved lighting; and practice in getting up from the floor (provided by the occupational therapists). The nurse completed a review of drugs and blood pressure readings. As required, the participants were referred to other agencies such as the family doctor for a medical review, or social care for help at home. The same fall prevention team also provided an established rolling program of 12 group sessions on fall prevention, twice weekly over 6 weeks, in local community centers. Each session lasted 2 hours, including 1 hour of muscle strengthening and balance training led by a physical therapist and 1 hour of education and functional activities led by an occupational therapist. Sessions also covered advice on nutrition, pacing, strategies for coping with activities of daily living, hazards in the home, equipment, footwear, and how to get up from the floor. Participants received as many sessions in their own homes as deemed clinically necessary and attended as many group sessions in the rolling program as they wished, up to a maximum of 12. The number of techniques used, their duration, and type was recorded for both the home and the group sessions.	Participants allocated to the control group had no further study intervention after recruitment and were advised by letter to use existing social and medical services as usual.	Nursing professionals, physical therapists, occupational therapists

Table 4. Intervention details, for multifactorial interventions, by author

Author, Year	IG Description	CG Description	Research team personnel delivering assessment
Lord, 2005[80]	The extensive intervention comprised the physiological profile assessment (PPA) report outlining fall risk, a profile of test results, and specific written recommendations for preventing falls. Subjects allocated to this intervention also received a counseling session after the assessment, at which the report and recommendations were explained. If subjects had one or more PPA strength, reaction time, or balance standardized (z) test scores less than -1, they received individualized exercises aimed at improving strength, coordination, and balance. If subjects had one or more PPA vision standardized test scores less than -1, they received interventions for maximizing vision, including referral to an eye specialist, change in spectacles, and cataract surgery. Finally, if subjects had one or more PPA peripheral sensation standardized test scores less than -1, they received a counseling intervention concerned with strategies to compensate for reduced peripheral sensation. Brief descriptions of the interventions follow: The Individualized Exercise Intervention: The exercise classes were conducted twice weekly over a 12-month period at eight sites in northern Sydney. This program was conducted in four 10- to 12-week terms with 2-week inter-term breaks and a 5-week summer vacation break. Five accredited fitness instructors trained to provide the same program led the classes (with one instructor assigned to an exercise venue and exercise session). The number of participants in each exercise class ranged from 9 to 15 (average = 11). The classes comprised a 5- to 10-minute warm-up, a 30-minute conditioning component done as a group, a 10-minute individualized program component and a 5- to 10-minute cool-down. The group conditioning component included exercises aimed at improving strength, flexibility, coordination, and balance. The individualized exercise regimes were based on the subjects' fall risk profiles. Subjects with muscle weakness in specific muscle groups received specific exercises to improve their strength; those with poor balance received standing, leaning, and stepping balance training; and those who performed poorly in the reaction time tests received exercises that challenged speed and coordination. Specific strengthening exercises included seated resistance training, chair-assisted knee bends, wall squats, heel raises, and STS practice. Balance and reaction time and coordination exercises included choice stepping reaction time tasks, ball throw and catch, controlled leaning balance using a sway-meter, step ups onto and over a block, and walking on uneven surfaces. For each exercise, an initial target number of eight repetitions was selected, and this was then increased using the Borg perceived scale of exertion and using strength training progressions according to the American College of Sports Medicine guidelines. Exercise intensity was also increased through the use of weighted ankle cuffs, weight belts, and elastic resistance bands. Individual progression was documented using exercise diaries, which included the number of repetitions completed and the exercise intensity. The Visual Intervention: The visual intervention involved referral to an eye care specialist if participants had not had an eye examination in the previous 6 months. The interventions included new glasses as required, use of single lens spectacles when	The CG received no intervention. At the end of the 12-month trial, these participants received the report outlining their fall risk, a profile of test results, and specific recommendations for preventing falls based on performance.	Unspecified multidisciplinary/ research teams

Table 4. Intervention details, for multifactorial interventions, by author

Author, Year	IG Description	CG Description	Research team personnel delivering assessment
	walking outside the home, and cataract surgery if indicated. A demonstration of the effects of multifocal glasses on distance edge contrast sensitivity was included in a counseling session, and a rationale for not wearing multifocal glasses when walking outside the home was provided. The subjects also received written advice about how to maximize their vision, including wearing spectacles at all times when ambulating, wearing a hat and sunglasses to reduce glare in bright sunshine, taking care when walking outside at night or at dusk, and ensuring that lights are on when walking in the home at night. The Peripheral Sensation Counseling Intervention: This intervention involved counseling about the role that reduced lower limb sensation plays in impaired stability. Subjects were advised to take the following precautions: take particular care when walking on irregular or soft surfaces such as uneven ground and thick carpets, use a walking stick or a sturdy umbrella as a sensor to compensate for sensation loss, wear shoes with low heels and firm rubber soles to maximize balance, and have an assessment with their primary care physician to assess whether any medical condition, such as diabetes mellitus, could be leading to the sensory loss.		
Moller, 2014[81]	The intervention started in 2006 with two nurses working as CMs. The intervention comprised four dimensions: (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, and more). The intervention always included an evaluation of prescribed medications. One of the physicians involved in the project was contacted if any problems with the medication were detected; and (4) safety and continuity (the case managers were contactable by phone during office hours). The CM performed at least one home visit per month during 12 months. During the visit an assessment with the Minimum Data Set for Home Care (MDS-HC) was made. One aspect of the intervention was fall prevention. After the pilot study, the intervention was expanded in 2008 by also employing two physical therapists (PTs). The main reasons for this were that a low degree of physical activity and falls were seen as problems. Sixty-one of the 80 participants in the IG therefore received home visits from both a PT and nurse. The PTs worked together with the nurses, but focused mainly on fall prevention and support for physical exercise. Initially an assessment including the Berg Balance Scale, General Motor Function assessment scale, Fukuda Stepping test, and of deep sensibility in the lower extremities was conducted to assess physical function. The instruments were chosen to obtain an estimation of general physical ability and to examine various risk factors for falls involved in human postural control. They were also chosen because they could be performed at the participants' homes. The results of the assessment, together with the information collected in MDS-HC, helped to create an individual nonsupervised home exercise program that was prescribed in consultation with the participant. Because of the variability in the participant's functional ability, the intensity, frequency, and duration of the individual	No description	Nursing professionals, physical therapists

Table 4. Intervention details, for multifactorial interventions, by author

Author, Year	IG Description	CG Description	Research team personnel delivering assessment
	exercise programs varied, but always included components of leg muscle strength and balance. Efforts were made to continuously, (i.e., at least once a month) support and motivate the participants to be physically active and to evaluate and modify the home exercise program if needed. The intervention also included information about fall prevention and referral to a physician, PT, or occupational therapist in primary or community health care was made when needed. A brief standardized home safety checklist (only available in Swedish) was used to assess environmental risk factors for falls and corrections were made when needed. During the 12-month intervention the PTs performed visits (mean = 10.4) and telephone calls (mean = 0.8) and the nurses performed an average of 11.1 home visits and 1.9 telephone calls for those completing the intervention. For dropouts, the mean number of PT visits and telephone calls were 2.5 and 1.0, respectively, and the mean number of nurse visits and telephone calls were 3.7 and 1.0. The CMs and PTs documented the intervention and were supported by two primary care physicians who were part of the project group.		
Newbury, 2001[82]	An assessment instrument incorporating subjective questions and established instruments was developed. The included components: hearing; vision; physical condition; medication; compliance; vaccination; alcohol and tobacco use; cognition (using Folstein mini-mental state); mood (GDS-15); ADL (Barthel); mobility; nutrition (Australian Nutrition Screening Initiative); social; housing. The assessment took an average of 90 minutes. Also completed SF-36.	Completed SF-36 and usual care.	Nursing professionals
Palvanen, 2014[83]	Strength and balance training: All participants who got less than 8 points from the SPPB test battery received individually tailored strength and balance home-training program or they were referred to a group training supervised by a professional exercise leader. The strengthening program consisted of a combination of exercises for hip abductors and adductors, knee extensors and flexor and ankle dorsiflexors and plantarflexors. The balance program included exercises for both static and dynamic balance, such as one-leg stance, tandem-stance, tandem-walk and weight shifting to difference directions. Many of the exercises were strength-balance combination trainings, such as half-squat, heel-walking, toe-walking, sit-to-stand, and step-on-a-chair. Hip protectors and mobility assistive devices: Use of hip protectors was recommended to all high-risk participants with at least 2 inclusion criteria, especially if they were 80 years of age or older. Similarly, wintertime use of anti-slip shoe devices was advised. Participants were also advised to the use of assistive device, such as a cane or walker, if the measured time in TUG-test was more than 20 seconds. General physical activity and exercise: Advice to increase general physical activity according to the participant's functional ability was given by the Chaos Clinic physical therapist – both orally and by a written physical activity prescription. In addition, the participants received a written home exercise brochure with schematic drawings of balance and low extremity muscle strength training, followed by those of flexibility and endurance training.	The control group received a general injury prevention brochure of the Finnish Prevention of Home Accidents Campaign.	Medical doctors, nursing professionals, physical therapists, unspecified multidisciplinary/ research teams, exercise instructor

Table 4. Intervention details, for multifactorial interventions, by author

Author, Year	IG Description	CG Description	Research team personnel delivering assessment
	Nutrition advice: Guidance for proper nutrition concentrated on information about healthy diet and adequate calcium (1000–1500 mg per day) and vitamin D (600–800 IU per day) intake. If necessary, supplements were recommended and prescribed. Medical review and referrals: The participants were referred to their personal primary care physician for diagnosis and treatment if untreated illnesses or symptoms increasing the risk of falling were found in the medical examination. A referral to optician or ophthalmologist was made if the distance visual acuity was less than 10/20 (Snellen Chart) with or without glasses in the better eye, or less than 6/20 in the poorer eye, or if there was a clear difference in vision between eyes (anisometropia). Similarly, participants with untreated cataract were recommended to contact ophthalmologist for expedited cataract surgery. Medication review: Special attention was paid to medications that were known to increase the risk of falling, especially psychotropic drugs. Reduction of these medications was recommended and redundant psychotropic medications were withdrawn. Alcohol and smoking: If necessary, reduction in alcohol consumption was advised, as well as request to stop smoking. Home hazard assessment and modification: A 1-hour structured home visit was carried out by the physical therapistor the nurse to assess hazards related to safety at home and its environment. This extrinsic risk factor survey was carried out according to the structured checklist made by the Finnish Prevention of Home Accidents Campaign. After the assessment, instructions to reduce and modify the home hazards were given. The home visit also served for reviewing and reinforcing the earlier given nutritional and home exercise advice.		
Perula, 2012[84]	The health centers' medical personnel (family doctors, nurses, and physical therapists) performed the interventions, coordinated by a specialist in physical medicine and rehabilitation. The IG received a multifactorial approach with group and individual activities (appendix 1). The exercise program was designed following the principles described by Campbell, Lord, and colleagues. The workshop included blended exercises for improving flexibility, muscle strength, balance, and gait. Physical activities guidelines were provided in order to improve the aerobic conditioning. Participants received five 90-minute sessions over 3 weeks of treatment. At the end of the sessions participants received a handbook with additional instructions to be implemented at home. To compensate the possible increase of falls with the levels and type of physical activity, time was limited to 120 minutes or more a week of moderate exercise. Moderate physical activities were explained to the workshop participants as "those that require a physical effort that make them breathe a bit harder than normal." We consider moderate physical activities as those between 4 and 6 metabolic equivalents of tasks, such as walking at 5 to 6km/h, riding a bicycle on level ground, swimming at a slow pace, doing exercise using light weights (2–5kg), and gardening. Group Activities	The CG participants received a minimal intervention—a brief piece of advice at the consultation on fall prevention and information leaflet—and received the usual clinical care in their health center. All patients participated in follow-up visits after 3, 6, and 12 months; IG patients had an additional visit at month 9 (the specific aim for this visit was to verify environmental changes recommended to reduce the risk of falling).	Medical doctors, nursing professionals, physical therapists, exercise instructor

Table 4. Intervention details, for multifactorial interventions, by author

Author, Year	IG Description	CG Description	Research team personnel delivering assessment
	1. Health education session given by a nurse. Objectives: to report on the importance of falls among older adults, their frequency and consequences, individual and environmental risk factors, and recommend individual strategies of prevention and guidelines to follow if you have a fall. 2. Physical exercise workshop given by a physical therapist. Objectives: to do combined exercises (individualized according to combined functional capabilities of the participants) to improve flexibility and muscle strength, balance, and gait; to provide some physical activity guidelines to improve the level of aerobic conditions. 3. Practice sessions. Five 90-min sessions distributed over 3wk. Objectives: to learn and practice the exercises. A manual with instructions handed out for participants to continue in their homes (recommending walking at least 30min a day and doing the exercises for 30min at least 4d/wk). Groups were between 10 –16 people. Individual Activities 1. Motivational interview at the family physician's consultation. Objectives: to ensure adherence to recommendations on preventing falls and practicing the exercises, to spot clinical problems considered as fall risk factors and proceed to their treatment. Information leaflet handed out. 2. Home visits (at the beginning and at month 9) by a nurse. Objectives: to assess the environmental conditions and give recommendations, where appropriate, to change them if environmental fall risk factors were found.		
Russell, 2010[85]	A physical therapist, occupational therapist, doctor, or research fellow (allocation depending on time availability) conducted a baseline assessment at the participant's home using a structured protocol. The baseline assessment included demographics, index fall circumstances and injuries, the Falls Risk for Older People in the Community (FROP-Com) assessment, Geriatric Depression Scale Short Form, Modified Falls Efficacy Scale, body mass index, and assessment for postural hypotension. Participants randomized to the intervention group were offered a targeted multifactorial fall-prevention program consisting of referrals to existing community services and health promotion recommendations, in addition to standard care. The assessor developed an individualized program of referrals and recommendations based on the results of the baseline assessment and using the intervention recommendation guidelines. Referrals were made by the baseline assessor, with the participant's consent, to physiotherapy, occupational therapy, podiatry, dietetics, and the participant's family physician. Participants found to be at high risk of falls (FROP-Com score >=25) were referred to a fall clinic for a comprehensive multidisciplinary assessment. Health promotion recommendations included advice to make an appointment with an optometrist, purchase hip protectors, improve footwear safety, and make minor home improvements (e.g., remove loose matting). The participant's personal preferences were taken into account, as were interventions already in	Participants allocated to the standard care group received standard care arranged by ED staff and a letter informing them of their FROP-Com fall risk (low, moderate, or high). The letter advised participants to speak to their family physician about their risk of falling.	Medical doctors, physical therapist, occupational therapists, research fellow

Table 4. Intervention details, for multifactorial interventions, by author

Author, Year	IG Description	CG Description	Research team personnel delivering assessment
	progress after advice from the ED or another source. Community services were selected from all available sources in the participant's locality. Each service provider was sent the relevant assessment results and study information, including a summary of the study aims and methodology.		
Salminen, 2009[86]	Gerriatric assessment, counseling and guidance in fall prevention, home hazards assessment, group physical exercise, home exercise, lectures in groups, and psychosocial groups. All participants in the IG had one 45-minute contact with an experienced geriatrician. The assessment included measurements of specific risk factors of falling, such as polypharmacy, use of psychotropic and other medications that increase the risk of falls, diseases and disorders affecting balance and gait, poor eyesight, poor nutritional status, and depression. During interviews with the geriatrician, the rationale for using every drug was marked in the patient record. Taking into account the diagnosed diseases and based on these pieces of information, the geriatrician assessed the appropriateness, total amount, and daily dosage of each drug used by the participants in the IG. A new drug was prescribed if the interviews and clinical examinations showed a new or inappropriately treated disease. Psychotropic drugs, opioids, and strong anticholinergics were defined as FRIDs. Individual plans were created for the participants in the IG to gradually reduce their total amount or daily doses of FRIDs. The needs and practical instructions for changes of drugs were discussed with the participants and provided in writing. The changes were entered in the medical records of each participant, and the participants were referred to primary care physicians for follow-up regarding changes in drugs. Distance visual acuity of all participants in the IG was assessed. A referral to an ophthalmologist was made if distance visual acuity was less than 0.5 (Snellen Chart) with or without glasses, the difference in vision between eyes was greater than 0.3, or the participant had complaints about poor vision. Alendronate (70 mg/wk) was prescribed depending on bone density measurement results. All participants were prescribed calcium (500 mg/d) and vitamin D3 (400 IU/d) supplements, if not previously taken. A trained public health nurse gave all participants in the IG oral and written information about minimizing internal risk factors of falling, safe environment, healthy diet, calcium and vitamin D supplementation, and use of hip protectors. Home hazards assessment conducted by trained nursing students included a thorough assessment of the home environment with a detailed form. According to the assessments, participants received instructions for modifications to improve safe home environments. The home environment was rechecked and the modifications performed were checked after a year. Results about changes in home environments will be described in a forthcoming paper. The subjects in the IG were divided into three physical exercise groups according to their physical function as assessed according to the BBS, muscle strength, and peak expiratory flow. Exercises were performed in groups of four to 10 every second week under the guidance of aphysical therapist. Each session (45–50 minutes) began with	Subjects attended one session of counseling and guidance on specified risk factors for falling at the beginning of the follow-up.	Medical doctors, nursing professionals, other modern health professionals, nursing student, physical therapist

Table 4. Intervention details, for multifactorial interventions, by author

Author, Year	IG Description	CG Description	Research team personnel delivering assessment
	warming up (5 minutes), including brisk walking and upper body movements. Balance, coordination, and weight-shifting exercises (15 minutes) included standing on one foot, toes, and heels; semitandem stance and squat, tandem stance and squat; reaching forward; bending down; marching in place lifting the knees; and walking exercises such as heel–toe walking, walking backward, stepping sideward, walking in a figure eight, and tandem walking. Circuit training for muscle strength (20 minutes) included training of the lower extremities (hip and knee extensors and flexors, ankle plantar and dorsal flexors) and the abdominal and back muscles using the participants' body weight. Muscle strength training consisted of sit-to-stand, one-leg squat, and toe and heel rises. Each exercise was performed for 45 seconds, and the rest time between the exercises was approximately 30 seconds, including the transition from one exercise to another. Two to four circuits were performed with 3- to 5-minute rest between the circuits. Cool-down (5–10 minutes) included stretching of the muscle groups trained and relaxation exercises. The intensity of the exercises was measured after each session using the Borg Rating of Perceived Exertion Scale, and intensity was progressively increased according to subjects' fitness level. Holding onto a rail was allowed if required by participants' health status. The use of the rail was gradually reduced during the intervention. The subjects were advised to perform similar physical exercises three times a week at home. The subjects received written information for performing home exercises and were encouraged to record their daily physical activity in exercise diaries. Lectures by health professionals were provided to IG participants once a month on various topics such as causes of falling, fall prevention, nutrition, home hazards, and physical exercise. One lecture covered medications as risk factors for falls. Psychosocial group activities offered recreational activities and psychological support. IG participants were divided into two groups according to mental health. Those with few contacts, who felt lonely or depressed (>10 sum points on the GDS) were advised to join the smaller ''support'' group. All the others were referred to a larger psychosocial group. Nursing students organized the sessions once a month.		
Spice, 2009[87]	Secondary care intervention group participants attended a one-stop multi-disciplinary clinic with referral for investigations, interventions (including Homecheck) and follow-up if necessary. Intervention assessments in the primary and secondary groups were standardized: further management of each participant was then individualized, with no specific protocol, and interventions were recorded. Potential components of intervention included: Medication changes, Physiotherapy, OT, Nursing interventions, Homecheck, and/or Social services (Appendix 7).The baseline assessment looked at demographic information, abbreviated mental test score, modified Barthel index, timed 'Get up and Go' test, medical diagnoses, drug history, details of the index fall and previous falls and risk factors for osteoporosis.	The usual care group received a baseline assessment, but was managed by their primary care team without specific guidance: referral to routine services was at the discretion of the primary care clinicians.	Nursing professionals

Table 4. Intervention details, for multifactorial interventions, by author

Author, Year	IG Description	CG Description	Research team personnel delivering assessment
Tinetti, 1994[88]	The baseline assessments were conducted in the subjects' homes by the study nurse practitioner and physical therapist, who were unaware of the group assignments. The nurse practitioner obtained demographic data, a history of falls, and information on depressive symptoms, the presence of chronic diseases, and the level of independence in activities of daily living and administered the Falls Efficacy Scale, a measure of the subject's degree of confidence in performing 10 common activities (such as walking and stair climbing) without falling, and the ambulation and mobility subscales of the Sickness Impact Profile. She also assessed corrected near vision and hearing. The names and dosages of all prescription and nonprescription medications were recorded from the containers. The number of hazards for falling was determined by a room-by-room examination of walking paths, furniture, and stairs. Within one week of the nurse practitioner's assessment, the physical therapist visited the subjects to assess the risk factors (impairment in gait, impairment in transfer skills or balance, impairment in leg or arm muscle strength or range of motion). Strength and joint impairment were identified by manual muscle testing and tests of range of motion, respectively. The assessments of balance and transfer skills involved observing the subjects for instability while they were sitting, moving to and from a chair or bed, standing, carrying objects, bending over, and reaching. Deviation from a path, missed steps, step height and length, stability in turning, trunk position, and appropriate use of walking aids were observed while the subjects walked 6.1 m (20 ft) on flat and uneven surfaces.These assessments were repeated for 250 of the 301 participants (83 percent) a median of 4.5 months after the base-line assessment. The staff members performing the reassessments did not know the subjects' group assignments. Interventions: 1. Postural hypotension - behavioral recommendations, such as ankle pumpsor hand clenching and elevation of head or bed; decrease in dosage, discontinuation, or substitution for medications that may contribute. 2. Use of benzodiazepine - education about the appropriate use of sedative-hypnotic agents; nonpharmocologic treatment of sleep problems, such as sleep restriction; tapering and discontinuation of medications 3. Use of 4+ medications - review of medications with PCP 4. Inability to transfer safely to bathtub or toilet - training in transfer skills; environmental alterations, such as grab bars or handrails on stairs 5. Environmental hazards - appropriate changes, such as removal of hazards, safer furniture, and installation of structures such as grab bars or handrails on stairs. 6. Gait impairment - Gait training; use of appropriate assistive device; balance or strengthening exercises if indicated 7. Impairment in transfer skills or balance - balance exercises; training in transfer skills if indicated; environmental alterations Impairment in leg or arm muscle strength or range of motion - exercises with restrictive bands and putty; resistance was increased when the subject was able to complete 10 repetitions through the full range of motion	Usual care and social visits: The subjects assigned to the control group received home visits from social-work students, during which structured interviews were conducted. The number of social visits was matched to the estimated number of visits by a nurse practitioner or physical therapist that would be required for subjects in the intervention group who had comparable risk factors.	IG: Nursing professionals, physical therapist CG: Social work students

Table 4. Intervention details, for multifactorial interventions, by author

Author, Year	IG Description	CG Description	Research team personnel delivering assessment
van Haastregt, 2000[89]	Participant in the intervention group received five home visits from a community nurse over a period of one year. During the home visits they were screened for several medical, environmental, and behavioral factors potentially influencing falls and mobility. The screening was followed by advice, referrals, and other actions aimed at dealing with the hazards observed. The nurses followed a structured protocol for the home visits, which focused on falls, fear of falling, mobility, physical health, drugs, activities of daily living, social functioning, cognitive functioning, and psycho-social functioning. The protocol also included a check-list for home safety.	Usual care	Nursing professionals
Vind, 2009[90]	A team consisting of a doctor, a nurse, and a physical therapistexamined participants in the intervention group during two initial visits at the geriatric outpatient clinic. The assessment performed by the doctor lasted 1 hour, and those by the nurse and physical therapist lasted 1.5 hours each. Standardized assessments, with clear definitions of which results were normal and abnormal, were performed. Assessment Components: 1. Medical: medical history, drug review, Mini-Mental State Examination, Geriatric Depression Scale, PPA short, vision and visual acuity, blood samples, electrocardiogram, clinical examination focusing on cardiovascular, neurological and vestibular deficiencies, dual-energy X-ray absorptiometry scan, orthostatic blood pressure. 2. Cardiovascular: event recording, head-up tilt test, carotid sinus massage in supine and head-up position. 3. Physical ability: Berg Balance Scale, Dynamic Gait Index, sit to stand in 30 seconds, Timed Up and Go, dynamic visual acuity. After assessments, the team and a senior geriatrician characterized falls as a single, well-explained fall, repeated or unexplained falls, or falls with unconsciousness. Discovered risk factors were discussed, and individual interventions were planned and offered to the patients. Most interventions took place at the falls clinic at the outpatient department and were performed by the research team. The doctor initially investigated untreated medical disease and initiated treatment and modified drugs if indicated. In case of suspicion of more-serious neurological or cardiological disease, patients were referred to specialists in the field within the hospital. Pacemakers were implanted at another hospital after referral. Follow-up visits were provided for evaluation. Participants offered intervention by the physical therapistwere prescribed and instructed in progressive, individualized exercise that was evaluated and intensified at follow-up visits; upon completion of the planned program, they were informed about possibilities for continued exercise in their local community, along with prescribed home exercises. Intervention Components: 1. Medical: By research team: investigation and treatment of untreated medical disease, drug modification if possible, correction of vitamin deficiency, treatment of osteoporosis, advice or referral to optician or ophthalmologist. By referral: suspicion of serious neurological disease, referral to neurologist. 2. Cardiovascular: By research team: treatment of atrial fibrillation, advice and, if	Participants in the control group received usual care, as planned during admission or in the emergency department.	Medical doctors, nursing professionals, physical therapists

Table 4. Intervention details, for multifactorial interventions, by author

Author, Year	IG Description	CG Description	Research team personnel delivering assessment
	indicated, drug modification, compression stockings. By referral: other arrhythmias, medical treatment of vasodepressor syncope, pacemaker implantation. 3. Physical ability: By research team: hospital-based, individualized, progressive strength and balance training and vestibular rehabilitation in combination with instruction in home exercises regarding strength, balance, and vestibular rehabilitation.		
Wagner, 1994[91]	The goal of the experimental intervention was to modify risk factors for disability and falls among seniors considered to be at risk. Specific interventions targeted those seniors who were physically inactive, drank alcohol to excess, had hazards in the home (for those with an increased risk of falls), used prescription drugs that increased the risk of falls or mental impairment, or had uncorrected hearing or visual impairments. The individuals in group 1 received invitations to attend a 60- to 90-minute visit with a specially trained nurse/educator. The objectives of the visit were to review risk factors assessed on the baseline questionnaire, perform screening audiometry and blood pressure measurement, develop a tailored follow-up intervention plan to address identified risk factors, and motivate seniors to increase physical and social activity. The follow-up options included interventions for each of the six risk factors mentioned above. The exercise intervention, which was designed for this study, consisted of a 2-hour exercise orientation class that tested fitness using a timed walk of one-quarter mile and used instruction and encouragement to begin a program of brisk walking. The alcohol intervention included screening and referral to the Cooperative's alcohol treatment program for those with suspected alcoholism; for those at high risk but not meeting the criteria for alcoholism, a booklet was provided that was designed by the project team and that highlighted both the pharmacological effects of alcohol in older adults and behavioral strategies for limiting use. The nurse encouraged seniors at high risk of falling to have home safety inspections conducted either by a trained volunteer or by the participant or family with guidance from an instructional home safety checklist. For each intervention subject, the nurse received a drug profile generated from the Cooperative's computerized pharmacy database. After the visit, the nurse notified a pharmacist about those seniors taking psychoactive drugs (psychotropics and cardiovascular agents such as sedative-hypnotics, tranquilizers, antidepressants, and alpha- and beta-blockers), paying particular attention to those who reported drowsiness or dizziness. The pharmacist reviewed the drug and questionnaire data, examined the medical record if needed, and made written recommendations for regimen changes to the patient's primary care team. Interventions for the hearing and vision impaired were designed primarily to provide supports and encouragement, not medical treatment. Patients with previously unknown or untreated hearing deficits were referred for formal audiological and hearing aid evaluation. Behavioral intervention classes were provided for patients with uncorrectable hearing deficits. Seniors with uncorrectable visual impairments received information about resources in the community designed to assist those with poor vision in maintaining activity and function. The nurse provided follow-up phone calls and mailed reminders. One or two follow-up	Usual care controls received no specific preventive interventions.	Nursing professionals

Table 4. Intervention details, for multifactorial interventions, by author

Author, Year	IG Description	CG Description	Research team personnel delivering assessment
	phone calls were made in the first month after the visit for those receiving interventions. Written summaries of risk factors and the prevention plan were placed in the subject's medical record in hopes that the primary care team would reinforce intervention efforts.		

Abbreviations: ADL = activities of daily living; APH = advanced practice nurse; CG = control group; CHS = Cardiovascular Health Study; CM(s) = case manager(s); d = day(s); DVD = digital versatile disk; ECG = electrocardiogram; ED = emergency department; FRID(s) = fall-risk increasing drugs; FROP-Com = Falls Risk for Older People in the Community; ft = feet; GDS = Geriatric Depression Scale; GP = general practice/general practitioner; HCP = health consultation program; IG = intervention group; IU = international unit(s); kg = kilogram(s); m = meter(s); mg = milligram(s); min = minute(s); ng/mL = nanograms per milliliter; NR = not reported; OT = occupational therapy/ist; OU = oculus uterque (both eyes); PCP = primary care provider; PPA = physiological profile assessment; PT(s) = physical therapist(s); RA = research associate/assistant; SF-36 = short form 36; SPPB = short physical performance battery; STS = sit-to-stand; TUG = Timed Up-and-Go; UK = United Kingdom; wk(s) = week(s)

Table 5. Falls, for multifactorial interventions, by author

Author, Year	Time	Group	Number of falls	Number analyzed	Event rate, per person-year†	IRR†	(95% CI)	
Close, 1999[67]	12	IG1	183	184	0.99	0.42	(0.35,	0.49)
		CG	510	213	2.39			
Cohen, 2015[68]	6	IG1	NR	NR	NR	0.79*	(0.69	0.91)
	9	IG1	NR	NR	NR	0.80*	(0.71	0.89)
	12	IG1	NR	NR	NR	0.87*	(0.79	0.96)
Conroy, 2010[69]	12	IG1	260	172	1.7*	0.64**	(0.43	0.95)
		CG	417	172	2.7*			
Davison, 2005[70]	12	IG1	435	144	3.3*	0.65	(0.58,	0.72)
		CG	1251	149	5.1*			
Elley, 2008[72]	12	IG1	285	155	1.9*	0.96**	(0.70	1.34)
		CG	299	157	2.0*			
Fairhall, 2014[73]	12	IG1	183	120	1.52	1.12**	(0.78	1.63)
		CG	178	121	1.47			
Ferrer, 2014[74]	12	IG1	57	164	0.35	0.85*	(0.51	1.40)
		CG	62	164	0.38			
Hogan, 2001[76]	12	IG1	241	79	3.05	0.82	(0.70,	0.97)
		CG	311	84	3.70			
Lightbody, 2002[78]	6	IG1	141	155	1.82	0.85	(0.68,	1.06)
		CG	171	159	2.15			
Logan, 2010[79]	12	IG1	NR	NR	3.5*	0.45**	(0.35	0.58)
		CG	NR	NR	7.7*			
Lord, 2005[80]	12	IG1	183	202	0.91	1.03**	(0.78	1.35)
		CG	175	201	0.87			
Moller, 2014[81]	12	IG1	96	80	1.20	1.03	(0.77,	1.38)
		CG	85	73	1.16			
Palvanen, 2014[83]	12	IG1	608	661	0.95*	0.72*	(0.61	0.86)
		CG	825	653	1.3*			
Russell, 2010[85]	12	IG1	908	344	2.8*	0.87**	(0.65	1.17)
		CG	1449	354	4.2*			
Salminen, 2009[86]	12	IG1	243	292	0.83	0.92*	(0.72	1.19)
		CG	271	297	0.91			
Tinetti, 1994[88]	12	IG1	94	147	0.6*	0.69	(0.43	1.10)
		CG	164	144	0.9*			
Vind, 2009[90]	12	IG1	422	196	2.15	1.06	(0.92,	1.22)
		CG	398	196	2.03			

Abbreviations: CG = control group; CI = confidence interval; IG = intervention group; IRR = incidence rate ratio; NR = not reported

† Calculated

* Author reported event rate or IRR, no adjustment or adjustment not reported

**Author reported event rate or adjusted IRR

Table 6. Injurious falls, for multifactorial interventions, by author

Author, year	Outcome	Outcome description	Time, months	Group	Events	N analyzed	Event rate, per person-year[†]	IRR[†]	(95% CI)	
Elley, 2008[72]	Injurious falls	Combines serious and moderate injuries from falls. Serious included fracture, hospital admission, or sutures. Moderate included bruising, sprains, cuts, abrasions, seeking medical attention or a decrease in physical function for a period of 3 days or more.	12	IG	170	155	1.14*	1.09	(0.87,	1.35)
				CG	156	157	1.05*			
Fairhall, 2014[73]	Injurious falls	NR	12	IG	75	120	0.62	0.97	(0.71,	1.33)
				CG	78	121	0.64			
Lightbody, 2002[78]	Falls resulting in admission	NA	6	IG	8	155	0.10	0.82	(0.32,	2.08)
				CG	10	159	0.12			
Moller, 2014[81]	Injurious falls	NR	12	IG	40	80	0.5	0.96	(0.62,	1.50)
				CG	38	73	0.52			
	Falls with injuries resulting in health care	NA	12	IG	19	80	0.24	1.16	(0.59,	2.27)
				CG	15	73	0.20			
Palvanen, 2014[83]	Fall-induced injuries	Includes soft tissue bruises and contusions, wounds and lacerations, bone fractures, joint distortions and dislocations, head injuries other than fractures, other injuries.	12	IG	351	661	0.55*	0.74*	(0.61,	0.89)
				CG	468	653	0.75*			
Russell, 2010[85]	Fall-induced injuries	NR	12	IG	352	344	1.07*	1.08**	(0.78,	1.48)
				CG	344	354	1.01*			
	Fall-induced serious injuries	NR	12	IG	30	344	0.09*	1.31**	(0.77,	2.23)
				CG	26	354	0.08*			
	Fall-related ER visit	NA	12	IG	57	344	0.18*	1.03**	(0.68,	1.54)
				CG	58	354	0.18*			
Salminen, 2009[86]	Falls with major injuries	Joint dislocations, lacerations requiring sutures, fractures and severe head injuries (e.g., hemorrhages)	12	IG	14	293	0.048	1.42	(0.63,	3.21)
				CG	10	298	0.034			
			24	IG	26	293	0.044	1.02	(0.59,	1.75)
				CG	26	298	0.044			
			36	IG	39	293	0.044	1.07	(0.68,	1.68)
				CG	37	298	0.041			
	Falls resulting in medical care	NA	12	IG	48	293	0.16	1.04*	(0.64,	1.69)
				CG	48	298	0.16			
			24	IG	80	293	0.14	0.83	(0.62,	1.12)
				CG	98	298	0.16			

Table 6. Injurious falls, for multifactorial interventions, by author

Author, year	Outcome	Outcome description	Time, months	Group	Events	N analyzed	Event rate, per person-year†	IRR†	(95% CI)	
			36	IG	124	293	0.14	0.87*	(0.63,	1.21)
				CG	146	298	0.16			
Tinetti, 1994[88]	Falls causing serious injury	Serious injuries included fractures, head injuries requiring hospitalization, joint dislocations or severe sprains, and lacerations requiring suturing.	12	IG	13	147	0.088	0.71	(0.27,	1.87)
				CG	18	144	0.12			
	Falls resulting in medical care	NA	12	IG	25	147	0.17	0.68	(0.34,	1.36)
				CG	36	144	0.25			
Vind, 2009[90]	Injurious falls	Leading to a visit to a primary care physician or emergency department or hospitalization	12	IG	44	196	0.22	0.79	(0.53,	1.17)
				CG	56	196	0.29			
	Fall-related admission	NA	12	IG	39	196	0.20	2.44	(1.36,	4.36)
				CG	16	196	0.08			
	Fall-related ER visit	NA	12	IG	41	196	0.21	1.32	(0.83,	2.11)
				CG	31	196	0.16			

Abbreviations: CG = control group; CI = confidence interval; ER = emergency room; IG = intervention group; IRR = incidence rate ratio; NA = not applicable; NR = not reported

† Calculated
* Author reported, unadjusted or adjustment not reported
** Author reported, adjusted

Table 7. Fractures, for multifactorial interventions, by author

Author, year	Outcome	Time, months	Group	Events	N analyzed	Event rate,† per person-year	IRR†	(95% CI)	
Fairhall, 2014[73]	Fall resulting in fracture	12	IG	13	120	0.11	1.09	(0.50,	2.39)
			CG	12	121	0.099			
Palvanen, 2014[83]	Fall-related fracture	12	IG	33	661	0.05*	0.77*	(0.48,	1.23)
			CG	42	653	0.07*			
Russell, 2010[85]	Fall-related peripheral fracture	12	IG	11	344	0.03*	0.76**	(0.35,	1.63)
			CG	17	354	0.05*			
Salminen, 2009[86]	Fall-related fracture	12	IG	11	293	0.038	1.40	(0.56,	3.48)
			CG	8	298	0.027			
		24	IG	16	293	0.027	0.86	(0.44,	1.67)
			CG	19	298	0.032			
		36	IG	27	293	0.031	0.98	(0.58,	1.66)
			CG	28	298	0.031			
	Fall-related hip fracture	12	IG	1	293	0.0034	1.02	(0.06,	16.26)
			CG	1	298	0.0034			
		24	IG	2	293	0.0034	1.02	(0.14,	7.22)
			CG	2	298	0.0034			
		36	IG	4	293	0.0046	1.02	(0.25,	4.07)
			CG	4	298	0.0045			
Vind, 2009[90]	Hip fracture	12	IG	6	196	0.031	0.55	(0.20,	1.47)
			CG	11	196	0.056			

Abbreviations: CG = control group; CI = confidence interval; IG = intervention group; IRR = incidence rate ratio.

† Calculated
* Author reported, unadjusted or adjustment not reported
** Author reported, adjusted

Table 8. People experiencing a fall, for multifactorial interventions, by author

Author, Year	Time, months	Number of falls per person	Group	People experiencing a fall, n	n analyzed	Percent	RR[†]	(95% CI)	
Ciaschini, 2009[66]	6	≥1	IG	26	101	25.7	1.51**	(0.88,	2.61)
			CG	17	100	17.0			
Close, 1999[67]	12	≥1	IG	59	184	32.1	0.62	(0.48,	0.79)
			CG	111	213	52.1			
		≥3	IG	21	184	11.4	0.44	(0.28,	0.70)
			CG	55	213	25.8			
Cohen, 2015[68]	6	≥1	IG	229	1661	13.8	0.82*	(0.70,	0.96)
			CG	305	1815	16.8			
	9	≥1	IG	312	1615	19.3	0.78*	(0.68,	0.89)
			CG	434	1756	24.7			
	12	≥1	IG	416	1586	26.2	0.89*	(0.79,	1.00)
			CG	504	1715	29.4			
Conroy, 2010[69]	12	≥1	IG	69	136	50.7	0.96	(0.76,	1.21)
			CG	73	138	52.9			
		≥2	IG	38	136	27.9	1.01	(0.69,	1.49)
			CG	38	138	27.5			
Davison, 2005[70]	12	≥1	IG	94	144	65.3	0.95*	(0.81,	1.12)
			CG	102	149	68.5			
de Vries, 2010[71]	12	≥1	IG	55	106	51.9	0.93	(0.73,	1.19)
			CG	62	111	55.9			
		≥2	IG	37	106	34.9	1.11	(0.76,	1.62)
			CG	35	111	31.5			
Elley, 2008[72]	12	≥1	IG	106	155	68.4	1.10	(0.93,	1.29)
			CG	98	157	62.4			
		≥2	IG	69	155	44.5	1.29	(0.98,	1.71)
			CG	54	157	34.4			
Fairhall, 2014[73]	12	≥1	IG	72	120	60.0	1.08	(0.87,	1.35)
			CG	67	121	55.4			
		≥2	IG	32	120	26.7	0.87	(0.58,	1.30)
			CG	37	121	30.6			
Ferrer, 2014[74]	12	≥1	IG	40	142	28.2	1.12	(0.75,	1.66)
			CG	33	131	25.2			
Hendriks, 2008[75]	12	≥1	IG	55	124	44.4	0.97	(0.74,	1.28)
			CG	61	134	45.5			
		≥2	IG	32	124	25.8	1.02	(0.67,	1.54)
			CG	34	134	25.4			
Hogan, 2001[76]	12	≥1	IG	54	79	68.4	0.94	(0.77,	1.15)
			CG	61	84	72.6			
		≥3	IG	26	79	32.9	0.79	(0.53,	1.18)
			CG	35	84	41.7			

Table 8. People experiencing a fall, for multifactorial interventions, by author

Author, Year	Time, months	Number of falls per person	Group	People experiencing a fall, n	n analyzed	Percent	RR[†]	(95% CI)	
Lightbody, 2002[78]	6	≥1	IG	39	155	25.2	0.98	(0.67,	1.42)
			CG	41	159	25.8			
Logan, 2010[79]	12	≥1	IG	81	102	79.4	0.84	(0.76,	0.94)
			CG	96	102	94.1			
Lord, 2005[80]	12	≥1	IG	93	202	46.0	1.03*	(0.83,	1.27)
			CG	90	201	44.8			
		≥2	IG	49	202	24.3	1.08*	(0.76,	1.54)
			CG	45	201	22.4			
Moller, 2014[81]	12	≥1	IG	44	80	55.0	1.15	(0.84,	1.56)
			CG	35	73	47.9			
		≥2	IG	19	80	23.8	0.75	(0.45,	1.27)
			CG	23	73	31.5			
		≥3	IG	13	80	16.3	1.08	(0.52,	2.25)
			CG	11	73	15.1			
Palvanen, 2014[83]	12	≥1	IG	296	661	44.8	0.84	(0.75,	0.94)
			CG	349	653	53.4			
Perula, 2012[84]	6	≥1	IG	10	133	0.15	0.66	(0.33,	1.30)
			CG	31	271	0.23			
	12	≥1	IG	23	133	0.17	0.73	(0.48,	1.12)
			CG	64	271	0.24			
Russell, 2010[85]	12	≥1	IG	163	320	50.9	1.11*	(0.95,	1.31)
			CG	151	330	45.8			
Salminen, 2009[86]	12	≥1	IG	140	292	47.9	1.09	(0.91,	1.30)
			CG	131	297	44.1			
Spice, 2009[87]	12	≥1	IG	158	210	75.2	0.90	(0.77,	1.05)
			CG	133	159	83.6			
Tinetti, 1994[88]	12	≥1	IG	52	147	35.4	0.76**	(0.53,	1.06)
			CG	68	144	47.2			
van Haastregt, 2000[89]	12	≥1	IG	63	129	48.8	1.13	(0.87,	1.48)
			CG	53	123	43.1			
		≥2	IG	34	129	26.4	1.12	(0.73,	1.72)
			CG	29	123	23.6			
	18	≥1	IG	68	120	56.7	1.12	(0.88,	1.43)
			CG	58	115	50.4			
		≥2	IG	43	120	35.8	1.18	(0.82,	1.70)
			CG	35	115	30.4			
Vind, 2009 [90]	12	≥1	IG	110	196	56.1	1.09	(0.91,	1.31)
			CG	101	196	51.5			
		≥3	IG	43	196	21.9	0.98	(0.67,	1.42)
			CG	44	196	22.4			

Table 8. People experiencing a fall, for multifactorial interventions, by author

Author, Year	Time, months	Number of falls per person	Group	People experiencing a fall, n	n analyzed	Percent	RR†	(95% CI)	
Wagner, 1994[91]	12	≥1	IG	175	635	27.6	0.75	(0.64,	0.88)
			CG	223	607	36.7			

Abbreviations: CG = control group; CI = confidence interval; IG = intervention group; RR = relative risk

† Calculated
* Author reported RR, unadjusted or adjusted not reported
** Author reported RR, adjusted for clustering

Table 9. People experiencing an injurious fall, for multifactorial interventions, by author

Author, year	Outcome	Detailed outcome description	Time, months	Group	Person with injury	N analyzed	RR[†]	(95% CI)	
Close, 1999[67]	Person with serious injury from fall	NR	12	IG	8	184	0.58	(0.25,	1.32)
				CG	16	213			
Cohen, 2015[68]	Person with injurious fall	NR	6	IG	136	1661	0.79*	(0.64,	0.98)
				CG	189	1815			
			9	IG	186	1615	0.73*	(0.62,	0.87)
				CG	276	1756			
			12	IG	254	1586	0.82*	(0.71,	0.96)
				CG	333	1715			
Conroy, 2010[69]	Person with injurious fall	NR	12	IG	56	136	1.03	(0.78,	1.38)
				CG	55	138			
Davison, 2005[70]	Person with fall-related admission	NA	12	IG	14	159	0.80*	(0.41,	1.56)
				CG	17	154			
	Person with fall-related ER visit	NA	12	IG	25	159	0.90*	(0.55,	1.47)
				CG	27	154			
Hendriks, 2008[75]	Person with injurious fall	Sought medical care after a fall	12	IG	14	124	0.76	(0.40,	1.43)
				CG	20	134			
Hogan, 2001[76]	Person with fall-related admission	NA	12	IG	5	79	0.89	(0.28,	2.79)
				CG	6	84			
	Person with fall-related ER visit	NA	12	IG	9	79	1.20	(0.49,	2.95)
				CG	8	84			
Imhof, 2012[77]	Person with a fall with consequences	Fractures, hematomas, open wounds, or pain for several days.	9	IG	131	207	0.80	(0.71,	0.91)
				CG	162	206			
Lord, 2005[80]	Person with injurious fall	Falls that resulted in bruises, strains, cuts and abrasions, back pain, and fractures.	12	IG	80	202	1.19*	(0.92,	1.54)
				CG	67	201			
Moller, 2014[81]	Person with injurious fall	NR	12	IG	30	80	1.01	(0.67,	1.53)
				CG	27	73			
	Person with a fall resulting in medical care	NA	12	IG	15	80	1.52	(0.71,	3.26)
				CG	9	73			
Russell, 2010[85]	Person with fall-related injury	NR	12	IG	118	320	1.06*	(0.86,	1.29)
				CG	115	330			
	Person with serious injury from fall	NR	12	IG	23	320	1.03*	(0.59,	1.80)
				CG	23	330			
Salminen, 2009[86]	Person with a fall resulting in medical care	NA	36	IG	89	293	1.10	(0.86,	1.42)
				CG	82	298			
Spice, 2009[87]	Person with fall-related admission	NA	12	IG	39	210	1.09	(0.56,	2.14)
				CG	27	159			

Table 9. People experiencing an injurious fall, for multifactorial interventions, by author

Author, year	Outcome	Detailed outcome description	Time, months	Group	Person with injury	N analyzed	RR†	(95% CI)	
Tinetti, 1994[88]	Person with serious injury from fall	Serious injuries included fractures, head injuries requiringhospitalization, joint dislocations or severe sprains, and lacerations requiring suturing.	12	IG	12	147	0.84	(0.31,	2.29)
				CG	14	144			
	Person with a fall resulting in medical care	NA	12	IG	21	147	0.79	(0.39,	1.62)
				CG	26	144			
van Haastregt, 2000[89]	Person with injurious fall	NR	12	IG	26	129	1.18	(0.70,	1.98)
				CG	21	123			
			18	IG	33	120	1.26	(0.80,	1.99)
				CG	25	115			
	Person with a fall resulting in medical care	NA	12	IG	15	129	1.30	(0.62,	2.72)
				CG	11	123			
			18	IG	21	120	1.44	(0.77,	2.69)
				CG	14	115			
Vind, 2009[90]	Person with injurious fall	NR	12	IG	34	196	0.97	(0.63,	1.49)
				CG	35	196			
Wagner, 1994[91]	Person with injurious fall	NR	12	IG	63	635	0.68	(0.51,	0.93)
				CG	88	607			
	Person with a fall resulting in medical care	NA	12	IG	42	635	0.70	(0.48,	1.03)
				CG	57	607			

Abbreviations: CG = control group; CI = confidence interval; ER = emergency room; IG = intervention group; NA = not applicable; NR = not reported; RR = relative risk

† Calculated

* Author reported, unadjusted or adjustment not reported

** Author reported, adjusted

Table 11. Mortality, for multifactorial interventions, by author

Author, year	Outcome	Time, months	Group	Person with fracture	N analyzed	RR	(95% CI)	
Ciaschini, 2009[66]	Person with fragility fracture	6	IG	1	101	0.17*	(0.02,	1.35)
			CG	6	100			
Davison, 2005[70]	Person with hip fracture	12	IG	1	159	0.48*	(0.04,	5.29)
			CG	2	154			
Perula, 2012[84]	Person with fall-related fracture	12	IG	1	133	1.02*	(0.09,	11.2)
			CG	2	271			
Russell, 2010[85]	Person with peripheral fracture from a fall	12	IG	8	320	0.55*	(0.24,	1.28)
			CG	15	330			
Spice, 2009[87]	Person with fall-related fracture	12	IG	40	210	0.87	(0.47,	1.59)
			CG	35	159			

Abbreviations: CG = control group; CI = confidence interval; IG = intervention group; RR = relative risk

* Author reported, unadjusted or adjustment not reported

Table 11. Mortality, for multifactorial interventions, by author

Author, year	Time, months	Group	Deaths	n analyzed	RR†	(95% CI)	
Ciaschini, 2009[66]	12	IG1	6	101	1.49	(0.43,	5.10)
		CG	4	100			
Close, 1999[67]	12	IG1	19	184	0.81	(0.47,	1.42)
		CG	27	213			
Conroy, 2010[69]	12	IG1	9	182	0.99	(0.40,	2.45)
		CG	9	181			
Davison, 2005[70]	12	IG1	3	159	0.58	(0.14,	2.39)
		CG	5	154			
Elley, 2008[72]	12	IG1	7	155	1.77	(0.53,	5.93)
		CG	4	157			
Ferrer, 2014[74]	12	IG1	9	164	1.13	(0.44,	2.84)
		CG	8	164			
	24	IG1	11	164	0.55	(0.27,	1.11)
		CG	20	164			
Hendriks, 2008[75]	12	IG1	5	166	5.03	(0.59,	42.60)
		CG	1	167			
Hogan, 2001[76]	12	IG1	2	79	0.43	(0.08,	2.13)
		CG	5	84			
Imhof, 2012[77]	9	IG1	8	231	1.14	(0.42,	3.09)
		CG	7	230			
Lightbody, 2002[78]	6	IG1	11	171	1.63	(0.65,	4.10)
		CG	7	177			
Logan, 2010[79]	12	CG	16	102	0.88	(0.45,	1.70)
		IG1	14	102			
Lord, 2005[80]	6	IG1	1	210	0.32	(0.03,	3.09)
		CG	3	204			
	12	IG1	2	210	0.32	(0.07,	1.59)
		CG	6	204			
Moller, 2014[81]	6	IG1	6	80	5.47	(0.68,	44.40)
		CG	1	73			
	12	IG1	9	80	2.74	(0.77,	9.72)
		CG	3	73			
Newbury, 2001[82]	12	IG1	1	50	0.20	(0.02,	1.65)
		CG	5	50			
Palvanen, 2014[83]	12	IG1	3	661	0.37	(0.10,	1.39)
		CG	8	653			
Perula, 2012[84]	12	IG1	1	133	1.02	(0.02,	55.2)
		CG	2	271			
Russell, 2010[85]	12	IG1	13	351	1.49	(0.64,	3.43)
		CG	9	361			
Salminen, 2009[86]	12	IG1	6	293	1.53	(0.43,	5.35)
		CG	4	298			
	24	IG1	9	293	0.92	(0.38,	2.22)
		CG	10	298			
	36	IG1	17	293	1.24	(0.62,	2.46)
		CG	14	298			
Spice, 2009[87]	12	IG1	34	210	0.89	(0.45,	1.75)
		CG	29	159			
Tinetti, 1994[88]	12	IG1	7	147	1.37	(0.30,	6.35)
		CG	5	144			
van Haastregt, 2000[89]	18	IG1	10	159	0.71	(0.32,	1.54)
		CG	14	157			
Vind, 2009[90]	12	IG1	4	196	1.00	(0.25,	3.94)
		CG	4	196			
Wagner, 1994[91]	24	IG1	17	635	0.74	(0.40	1.38)
		CG	22	607			

Abbreviations: CG = control group; CI = confidence interval; IG = intervention group; RR = relative risk

† Calculated

Table 12. People transitioning to institutional care, for multifactorial interventions, by author

Author, Year	Time	Group	Events	N analyzed	Percent	RR	(95% CI)	
Close, 1999[67]	12	IG	18	184	9.8	1.16	(0.62,	2.16)
		CG	18	213	8.5			
Conroy, 2010[69]	12	IG1	3	166	1.8	3.07	(0.32,	29.2)
		CG	1	170	0.6			
Ferrer, 2014[74]	12	IG	3	164	1.8	0.43	(0.11	1.63)
		CG	7	164	4.3			
Hogan, 2001[76]	12	IG	2	79	2.5	2.13	(0.20,	23.00)
		CG	1	84	1.2			
Imhof, 2012[77]	9	IG	4	231	1.7	0.57	(0.17,	1.92)
		CG	7	230	3.0			
Newbury, 2001[82]	12	IG	2	45	4.4	0.98	(0.14,	6.64)
		CG	2	44	4.5			
Spice, 2009[87]	12	IG	37	210	17.6	0.88	(0.46,	1.66)
		CG	32	159	20.1			

Abbreviations: CG = control group; CI = confidence interval; IG = intervention group; RR = relative risk

Table 13. People hospitalized, for multifactorial interventions, by author

Author, Year	Time, months	Group	events	N analyzed	Percent	RR	95% CI	
Close, 1999[67]	12	IG	NR	184	NR	0.61*	(0.35,	1.05)
		CG	NR	213	NR			
Logan, 2010[79]	12	IG	53	102	52.0	0.98	(0.76,	1.27)
		CG	54	102	52.9			
Tinetti, 1994[88]	12	IG	32	147	21.8	0.87	(0.49,	1.54)
		CG	36	144	25.0			
Wagner, 1994[91]	12	IG	3	635	0.47	0.57	(0.14,	2.39)
		CG	5	607	0.82			

Abbreviations: CG = control group; CI = confidence interval; IG = intervention group; RR = relative risk

* Odds ratio

Table 14. ADL, IADL, QOL, for multifactorial interventions, by author

Author, year	Instrument (score range**)	Time, months	Group	n analyzed	Mean (SD)	Mean change from baseline (SD)
ADL						
Close, 1999[67]	Barthel ADL (0-20)	0	IG	184	19 (1.6)	NA
			CG	213	18.7 (2.1)	
		12	IG	184	18.6 (2.5)	-0.4 (2.2)*
			CG	213	17.3 (3.7)	-1.4 (3.2)*
de Vries, 2010[71]	Barthel ADL (0-20)	12	IG	106	NR	-0.23 (2.24)
			CG	111	NR	-0.15 (1.90)
Fairhall, 2014[73]	Barthel ADL (0-100)	0	IG	120	93.9 (11.1)	NA
			CG	121	92.5 (14.3)	
		12	IG	106	89.5 (17.5)	-5.6 (14.6)
			CG	107	86.1 (24.7)	-6.1 (20.8)
Lightbody, 2002[78]	Barthel ADL (0-20)	0	IG	171	19 (2.0)	NA
			CG	288	19 (2.3)	
		6	IG	155	18.5 (2.4)	-0.5 (2.2)*
			CG	159	17.8 (3.6)	-1.2 (3.2)*
Logan, 2010[79]	Barthel ADL (0-20)	0	IG	102	15‡ (13, 18)	OR (95% CI): 2.9† (1.2, 7.2)
			CG	102	15‡ (12, 17)	
		12	IG	102	15‡ (12, 17)	
			CG	102	15‡ (12, 18)	
Spice, 2009[87]	Barthel ADL (0-20)	12	IG/CG	369	NR	Mean difference in change (95% CI): 0.63 (0.10, 1.16)
Vind, 2009[90]	Barthel ADL (0-100)	0	IG	196	98.4 (3.6)	NR
			CG	196	98.0 (5.2)	
		6	IG	196	98.4 (5.9)	
			CG	196	98.4 (4.1)	
		12	IG	196	97.1 (9.3)	-1.3 (8.1)*
			CG	196	98.3 (3.6)	0.3 (4.6)*
IADL						
de Vries, 2010[71]	Lawton and Brody (0-8)	12	IG	106	NR	-0.15 (1.73)
			CG	111	NR	0.01 (1.61)
Hendriks, 2008[75]	Frenchay Activities Index (0-45)	0	IG1	166	23.2 (8.7)	NR
			CG	167	23.7 (8.6)	
		12	IG1	124	25.6 (8.0)	
			CG	134	24.5 (9.1)	
van Haastregt, 2000[89]	Frenchay Activities Index (13-52)	0	IG1	159	33.0 (7.5)	NR
			CG	157	31.8 (7.6)	
		12	IG1	129	33.5 (6.9)	
			CG	123	30.9 (8.0)	
		18	IG1	120	33.1 (7.3)	
			CG	115	31.5 (7.7)	
Vind, 2009[90]	Frenchay Activities Index (0-45)	0	IG1	196	29.5 (6.7)	NR
			CG	196	28.5 (8.2)	
		6	IG1	196	29.4 (6.9)	
			CG	196	28.2 (7.9)	
		12	IG1	196	30.1 (6.9)	
			CG	196	29.4 (7.3)	
ADL/IADL						
Elley, 2008[72]	Nottingham Extended Activities of Daily Living (0-22)	0	IG1	135	19.0‡ (18.0, 21.0)	NR
			CG	145	19.0‡ (16.0, 20.0)	
		12	IG1	135	18.0‡ (17.0, 20.0)	
			CG	145	19.0‡ (17.0, 20.0)	
Logan, 2010[79]	Nottingham Extended Activities of Daily Living (0-22)	0	IG1	102	6‡ (3, 9)	NR
			CG	102	8.5‡ (4, 12)	
		12	IG1	102	8‡ (4, 13)	
			CG	102	6‡ (1, 10)	

Table 14. ADL, IADL, QOL, for multifactorial interventions, by author

Author, year	Instrument (score range**)	Time, months	Group	n analyzed	Mean (SD)	Mean change from baseline (SD)
Moller, 2014[81]	Sonn and Asberg (NR)	0	IG	80	2‡ (1, 3)	NR
			CG	73	2‡ (1, 3)	
		12	IG	80	2‡ (1, 3.35)	
			CG	73	2‡ (1, 3.5)	
QOL						
de Vries, 2010[71]	EuroQol EQ-5D (0-1)	12	IG1	106	NR	0.01 (0.16)
			CG	111	NR	0.07 (0.16)
	SF-12 Mental Component (0-100)	12	IG1	106	NR	-0.31 (11.4)
			CG	111	NR	-1.43 (10.2)
	SF-12 Physical Component (0-100)	12	IG1	106	NR	2.60 (8.6)
			CG	111	NR	1.86 (8.8)
Elley, 2008[72]	SF-36 Mental Component (0-100)	0	IG1	135	57.5‡ (50.1, 61.8)	NR
			CG	145	58.7‡ (53.1, 62.5)	
		12	IG1	135	56.7‡ (48.8, 61.3)	
			CG	145	57.7‡ (49.4, 61.9)	
	SF-36 Physical Component (0-100)	0	IG1	135	35.4‡ (29.4, 43.8)	NR
			CG	145	36.5‡ (29.7, 43.9)	
		12	IG1	135	39.4‡ (29.9, 46.0)	
			CG	145	37.2‡ (29.0, 45.4)	
Fairfall, 2014[73]	EQ5D VAS (0-100)	0	IG1	120	58.2 (15.8)	NR
			CG	121	57.9 (18.4)	
		12	IG1	107	57.5 (20.8)	
			CG	108	57.7 (19.7)	
Vind, 2009[90]	SF-36 Mental Component (0-100)	0	IG1	196	77.4 (19)	NR
			CG	196	76.1 (23)	
		6	IG1	196	80.6 (18)	
			CG	196	79.4 (21)	
		12	IG1	196	81.5 (18)	
			CG	196	78.1 (23)	
	SF-36 Physical Component (0-100)	0	IG1	196	61.4 (27)	NR
			CG	196	62.4 (27)	
		6	IG1	196	69.1 (24)	
			CG	196	66.6 (28)	
		12	IG1	196	67.9 (25)	
			CG	196	65.2 (27)	

Abbreviations: ADL = activities of daily living; CG = control group; CI = confidence interval; IADL = instrumental activities of daily living; IG = intervention group; EQ5D = EuroQol five dimensions questionnaire; EuroQol = European quality of Life; NA = not applicable; NR = not reported; SD = standard deviation; SF = short form; VAS = visual analogue scale

* Calculated
** Higher scores indicate better function for all instruments
‡ Median (IQR)
† Odds ratio (95% CI), dichotomous outcome based on a median split of the Barthel Index at a score of 15

Table 15. Study characteristics, for exercise interventions, by author

Author, Year	Quality	Aim	Country	Target Population	Recruitment Setting	Inclusion/Exclusion Criteria
Barnett, 2003[104]	Fair	To determine whether participation in a weekly supervised group exercise program with ancillary home exercises over one year improves physical functioning, health status and prevents falls in at-risk community-dwelling older people	Australia	Aged 65 years and older at risk of falling	Hospital, Clinic	Inclusion: 65 years or older; attended one of 24 GP clinics or two acute hospital physiotherapy departments in South Western Sydney, Australia; one or more physical performance impairments found to be important risk factors for falls that could be addressed by exercise participation (lower limb weakness, poor balance and slow reaction time; as assessed by an inability to stand from a 45 cm high chair in less than 2 seconds; a need to step to maintain balance when performing a near-tandem balance test; and an inability to catch a rod dropped from above the hand within 300 ms. Exclusion: Cognitive impairments; degenerative conditions such as Parkinson's disease; a medical condition involving the neuromuscular, skeletal or cardiovascular system that precluded taking part in an exercise program.
Bucher, 1997[100]	Fair	To test the effect of strength and endurance training on gait, balance, physical health status, fall risk, and health services use in older adults	USA	Older adults aged 68-85 years with at least mild deficits in strength and balance were selected from a random sample of enrollees in a health maintenance organization	HMO	Inclusion: Eligible subjects were between 68 and 85 years of age; unable to do an eight-step tandem gait without errors; below the 50th percentile in knee extensor strength for the subject's height and weight. Exclusion: Subjects with active cardiovascular, pulmonary, vestibular, and bone diseases; a positive cardiac stress test; body weight >180% of ideal; major psychiatric illness, active metabolic diseases; chronic anemia; amputation; chronic neurological or muscle disease; inability to walk; dependency in eating, dressing, transfer or bathing; terminal illness; inability to speak English or fill out written forms.
Campbell, 1997[105]	Fair	To assess the effectiveness of a home exercise program of strength and balance retraining exercises in reducing falls and injuries in elderly women	New Zealand	Women aged 80 years and older living in the community	Clinic	Inclusion: Women; aged 80 years and older; living in the community; able to move around within their own home; not receiving physiotherapy Exclusion: Women unable to comply with study requirements (score of <7 out of 10)

Table 15. Study characteristics, for exercise interventions, by author

Author, Year	Quality	Aim	Country	Target Population	Recruitment Setting	Inclusion/Exclusion Criteria
El-Khoury, 2015[110]	Fair	To assess the effectiveness of a 2-year exercise program of progressive balance retraining in reducing injurious falls among women aged 75-85 years at increased risk of falls and injuries and living in the community	France	Women aged 75-85 years, living in their own home, and with diminished balance and gait capacities	Population-based register	Inclusion: Women; aged 75-85 years; living in the community; diminished balance or gait capacities, as assessed by the time they took to walk a 6-meter course (average of two measures) and the tandem walk test (ability to do four consecutive tandem steps) Exclusion: Took >12.5 seconds to walk 6 meters or were unable to stand for 10 seconds with their feet together; medical conditions involving the neuromuscular, skeletal, or cardiovascular systems; expected to move away within the next six months; would have difficulty attending exercise classes regularly or were already taking exercise classes
Fitzharris, 2010[117]	Fair	To examine the effectiveness of the Whitehorse NoFalls trial on all falls, falls resulting in injury and falls requiring medical care	Australia	Community-dwelling people aged 70 years or older	Population-based register	Inclusion: Community-dwelling; aged 70 years or older; living in the City of Whitehorse local government area; living in one's own home or apartment, or leasing similar accommodations and permitted to make modifications Exclusion: Did not expect to remain in the area for 2 years (except for short absences); participated in regular to moderate physical activity with a balance improvement component in the previous 2 months; could not walk 10-20 meters without rest, help, or having angina; severe respiratory or cardiac disease; psychiatric illness prohibiting participation; dysphasia; had recent major home modifications; had an education and language adjusted score > 4 on the short portable mental status questionnaire; did not have the approval of their general practitioner
Freiberger, 2012[115]	Good	To determine the long-term effects of three strength and balance exercise interventions on physical performance, fall-related psychological outcomes, and falls in older people	Germany	Community-dwelling adults aged 70 to 90 years who had fallen in the past 6 months or reported fear of falling	Health insurance company membership database	Inclusion: Community-dwelling; aged 70 years or older; fallen in the past 6 months or reported fear of falling; provided signed informed consent; completed baseline assessment Exclusion: Unable to ambulate independently; cognitive impairment (as noted by a score <25 on the Digit Symbol Substitution Test)

Table 15. Study characteristics, for exercise interventions, by author

Author, Year	Quality	Aim	Country	Target Population	Recruitment Setting	Inclusion/Exclusion Criteria
Gawler, 2016[113]	Fair	To evaluate the impact of two exercise promotion programs on physical activity in people aged 65 years or older	UK	Adults aged 65 years or older	Clinic	Inclusion: Aged 65 years or older; could walk independently both indoors and outdoors (with or without a walking aid and without help from another person); physically able to take part in a group exercise class Exclusion: Three or more self-reported falls in the previous year; resting BP >180/100 mmHg, tachycardia >100 beats per minute, significant drop in BP during exercise, considered by their general practitioner to have uncontrolled hypertension; psychiatric conditions which would prevent participation in an exercise class (e.g. psychotic illness); uncontrolled medical problems (e.g. acute systemic illness such as pneumonia, poorly controlled angina, acute rheumatoid arthritis, unstable or acute heart failure); conditions requiring a specialist exercise program (e.g. uncontrolled epilepsy, significant neurological disease or impairment; unable to maintain seated upright position or unable to move about independently indoors); significant cognitive impairment (resulting in the individual being unable to follow simple instructions); not living independently (e.g. living in residential or nursing homes); already receiving long-term physiotherapy or already in an exercise program
Gill, 2016[120]	Good	To evaluate the benefits of physical activity in older people	US	Sedentary older people with functional limitations	Community-based	Inclusion: Men and women; aged 70-89; sedentary (reported <20 min/week in past month performing structured physical activity (that is, exercise), and <125 min/week of moderate physical activity); had functional limitations, as evidenced by a short physical performance battery score 9 or less out of 12 (the short physical performance battery is an integrative measure of gait, balance and lower extremity strength); could walk 400 m in 15 minutes or less without the help of someone or a walker; had no major cognitive impairment (modified mini-mental state examination score 1.5 standard deviations below education specific and race specific norms); and could safely participate in the intervention as determined by medical history, physical exam, and electrocardiography Exclusion: NR

Table 15. Study characteristics, for exercise interventions, by author

Author, Year	Quality	Aim	Country	Target Population	Recruitment Setting	Inclusion/Exclusion Criteria
Kamide, 2009[119]	Fair	To investigate the effects of home-based exercise without home visits on physical function, falls, and bone mineral density in community-dwelling elderly women	Japan	Community-dwelling women 65 years or older	Employment agency for older people	Inclusion: Aged 65 years or older; able to walk independently without an assistive device; no history of cerebral vascular disease, neuromuscular disease, or fractures in the spine or lower limbs; no restrictions in physical activities; able to give written informed consent to participate in the study Exclusion: Cardiopulmonary disease; liver disease; kidney disease; hyperthyroidism; unstable diabetes mellitus; unstable hypertension; medication using prednisolone; performance of regular exercise
Karinkanta, 2015[109]	Fair	To assess whether combined resistance and balance-jumping training intervention has long-lasting effects in reducing injurious falls and fractures	Finland	Community-dwelling older women ages 70 years or older	Population-based register	Inclusion: Community-dwelling; women; aged 70-79 years; willingness to participate; full understanding of the study procedures; no history of any illness contraindicating exercise or limiting participation in the exercise program; no history of illness affecting balance or bones; no uncorrected vision problems; taking no medications known to affect balance or bone metabolism (within 12 months before the enrollment) Exclusion: Involved in high-intensity exercises more than twice a week; femoral-neck T score < –2.5, indicating osteoporosis and requiring medical attention
Kovacs, 2013[114]	Good	To investigate the effects of an adapted physical activity program on balance, risk of falls and quality of life in community-dwelling older women	Hungary	Community-dwelling women aged 60 years or over	Community-based	Inclusion: Women; 60 years or over; community-dwelling Exclusion: Progressive neurological or unstable cardiovascular diseases; severe pain in weight-bearing positions; regular participation in physical exercise in the past 6 months
Logghe, 2009[103]	Fair	To evaluate the effectiveness of tai chi chuan in fall prevention in elderly people living at home with a high risk of falling.	The Netherlands	Elderly people living at home with a high risk of falling	Clinic	Inclusion: Aged 70 years or older; living at home; high fall risk (one or more self-reported fall incidents in the year preceding the study or at least two of the following self-reported risk factors for falling: disturbed balance, mobility problems, dizziness, and the use of benzodiazepines or diuretics) Exclusion: NR

Table 15. Study characteristics, for exercise interventions, by author

Author, Year	Quality	Aim	Country	Target Population	Recruitment Setting	Inclusion/Exclusion Criteria
Luukinen, 2007[102]	Fair	To assess the effectiveness of an intervention planned and implemented by regional geriatric care teams in order to prevent falls in an elderly population	Finland	Home-dwelling population aged 85 years or older	Population-based register	Inclusion: Home-dwelling; aged 85 years or older Exclusion: NR
Morgan, 2004[106]	Fair	To evaluate the effect of an easily implemented, low-intensity exercise program on the incidence of falls and the time to first fall among a clinically defined population of elderly men and women	USA	Men and women aged 60 years or older with either a hospital admission lasting 2 days or longer or had been on bed rest for 2 days or more within the past month	Hospital, Assisted living/day care, Clinic	Inclusion: Aged 60 years or older; had either a hospital admission lasting 2 days or longer or had been on bed rest for 2 days or more within the past month Exclusion: Medical conditions that made it unsafe to participate in the exercise program or interfered with their ability to follow instructions; required use of oxygen therapy at home; planned future inpatient evaluations or treatments within the next 2 months; required human assistance, a wheelchair, or artificial limbs to ambulate
Ng, 2015[118]	Fair	To compare the effects of 6-month interventions with physical exercise, nutritional supplementation, cognitive training, and a combination of these interventions with usual care control in reducing frailty among community-dwelling older persons	Singapore	Community-dwelling frail and prefrail older adults	Community-based	Inclusion: Aged 65 years and older; able to ambulate without personal assistance; living at home; prefrail or frail, defined as one or more of the following: unintentional weight loss, slowness, weakness, exhaustion, and low activity Exclusion: Significant cognitive impairment (MMSE less than 24); major depression; severe audiovisual impairment; any progressive, degenerative neurologic disease; terminal illness with life expectancy <12 months; participating in other intervention studies; unavailable to participate for the full duration of the study
Robertson, 2001[101]	Fair	To assess the effectiveness of a trained district nurse individually prescribing a home based exercise program to reduce falls and injuries in elderly people	New Zealand	Persons aged 75 years and older	Clinic	Inclusion: Persons aged 75 years and older Exclusion: Inability to walk around own residence; receiving physiotherapy at the time of recruitment; not able to understand the requirements of the trial

Table 15. Study characteristics, for exercise interventions, by author

Author, Year	Quality	Aim	Country	Target Population	Recruitment Setting	Inclusion/Exclusion Criteria
Sherrington, 2014[112]	Fair	To investigate the effects of a home-based exercise program on falls and mobility among people recently discharged from hospital	Australia	Adults aged 60 years or over and had been admitted to and subsequently discharged from a hospital	Hospital	Inclusion: Aged 60 years and over; admitted to and subsequently discharged from nine aged care, rehabilitation and orthopedic wards at four public hospitals in Sydney, Australia Exclusion: Resided in a high-care residential facility (nursing home); cognitive impairment (MMSE score <24); insufficient English language to understand procedures; unable to walk more than 1 meter even with an assistive device or the help of one person; medical condition precluding a 12-month home exercise program (e.g., unstable cardiac disease or progressive neurological disease)
Trombetti, 2011[116]	Fair	To determine whether a 6-month music-based multitask exercise program would improve gait and balance and reduce fall risk in community-dwelling older adults at high risk of falling.	Switzerland	Community-dwelling adults 65 years or older at increased risk of falling	Community-based	Inclusion: 65 years or older; living in the community; without previous experience of Jaques-Dalcroze eurhythmics, except during childhood; at increased risk of falling (1 or more self-reported falls after the age of 65 years, balance impairment as assessed by a simplified Tinetti test with a score higher than 2 of 7, or 1 or 2 criteria of physical frailty) Exclusion: Medical history or physical examination revealed a neurological disease associated with motor deficit or an orthopedic disease with a significant impact on gait and/or balance that would compromise outcomes assessment; any other medical conditions that would limit participation; fully dependent on an assistive device
Uusi-Rasi, 2015[108]	Good	To determine the effectiveness of targeted exercise training and vitamin D supplementation in reducing falls and injurious falls among older women	Finland	Home-dwelling; women; aged 70 to 80 years old; history of at least one fall during the last 12 months; no regular use of vitamin D supplements	Population-based register	Inclusion: Home-dwelling; women; aged 70 to 80 years old; history of at least one fall during the last 12 months; no regular use of vitamin D supplements Exclusion: Moderate to vigorous exercise more than 2 hours per week; regular use of vitamin D or calcium plus vitamin D supplements, a recent fracture (during preceding 12 months); contraindication or inability to participate in the exercise program; marked decline in the basic activities of daily living (ADL); cognitive impairments; primary hyperthyroidism; degenerative conditions such as Parkinson's disease

Table 15. Study characteristics, for exercise interventions, by author

Author, Year	Quality	Aim	Country	Target Population	Recruitment Setting	Inclusion/Exclusion Criteria
Voukelatos, 2007[107]	Good	To determine the effectiveness of a 16-week community-based tai chi program in reducing falls and improving balance in people aged 60 and older	Australia	Relatively healthy community-dwelling people aged 60 and older	Community-based	Inclusion: Aged 60 and older; living in the community; had not practiced tai chi in the previous 12 months Exclusion: Degenerative neurological condition such as Parkinson's disease; dementia; severely debilitating stroke; severe arthritis; marked vision impairment; unable to walk across a room unaided
Voukelatos, 2015[111]	Fair	To investigate the impact of a 48-week, progressive walking program on falls in inactive, community-dwelling people aged 65 years and over	Australia	Inactive, community-dwelling people aged 65 years and over	Community-based	Inclusion: Inactive (i.e., <120 minutes of exercise per week); mobile (i.e., able to walk at least 50 meters with minimal aid); able to communicate in English Exclusion: Medical condition precluding participation in the study (e.g., dementia, Parkinson's disease, stroke, debilitating arthritis, severe vision impairment); participating in another research study

Abbreviations: ADL = activities of daily living; BMD = bone mineral density; BMI = body mass index; BP = blood pressure; ED = emergency department; GP = general practice; HMO = health maintenance organization; mmHg = millimeters of Mercury; MMSE = Mini-Mental State Examination; ms = milliseconds; NR = not reported; NS = not specified; UK = United Kingdom; USA = United States of America

Table 16. Population characteristics, for exercise interventions, by author

Author, Year	N randomized	Mean age	Females, %	SES	White, %	Definition of fall risk*	At risk of falling,* %	Baseline health or functional status
Barnett, 2003[104]	163 IG: 83 CG: 80	74.9	66.9	NR	NR	One or more physical performance impairments that have been found to be important risk factors for falls that could be addressed by exercise participation: lower limb weakness, poor balance and slow reaction time	100	Living alone: 27% Mean SF-36 General Health: 62.5
Bucher, 1997[100]	55 (126 randomized to other group) IG: 25 CG: 30	75	51	13 (years of formal education)	93	NR	NR	Fair/poor health: 9% ≥1 IADL dependency: 23% Fall in past year: 25%
Campbell, 1997[105]	233 IG: 116 CG: 117	84.1	100	NR	NR	NR	NR	Living alone: 77%
El-Khoury, 2015[110]	706 IG: 352 CG: 354	79.7	100	39.9 (% finished high school)	NR	Diminished balance or gait capacities (from inclusion)	100	Living alone: 68%
Fitzharris, 2010[117]	272 (818 randomized to other group) IG: 135 CG: 137	76.1 (total)	60 (total)	NR	NR	NA	NR	Living alone: 54% Fall in past month: 6% Mean ADL (IADL plus bathing): 5.3 Mean # of medications: 3.4
Freiberger, 2012[115]	144 (136 randomized to other group) IG: 64 CG: 80	76.1	41.7	38.2% (low education); 19.4% (low income)	NR	Fallen in the previous 6 months or fear of falling (inclusion)	100	Living alone: 34% Fallen in past 6 months: 33% Fear of falling: 44%
Gawler, 2016[113]	845 (411 randomized to other group) IG: 387 CG: 458	73 (total)	62 (total)	44% (completed some form of further education)	86 (total participants)	Falls Risk Assessment Tool	6 (at high risk)	For the n analyzed (n=830, IG1/IG2/CG combined) Living alone: 35%
Gill, 2016[120]	1635 IG: 818 CG: 817	78.9	67.2	66.9% (education beyond high school)	75.8	Sedentary with functional limitations	100	Mean SPPB Score: 7.4 Fall in past year: 49.9% Fall receiving medical attention in past year: 11.6%

Table 16. Population characteristics, for exercise interventions, by author

Author, Year	N randomized	Mean age	Females, %	SES	White, %	Definition of fall risk*	At risk of falling,* %	Baseline health or functional status
Kamide, 2009[119]	57 IG: 28 CG: 29	28	29	70.9	100 NR	NR	NR	Fall efficacy scale, mean points: 137.0
Karinkanta, 2015[109]	75 (74 randomized to 2 other groups) IG: 38 CG: 37	73.2	100	NR	NR	NA	NR	NR
Kovacs, 2013[114]	72 IG: 36 CG: 36	68.4	100	NR	NR	NA	NR	Risk of falls (Downton Index), median: 2 (Range from 0 to 11. A score of 3 or more indicates a high risk of falls) Fell in last year: 38%
Logghe, 2009[103]	269 IG: 138 CG: 131	77.2	71.0	69% (at least high school education)	NR	One or more self-reported fall incidents in the year preceding the study or at least two of the following self-reported risk factors for falling: disturbed balance, mobility problems, dizziness, and the use of benzodiazepines or diuretics	100	Previous falls: 62% Living alone: 49%
Luukinen, 2007[102]	437 IG: 217 CG: 220	88	79	NR	NR	Recurrent (>2) falls during the preceding year; frequent feelings of loneliness; poor self-rated health; poor visual acuity; poor hearing; depression; poor cognition; impaired balance; impaired chair rise; OR slow walking speed (from inclusion)	100	Recurrent falling (2+) in previous 12 months: 27%
Morgan, 2004[106]	229 IG: 119 CG: 110	80.6	70.7	NR	NR	Hospital admission lasting 2+ days or had been on bed rest 2+ days in the past month (from inclusion)	100	Participants w/ previous fall: 36%

Table 16. Population characteristics, for exercise interventions, by author

Author, Year	N randomized	Mean age	Females, %	SES	White, %	Definition of fall risk*	At risk of falling,* %	Baseline health or functional status
Ng, 2015[118]	98 (148 randomized to other group) IG: 48 CG: 50	70.2	56.1	23.5% (no formal schooling)	NR	Prefrail and frail older adults	100	Mean frailty score (range 0-5): 2.0 Prefrail: 73% Frail: 27% ≥5 comorbidities: 7% IADL-ADL dependency, mean: 2 (note: CG and IG varied considerably, IG=0 and CG=4)
Robertson, 2001[101]	240 IG: 121 CG: 119	80.9	68	NR	NR	NR	NR	Aged ≥80 years: 52% Living alone: 52% Fall in previous year: 37%
Sherrington, 2014[112]	340 IG: 171 CG: 169	81.2	73.8	NR	NR	Recently discharged from nine aged care, rehabilitation and orthopedic wards at four public hospitals	100	NR
Trombetti, 2011[116]	134 IG: 66 CG: 68	76	96.3	17.9% (high school education)	NR	At least one of the following: one or more self-reported falls after the age of 65 years; balance impairment as assessed by a simplified Tinetti test with a score higher than 2 of 7; and one or two criteria of physical frailty (unintentional weight loss, exhaustion, low physical activity level, slow walking speed, grip strength)	100	Unintentional weight loss: 11% Exhaustion: 26% Low PA level: 0.7% Slow walking speed: 14% Grip strength: 45%
Uusi-Rasi, 2015[108]	205 (204 randomized to other group) IG: 103 CG: 102	74.3	100	NR	NR	Fallen at least once in the previous 12 months (from inclusion)	100	ADL (range 6-36, lower scores indicate better functioning): 6.8 IADL (range 8-48, lower scores indicate better functioning): 9.9
Voukelatos, 2007[107]	702 IG: 353 CG: 349	69	84	14% (<intermediate level of education)	NR	NA	NR	Fair/poor self-reported health status (from SF-36): 15% IADL score of 16/16: 68% 1+ falls in previous year: 33%

Table 16. Population characteristics, for exercise interventions, by author

Author, Year	N randomized	Mean age	Females, %	SES	White, %	Definition of fall risk*	At risk of falling,* %	Baseline health or functional status
Voukelatos, 2015[111]	386 IG: 192 CG: 194	73.2	74	65.4% (highest level of education: post secondary)	NR	NA	NR	Living alone: 50%

Abbreviations: ADL = activities of daily living; BMI = body mass index; CG = control group; GP = general practitioner; IADL = instrumental activities of daily living; IG = intervention group; MMSE = Mini-Mental State Examination; NA = not applicable; NR = not reported; PD = Parkinson's Disease; SES = socioeconomic status; SF = short form; SPPB = short physical performance battery; TMIG-IC = Tokyo Metropolitan Institute of Gerontology Index of Competence; TUG = Timed Up-and-Go
* As defined by study authors

Table 17. Intervention details, for exercise interventions, by author

Author, Year	IG Description	CG Description	Format	Delivered By	Duration
Barnett, 2003[104]	After 5–10 minutes warm up including stretching of the major lower limb muscle groups, the participants performed exercises designed to improve balance and coordination (e.g., modified tai chi exercises, stepping practice, change of direction, dance steps and catching/throwing a ball), aerobic capacity (e.g., fast walking practice including change of pace and direction), and muscle strength (e.g., using the participants' body weight [sit to stand, wall press-ups] and using resistance bands). There was a 10-minute cool down where the participants performed gentle stretches, and then in a seated position practiced relaxation and controlled breathing. The complexity and speed of the exercise and the resistance of the bands were all steadily increased over the four terms. A home exercise program based on the class content was also given to the participants, with diaries to record participation. The exercise groups also received information on practical strategies for avoiding falls; such as hand and foot placement if a loss of balance occurred.	Written information about falls prevention, but no alternative non-exercise activity	Group	Exercise instructor	52 weeks 1-hour sessions (37 total)
Bucher, 1997[100]	Exercise consisted of endurance training (ET) and/or strength training (ST) in supervised classes. Exercise sessions began with a 10- to 15-min warm-up and ended with a 5- to 10-min cool-down. Endurance training used stationary cycles that allow both arms and legs to propel the wheel, at 75% of heart rate (HR) reserve. Strength training groups did resistance exercise of the upper and lower body using mainly weight machines. The weight machines included exercise for the lower body (leg press, leg extension, leg curl, hip adduction and abduction), trunk (rotary torso), and upper body (incline press and rowing). Training at the ankle joint involved strapping the foot to a metal plate with (adjustable) weights attached to the anterior, posterior, medial, and lateral plate. The weights provided resistance for training dorsiflexion, plantar flexion, inversion, and eversion.	Instructed to maintain usual activity levels	Group	Unspecified supervised setting	24-26 weeks 1-hour sessions (78 total) 3 times per week
Campbell, 1997[105]	The physical therapist prescribed a selection of exercises from the program at appropriate and increasing levels of difficulty, and a walking plan. Exercises included moderate intensity strengthening exercises with ankle cuff weights (0.5 kg and 1 kg) for the following muscle groups: hip extensor and abductor muscles, knee flexor and extensor muscles, inner range quadriceps, and ankle plantar and dorsiflexor muscles. Other exercises were standing with one foot directly in front of the other, walking placing one foot directly in front of the other, walking on the toes and walking on the heels, walking backwards, sideways, and turning around, stepping over an object, bending and picking up an object, stair climbing in the home, rising from a sitting position to a standing one, knee squat, and "active range of movement" exercises. Women were encouraged to walk outside the home at least 3 days per week.	Equal number of social visits (four times during the first 2 months and regular telephone calls during the year of follow up)	Individual	Physical therapists	52 weeks 30-minute sessions (156 total) 3 times per week

Table 17. Intervention details, for exercise interventions, by author

Author, Year	IG Description	CG Description	Format	Delivered By	Duration
El-Khoury, 2015[110]	The general objectives of the Ossébo program were to improve physical factors that affect balance and the risk of falling and injury from falls, to raise awareness of falling risks and ways of reducing them through behavioral changes, and to foster long term maintenance of regular physical activity for fall prevention through the integration of some exercises and healthy behaviors into participants' daily routine. It was divided into eight terms of about 12 sessions, each with specific objectives and a standardized framework. The exercises were designed to improve postural stability, muscle extensibility and to a lesser degree joint flexibility, balance, reaction time, coordination, muscle strength critical for posture and balance, and internal sense of spatial orientation. Participants were also expected to perform exercises at home at least once a week to reinforce the group sessions and foster the integration of balance training and physical activity into the routines of daily living for a healthier lifestyle. The home exercises (about six) were selected from those practiced with the group and adapted by the instructor to each participant's physical abilities.	Usual care; control group offered brochures about fall prevention which discussed the importance of physical activity, a balanced diet, and vitamin D supplementation and offered suggestions for assessing home hazards and managing drugs. Participants in both groups received newsletters twice a year reminding them about major risk factors for falls and prevention measures. At the end of the trial, participants in the control group were offered four free exercise sessions.	Individual, group	Exercise instructor	104 weeks 1-hour sessions (96 total) 1 time per week
Fitzharris, 2010[117]	The exercise intervention was a weekly strength and balance exercise class of 1 h for 15 weeks, supplemented by daily home exercises. The exercises were designed by a physical therapist to improve flexibility, leg strength, and balance, and 30-35% of the total content was devoted to balance improvement. Exercises could be replaced by a less demanding routine, depending on the participant's capability.	Usual care; the control group received a delayed intervention	Group	Physical therapists	15 weeks 1-hour sessions (15 total) 1 time per week
Freiberger, 2012[115]	All interventions included strength and balance exercises but differed regarding their second feature, endurance training (fitness) or fall risk education (multiple). The interventions were progressive over time, and each session had the following structure: a 5-minute discussion to introduce the session and address participants' well-being and questions; a 10-minute warm-up exercise including stretching, walking, and culminating activities; a 30-minute program that included the session's main components; a 10 minute cool-down including activities such as stretching and relaxation; and a 5-minute discussion of the exercises and participants' experiences. The fitness intervention comprised endurance training in addition to strength and balance exercises. The endurance training included walking with change of pace and direction and Nordic walking.	Usual care; no intervention	Group	Fall-prevention instructors	16 weeks 1-hour sessions (32 total) 2 times per week

Table 17. Intervention details, for exercise interventions, by author

Author, Year	IG Description	CG Description	Format	Delivered By	Duration
Gawler, 2016[113]	The FaME (Falls Management Exercise) program consists of one group exercise class in a local community center for a maximum of 15 participants and two home exercise sessions per week (based on the Otago Exercise Program). The intervention contains both floor exercises and cardiovascular exercises, including leg muscle strengthening and balance retraining, trunk and arm muscle strengthening, bone loading, endurance (including walking) and flexibility training, functional floor skills and adapted tai chi. Group exercises include retraining of the ability to get up from the floor and floor exercises to improve strength, balance and coping strategies to reduce the risk of complications resulting from a long lie.	Usual care; free to participate in any other exercise just as they would if they were not participating in the trial	Individual, Group	Postural stability instructors	24 weeks 1 hour (group exercise); 30 minutes (home exercise) (72 total) 1 per week (group exercise); 2 per week (home exercise)
Gill, 2016[120]	Participants in both groups receive an initial individual 45-minute face-to-face introductory session by a health educator who describes the intervention, communicates expectations, and answers questions. The physical activity intervention consisted of walking, with a goal of 150 min/week; strength; flexibility; and balance training. The intervention included two center-based visits a week and home based activity 3-4 times a week. The physical activity sessions were individualized and progressed toward a goal of 30 minutes of walking at moderate intensity, 3-5 minutes of large muscle group flexibility exercises, 10 minutes of primarily lower extremity strength training by means of ankle weights (two sets of 10 repetitions), and 10 minutes of balance training. The participants began with light intensity and gradually increased intensity over the first two to three weeks of the intervention.	Health education group attended weekly workshops during first 26 weeks and monthly sessions thereafter. Workshops covered topics of relevance to older people, such as negotiating the healthcare system, traveling safely, and preventive services. Program also included a 5 to 10 minute instructor led program of stretching exercises.	Individual, Group	NR	104-182 weeks 1-hour sessions (910 total) 2 per week (group exercise); 3-4 per week (home exercises)
Kamide, 2009[119]	Home-based exercise group; a 1-hour educational session that was followed by instruction in the exercise program was given to introduce subjects to the exercise program. The home-based exercise program consisted of stretching for the lower limb, strength training for the lower limb, balance training, and impact training, all of which could be performed at home. Stretching was used for warm-up and cool-down before and after exercise, and two lower limb exercises were performed. The subjects used a Thera-Band® for strength training and did four exercises for the hip and knee joints. The strength training in this program was presumed to be of moderate intensity and was performed as one or two sets of 15 repetitions of each exercise according to the subject's ability. Balance training consisted of a stepping exercise. When performing the stepping exercise, subjects stepped forward, backward, right, and left with one leg as quickly and safely as possible. The heel drop exercise was used for impact training.	Usual care; control group continued with usual daily activities with no restrictions on their exercise activities; a therapist contacted them every 3 months by telephone or mail.	Individual	Physical therapists	24 weeks Length and freq of sessions NR (72 total) 3 times per week

Table 17. Intervention details, for exercise interventions, by author

Author, Year	IG Description	CG Description	Format	Delivered By	Duration
Karinkanta, 2015[109]	Combination training program consisting of resistance and balance-jumping training in alternating weeks. The resistance training consisted of exercises for large muscle groups with increasing intensity from 50–60% of one-repetition maximum (1RM) to 75–80% of 1RM. The balance-jumping training comprised modified aerobics and step aerobics including a variety of balance, agility, and impact exercises. The degree of difficulty of movements, steps, impacts, and jumps was gradually increased.	Usual care; no training; control group participants asked to maintain their pre-study level of physical activity	Group	Exercise instructor	52 weeks 45-minute sessions (156 total) 3 times per week
Kovacs, 2013[114]	Exercise sessions started with a 5-10 minute warm-up including flexibility exercises and ended with a 5-10 minute cool-down consisting of stretching and breathing exercises. The warm-up period was followed by the Adapted Physical Activity program, which consisted of two parts. The first part involved structured exercises focusing on strengthening lower limb muscles and trunk muscles and practicing balance activities simulating everyday activities. The second part included competing in games on a pre-designed course with obstacles or adapted ball games.	Usual care; subjects asked not to start any type of regular exercise program and maintain their usual daily activities	Group	Physical therapists	25 weeks 1-hour sessions (50 total) 2 times per week
Logghe, 2009[103]	IG received tai chi lessons using a predefined protocol. The core of the lessons consisted of 10 positions derived from the Yang style. Chi kung exercises were used during the warm-up and cool-down periods. Instructors asked participants to practice tai chi positions at home at least twice a week for 15 minutes. IG participants also received a brochure explaining how to prevent fall incidents in and around the house.	Usual care; received a brochure explaining how to prevent fall incidents in and around the house; CG participants could use or apply for available services in the area as before	Group	Tai chi instructor	13 wks 1-hour sessions (26 total) 2 times per week
Luukinen, 2007[102]	Exercise intervention program consisting of home exercise, walking exercise, group exercise, and self-care exercise; individual intervention plans were made during home visits by a physical therapist and an occupational therapist based on risk factors. The home exercise interventions included exercises performed in a standing position for those who could manage that: marching in place, rising and standing on toes, ankle extension and flexion, hip abduction, hip extension and transfer of weight from one foot to the other. Exercises in a sitting position were suggested for those unable to exercise standing: chair stands, marching in a sitting position, knee extension, hip abduction, ankle flexion and extension and rotation with extended knees. Exercises in a lying position were suggested if the subject was unable to exercise in a standing or sitting position. The suggested exercises were: raising the pelvis, lifting an extended lower extremity, flexion and extension of the foot without lifting it from the ground, abduction and rotation of the hip, flexion and extension of the ankles. These exercises were recommended to be done three	Usual care; control subjects were asked to visit their physicians without a written intervention form	Individual, group	Physical therapists, occupational therapists	64 weeks Length and frequency of sessions Variable; not clearly described

Table 17. Intervention details, for exercise interventions, by author

Author, Year	IG Description	CG Description	Format	Delivered By	Duration
	times daily with 5–15 repetitions. Ankle cuff weights were not used, and the intensity of the exercise was not increased during the course of the intervention. Group exercises consisted mainly of physical exercises in small groups and rehabilitation for war veterans. The occupational therapist planned the self-care exercises, which aimed to improve the management of personal daily activities.				
Morgan, 2004[106]	The exercise program consisted of 30 minutes of exercises (the full session lasted 45 minutes), with sufficient rest periods within the session and a cool-down period. Exercises were performed in the sitting and standing postures. The physical restoration intervention was designed to directly affect neuromuscular functioning (i.e., muscle strength, joint flexibility), balance, and gait. Standard physical therapy exercises were selected to target these areas. The programs were individualized by allowing each participant to adjust the intensity of exercises according to his or her perception and progression.	Usual care; control participants were instructed to continue their usual activities during the study	Group	Physical therapist	8 weeks 45-minute sessions (24 total) 3 times per week
Ng, 2015[118]	Physical exercise was of moderate, gradually increasing intensity, tailored to participants' individual abilities. Participants performed the exercises in groups of 8 to 10, and were encouraged to continue daily individualized exercise assignments at home. The exercise program was designed to improve strength and balance for older adults, according to American College of Sports Medicine guidelines for older adults, based on a single set of 8 to 15 repetition maximum (RM), or 60% to 80% of 10 RM, starting with <50% 1 RM involving 8-10 major muscle groups. They included resistance exercises integrated with functional tasks; and balance training exercises involving functional strength, sensory input, and added attention-based demands were carried out at 3 levels of increasing demand.	Usual care; CG participants had access to standard care from health and aged care services that were normally available to older people; CG given an equal volume of artificially sweetened, vanilla-flavored liquid (ingredients: nondairy creamer, liquid caramel, sugar, and water), 2 capsules and 1 tablet (ingredients: cornstarch, lactose, magnesium stearate) that were identical in appearance to the active nutritional supplements.	Individual, group	Other modern health professionals	24 weeks 90-minute sessions (48 total) 2 times per week

Table 17. Intervention details, for exercise interventions, by author

Author, Year	IG Description	CG Description	Format	Delivered By	Duration
Robertson, 2001[101]	The intervention consisted of a set of muscle strengthening and balance retraining exercises that progressed in difficulty, and a walking plan. The program was individually prescribed during five home visits by the instructor at weeks 1, 2, 4, and 8, with a booster visit after six months. The number of repetitions of the exercise and the number of ankle cuff weights (1, 2, and 3 kg; range 0 to 6 kg) used for muscle strengthening were increased at each visit as appropriate. Participants were also asked to walk twice per week.	Usual care	Individual	Nursing professionals	52 weeks 30-minute sessions (156 total) 3 times per week
Sherrington, 2014[112]	Three experienced physical therapists delivered the intervention in participants' homes. Ten visits were scheduled over the 12-month study period, with more frequent visits at the beginning of the program to ensure safety and enable tailoring and progression of the program. Participants were asked to undertake a program of lower limb balance and strengthening exercises. The exercises were primarily conducted while standing and were based on the Weight-bearing Exercise for Better Balance program. The physical therapist prescribed the level of difficulty and number of repetitions for each exercise after an assessment of the participant's abilities. Exercises that primarily targeted postural control (balance) included standing with a narrower base (aiming for tandem or single leg stance), forwards and sideways stepping/walking, and graded reaching activities in standing. The lower limb extensor muscle groups (i.e. hip and knee extensors and ankle plantar flexors), which act to prevent collapse of the lower limb, were targeted with exercises aiming to enhance muscle strength and control. Strengthening exercises included sit-to-stand, forward and lateral step-ups onto a small block, and heel raises standing. The optimal intensity and type of exercises for each participant was re-assessed and adjusted by the study physical therapists to ensure that the intervention remained challenging. Participants were not given any specific advice about general physical activity levels. Participants were provided with a booklet of safety precautions, instructions and photographs of exercises for use in exercise sessions at home.	Usual care from health and community services. Participants in both groups received a 32-page education booklet about fall prevention. It included information about risk factors for falls, environmental modification for fall-risk reduction and what to do after a fall but did not offer any specific advice about exercise.	Individual	Physical therapists	52 weeks 20-30 minutes (self); physical therapist NR (322 total) 6 times per week (Self); 10 visits (from physiotherpists)

Table 17. Intervention details, for exercise interventions, by author

Author, Year	IG Description	CG Description	Format	Delivered By	Duration
Trombetti, 2011[116]	The intervention (i.e., Jaques-Dalcroze eurhythmics) featured various multitask exercises, sometimes involving the handling of objects (e.g., percussion instruments or balls), which became gradually more difficult over time. Basic exercises consisted of walking in time to the piano music and responding to changes in the piano music's rhythmic patterns. Exercises involved a wide range of movements and challenged the balance control system mainly by requiring multidirectional weight shifting, walk-and-turn sequences, and exaggerated upper body movements when walking and standing.	Usual care; subjects in the delayed intervention control group were instructed to maintain their usual physical and social activities. Both groups were asked to avoid any new additional exercise programs during the course of the study. No instructions were provided to perform any specific exercise outside class time.	Group	Experienced Jaques-Dalcroze eurhythmics program instructor	25 weeks 1-hour sessions (25 total) 1 time per week
Uusi-Rasi, 2015[108]	The exercise program consisted of supervised, progressive group training classes 2 times a week for the first 12 months and once a week for the remaining 12 months of the 24-month intervention. Training periods alternating between exercise hall and gym classes were led by physical therapists who also monitored attendance. Exercise hall classes focused on balance challenging, weight bearing, strengthening, agility, and functional exercises. Gym classes included a combination of pin-loaded weight machines, pulleys, and free-weights, beginning with 30% to 60% of one repetition maximum and progressing to a target level of 60% to 75% of one repetition maximum. Exercise intensity was estimated in metabolic equivalent tasks (METs) every 8 weeks. The exercisers also had a home-training program (5-15 minutes), modified from the supervised exercises, to be performed on all rest days.	Asked to maintain their pre-study level of physical activity.	Group	Physical therapists	104 weeks Length of sessions NR (78 total) 2 times per week (first 12 months); 1 time per week (next 12 months)
Voukelatos, 2007[107]	Tai chi classes; community-based and operated as normal without any modification for this research project; no restriction was made on the tai chi style taught by the instructors. The majority of classes involved Sun-style tai chi (83%), two classes involved Yang-style tai chi (3%), and the remainder involved a mixture of several styles (14%).	Usual care; CG participants were instructed not to do any tai chi elsewhere during the 24 week study period. At the end of the study period, control participants were offered a 16-week tai chi program.	Group	Tai chi instructor	16 weeks 1-hour sessions (16 total) 1 time per week

Table 17. Intervention details, for exercise interventions, by author

Author, Year	IG Description	CG Description	Format	Delivered By	Duration
Voukelatos, 2015[111]	The intervention group received a self-paced, 48-week walking program that involved three mailed printed manuals and telephone coaching. The walking program was delivered through three program manuals mailed out at the beginning of each stage (Weeks 1, 13, 25). Participants also received telephone coaching at the beginning of and approximately half-way through each stage, with extra calls in the first stage, to help modify and support adherence to their program. The walking program involved self-paced, progressive walking that could be undertaken at participants' preferred times and locations. The walking program was designed to gradually build a walking routine from an inactive starting level. It was guided by five constructs derived from social cognitive theory: knowledge, behavioral skills, goal-directed behavior, outcome expectations and reinforcement. The walking program was split into three stages focusing on frequency and duration of walks (12 weeks duration), walking intensity (12 weeks) and finally maintaining the level of walking achieved in the previous stages (24 weeks).	Usual care; participants in the control group were mailed information about health issues (nutrition, sleeping habits and mental health) at the same time the intervention group received their walking manuals. Control group participants were contacted via telephone at the same points in the study as intervention group participants to discuss the health information sent. At the end of the study control group participants were sent the walking program materials.	Individual	Self-directed	48 weeks Self-paced length and frequency of sessions (total NR)

Abbreviations: CG = control group; ET = endurance training; h = hour(s); HR = heart rate; IG = intervention group; kg = kilogram(s); min = minute(s); ng/mL = nanograms per milliliter; NR = not reported; OT = occupational therapy/ist; RM = repetition maximum; wk(s) = week(s)

Table 18. Components of exercise interventions, as defined by ProFaNE,† by author

Author, Year	Format*	Gait, balance, and functional training	Strength/ resistance	Flexibility	3-D	General physical activity	Endurance	Other
Barnett, 2003[104]	Combination	X	X	X			X	
Buchner, 1997[100]	Group		X				X	
Campbell, 1997[105]	Individual	X	X	X			X	
El-Khoury, 2015[110]	Combination	X						
Fitzharris, 2010[117]	Combination	X	X	X				
Freiberger, 2012[115]	Group	X	X				X	
Gawler, 2016[113]	Combination	X	X	X	X		X	
Gill, 2016[120]	Combination	X	X	X		X		
Kamide, 2009[119]	Individual	X	X	X				
Karinkanta, 2015[109]	Group	X	X					
Kovacs, 2013[114]	Group	X	X	X		X		
Logghe, 2009[103]	Combination				X			
Luukinen, 2007[102]	Combination	X		X		X		X
Morgan, 2004[106]	Group	X						
Ng, 2015[118]	Combination	X	X					
Robertson, 2001[101]	Individual	X	X			X		
Sherrington, 2014	Individual	X						
Trombetti, 2011[116]	Group	X						
Uusi-Rasi, 2015[108]	Combination	X	X					
Voukelatos, 2007[107]	Group				X			
Voukelatos , 2015[111]	Individual					X		

* Supervised, with the exception of Voukelatos, 2015

† Based on ProFaNE components (Lamb SE, Becker C, Gillespie LD, et al. Reporting of complex interventions in clinical trials: development of a taxonomy to classify and describe fall-prevention interventions. Trials. 2011;12:125).

Table 19. Falls, for exercise interventions, by author

Author, Year	Time, months	Group	Falls	N analyzed	Event rate, per person-year	IRR†	(95% CI)	
Barnett, 2003[104]	12	IG	NR	NR	0.6*	0.60*	(0.36,	0.99)
		CG	NR	NR	0.9*			
Campbell, 1997[105]	12	IG	88	116	0.9*	0.47*	(0.04,	0.90)
		CG	152	117	1.3*			
El-Khoury, 2015[110]	24	IG	533	352	0.8*	0.86	(0.77,	0.96)
		CG	640	354	0.9*			
Fitzharris, 2010[117]	18	IG	181	135	1.0*	0.87	(0.72,	1.07)
		CG	211	137	1.2*			
Freiberger, 2012[115]	24	IG	51	64	0.40	0.68**	(0.40,	1.16)
		CG	82	80	0.51			
Gawler, 2016[113]	6	IG	104	411	0.8*	0.93**	(0.64,	1.37)
		CG	116	458	0.9*			
Kamide, 2009[119]	12	IG	0	20	0.02	0.57	(0.02,	17.1)
		CG	1	23	0.04			
Logghe, 2009[103]	12	IG	115	138	0.83	1.21	(0.92,	1.60)
		CG	90	131	0.69			
Luukinen, 2007[102]	16	IG	NR	NR	1.2*	1.0	NR[β]	
		CG	NR	NR	1.2*			
Robertson, 2001[101]	12	IG	80	121	0.7*	0.54*	(0.32,	0.90)
		CG	109	119	1.0*			
Sherrington, 2014[112]	12	IG	177	171	1.04	1.43**	(1.07,	1.93)
		CG	123	169	0.73			
Trombetti, 2011[116]	6	IG	24	66	0.7*	0.49**	(0.27,	0.91)
		CG	54	68	1.6*			
Uusi-Rasi, 2015[108]	24	IG	NR	103	1.2*	1.07**	(0.77,	1.45)
		CG	NR	102	1.2*			
Voukelatos, 2007[107]	6	IG	86	347	0.50	0.67*	(0.47,	0.94)
		CG	126	337	0.75			
Voukelatos , 2015[111]	12	IG	NR	NR	0.7*	0.88**	(0.60,	1.29)
		CG	NR	NR	0.8*			

Abbreviations: CG = control group; CI = confidence interval; IG = intervention group; IRR = incident rate; NR = not reported

† Calculated

* Author reported event rate or IRR, no adjustment or adjustment not reported

** Author reported event rate or IRR, adjusted

β Could not calculate the 95% CI

Table 20. Injurious falls, for exercise interventions, by author

Author, year	Outcome	Detailed outcome description	Time	Group	Events	N analyzed	Event rate, per person-year[†]	IRR[†]	(95% CI)	
Barnett, 2003[104]	Injurious falls	Falls that resulted in bruises, strains, cuts and abrasions, back pain and fracture.	12	IG	NR	76	0.395*	0.66*	(0.38,	1.15)
				CG	NR	74	0.541*			
El-Khoury, 2015[110]	Falls causing serious injury	Serious falls were those that caused fractures; head injuries requiring admission to hospital; joint dislocations; sprains accompanied by reduced physical function; other non-specified serious joint injuries; and lacerations requiring sutures.	24	IG	68	352	0.097	0.79	(0.57,	1.08)
				CG	87	354	0.12			
	Injurious falls	Combined serious and moderate. Serious falls were those that caused fractures; head injuries requiring admission to hospital; joint dislocations; sprains accompanied by reduced physical function; other non-specified serious joint injuries; and lacerations requiring sutures. Injurious falls were classified as moderate if they resulted in bruising, sprains, cuts, abrasions, or reduction in physical function for at least three days or if the participant sought medical help.	24	IG	305	352	0.45*	0.80	(0.69,	0.93)
				CG	397	354	0.56*			
Fitzharris, 2010[117]	Injurious falls	A cut, scrape, gash, bruise or fracture was sustained; a head injury resulted or the fall resulted in hospitalization.	18	IG	101	135	0.585*	0.89	(0.68,	1.17)
				CG	115	137	0.654*			
	Falls with injuries resulting in health care	NA	18	IG	16	135	0.093*	0.91	(0.46,	1.79)
				CG	18	137	0.102*			
Freiberger, 2012[115]	Injurious falls	NR	24	IG	20	64	0.16	0.62**	(0.30,	1.30)
				CG	35	80	0.22			
Gawler, 2016[113]	Injurious falls	NR	6	IG	64	404	0.49*	0.77	(0.50,	1.20)
				CG	85	454	0.63*			
Gill, 2016[120]	Fall-induced serious injuries	Fall resulting in a clinical, non-vertebral fracture or that led to hospital admission for an injury.	31	IG	81	818	0.038*	0.87*	(0.65,	1.18)
				CG	94	817	0.044*			
	Fall-related admission	NA	31	IG	37	818	0.018*	0.78*	(0.51,	1.20)
				CG	48	817	0.022*			
Karinkanta, 2015[109]	Injurious falls	An event in which the subject contacted the health care provider (a nurse or doctor) or was taken to hospital due to a fall; that is, falling was mentioned in the patient file text written by the health-care professional.	60	IG	14	37	0.074*	0.49*	(0.25,	0.98)
				CG	22	35	0.122*			

Table 20. Injurious falls, for exercise interventions, by author

Author, year	Outcome	Detailed outcome description	Time	Group	Events	N analyzed	Event rate, per person-year†	IRR†	(95% CI)	
Luukinen, 2007[102]	Fall-induced injuries	Injuries included fractures, dislocations and soft tissue injuries needing suturing and even more severe injuries.	16	IG	NR	217	0.18*	0.95	NR‡	
				CG	NR	220	0.19*			
Robertson, 2001[101]	Injurious falls	Injurious falls combines serious and moderate. Fall events were classified as resulting in "serious" injury if the fall resulted in a fracture, admissions to hospital with an injury, or stitches were required, "moderate" injury if bruising, sprains, cuts, abrasions, or reduction in physical function for at least three days resulted or if the participant sought medical help, and "no" injury. The circumstances of "serious" injuries were confirmed from hospital and general practice records.	12	IG	42	121	0.36*	0.80	(0.53,	1.20)
				CG	49	119	0.452*			
	Serious injurious falls	Fall resulting in fracture, admission to hospital with an injury, or stitches were required.	12	IG	2	121	0.016	0.22	(0.05,	1.01)
				CG	9	119	0.076			
	Falls resulting in medical care	NA	12	IG	18	121	0.15	0.68	(0.37,	1.24)
				CG	26	119	0.22			
Sherrington, 2014[112]	Falls with injuries resulting in health care	NA	12	IG	61	171	0.36	1.14**	(0.76,	1.73)
				CG	53	169	0.31			
Uusi-Rasi, 2015[108]	Injurious falls	Injurious falls were those for which participants sought medical care (nurse, physician, or hospital) and included injuries such as bruises, abrasions, contusions, sprains, fractures, and head injuries.	24	IG	NR	103	0.065*	0.46**	(0.22,	0.95)
				CG	NR	102	0.132*			

Abbreviations: CG = control group; CI = confidence interval; IG = intervention group; IRR = incident rate ratio; NA = not applicable; NR = not reported

* Author reported, unadjusted or adjustment not reported
** Author reported, adjusted
† Calculated
‡ 95% CI could not be calculated

Table 21. Fractures, for exercise interventions, by author

Author, year	Outcome	Time, months	Group	Fractures	N analyzed	Event rate, per person-year	IRR†	(95% CI)	
Gill, 2016[120]	Fall-related fracture	31	IG	71	818	0.034*	0.87*	(0.63,	1.19)
			CG	84	817	0.039*			
	Hip fracture	31	IG	13	818	0.006	0.76	(0.37,	1.57)
			CG	17	817	0.008			
Karinkanta, 2015[109]	Fall-related fracture	60	IG	NR	37	NR	0.26*	(0.07,	0.97)
			CG	NR	35	NR			
Sherrington, 2014[112]	Fall-related fracture	12	IG	14	171	0.082	0.92	(0.45,	1.91)
			CG	15	169	0.089			

Abbreviations: CG = control group; CI = confidence interval; IG = intervention group; IRR = incident rate ratio

* Author reported, unadjusted or adjustment not reported
† Calculated

Table 22. People experiencing a fall, for exercise interventions, by author

Author, Year	Time, months	Number of falls per person	Group	People experiencing a fall, n	n analyzed	Percent	RR[†]	(95% CI)	
Barnett, 2003[104]	12	≥1	IG	27	76	35.5	0.71*	(0.49,	1.04)
			CG	37	74	50.0			
		≥2	IG	8	76	10.5	0.44*	(0.21,	0.96)
			CG	18	74	24.3			
Buchner, 1997[100]	12	≥1	CG	18	30	60.0	0.71	(0.48,	1.05)
			IG	32	75	42.7			
Campbell, 1997[105]	12	≥1	IG	53	116	45.7	0.86	(0.66,	1.12)
			CG	62	117	53.0			
		≥2	IG	22	116	19.0	0.65	(0.41,	1.05)
			CG	34	117	29.1			
El-Khoury, 2015[110]	24	≥1	IG	189	352	53.7	0.86	(0.75,	0.97)
			CG	222	354	62.7			
Fitzharris, 2010[117]	18	≥1	IG	76	135	56.3	0.82**	(0.70,	0.97)
			CG	87	137	63.5			
		≥2	IG	40	136	29.6	0.90	(0.63,	1.28)
			CG	45	137	32.8			
		≥3	IG	30	135	22.2	1.22	(0.76,	1.96)
			CG	25	137	18.2			
Gawler, 2016[113]	6	≥1	IG	56	404	13.9	0.95	(0.69,	1.33
			CG	66	454	14.5			
Kovacs, 2013[114]	6	≥1	IG	6	36	0.33	0.40	(0.16,	1.03)
			CG	15	36	0.83			
Logghe, 2009[103]	12	≥1	IG	58	138	42.0	0.93	(0.71,	1.23)
			CG	59	131	45.0			
Luukinen, 2007[102]	16	≥1	IG	126	217	58.1	0.94	(0.81,	1.10)
			CG	136	220	61.8			
		≥3	IG	38	217	17.5	0.90	(0.60,	1.33)
			CG	43	220	19.5			
Morgan, 2004[106]	12	≥1	IG	34	119	28.6	0.92	(0.62,	1.38)
			CG	34	110	30.9			
Ng, 2015[118]	6	≥1	IG	3	48	6.3	0.63	(0.16,	2.47)
			CG	5	50	10.0			
	12	≥1	IG	3	48	6.3	0.63	(0.16,	2.47)
			CG	5	50	10.0			
Sherrington, 2014[112]	12	≥1	IG	98	171	57.3	1.38**	(1.11,	1.73)
			CG	70	169	41.4			
Trombetti, 2011[116]	6	≥1	IG	19	66	28.8	0.69**	(0.44,	1.07)
			CG	32	68	47.1			
		≥2	IG	3	66	4.5	0.21**	(0.06,	0.67)
			CG	16	68	23.5			

Table 22. People experiencing a fall, for exercise interventions, by author

Author, Year	Time, months	Number of falls per person	Group	People experiencing a fall, n	n analyzed	Percent	RR†	(95% CI)	
Voukelatos, 2007[107]	6	≥1	IG	71	347	20.5	0.86*	(0.65,	1.14)
			CG	81	337	24.0			
		≥2	IG	15	347	4.3	0.54*	(0.28,	0.96)
			CG	27	337	8.0			
Voukelatos, 2015[111]	12	≥1	IG	54	159	34.0	0.90*	(0.67,	1.20)
			CG	68	180	37.8			
		≥2	IG	25	159	15.7	1.01*	(0.61,	1.67)
			CG	28	180	15.6			

Abbreviations: CG = control group; CI = confidence interval; IG = intervention group; RR = relative risk

† Calculated
* Author reported RR, not adjusted or adjustment not reported
** Author reported RR, adjusted

Table 24. Mortality, for exercise interventions, by author

Author, year	Outcome	Detailed outcome description	Time	Group	Person with injury	N analyzed	RR†	(95% CI)	
Barnett, 2003[104]	Person with injurious fall	NR	12	IG	22	76	0.77*	(0.48,	1.21)
				CG	28	74			
Campbell, 1997[105]	Person with injurious fall	Combined moderate and serious. "Serious" if falls resulted in a fracture or admission to hospital or if any wounds needed stitches and "moderate" if there was bruising, sprains, cuts, abrasions, or a reduction in physical function for at least three days, or if the woman sought medical help.	12	IG	27	103	0.67*	(0.45,	1.00)
				CG	43	110			
El-Khoury, 2015[110]	Person with injurious fall	Combined serious and moderate. Serious falls were those that caused fractures; head injuries requiring admission to hospital; joint dislocations; sprains accompanied by reduced physical function; other non-specified serious joint injuries; and lacerations requiring sutures. Injurious falls were classified as moderate if they resulted in bruising, sprains, cuts, abrasions, or reduction in physical function for at least three days or if the participant sought medical help	24	IG	170	352	0.90	(0.78,	1.05)
				CG	189	354			
Gill, 2016[120]	Person with serious injury from a fall	A fall resulting in a clinical, non-vertebral fracture or that led to hospital admission for an injury.	31	IG	75	818	0.89	(0.66,	1.20)
				CG	84	817			
	Person with fall-related admission	NA	31	IG	36	818	0.82	(0.53,	1.26)
				CG	44	817			
	Person with fall-related fracture	NA	31	IG	66	818	0.87	(0.63,	1.19)
				CG	76	817			
	Person with hip fracture	NA	31	IG	13	818	0.87	(0.41,	1.81)
				CG	15	817			
Karinkanta, 2015[109]	Injured fallers	An event in which the subject contacted the health-care provider (a nurse or a doctor) or was taken to hospital due to a fall; that is, falling was mentioned in the patient file text written by the health-care professional.	60	IG1	11	37	0.61	(0.34,	1.12)
				CG	17	35			

Abbreviations: CG = control group; CI = confidence interval; IG = intervention group; NR = not reported; RR = relative risk

* Author reported, unadjusted or adjustment not reported
† Calculated

Table 24. Mortality, for exercise interventions, by author

Author, year	Time, months	Group	Deaths	N analyzed	RR[T]	(95% CI)	
Barnett, 2003[104]	12	IG	0	83	0.16	(0.01,	3.16)
		CG	3	80			
Campbell, 1997[105]	12	IG	2	116	0.50	(0.09,	2.70)
		CG	4	117			
El-Khoury, 2015[110]	12	IG	2	352	0.67	(0.11,	3.99)
		CG	3	354			
	24	IG	5	352	0.84	(0.26,	2.72)
		CG	6	354			
Gill, 2016[120]	31	IG	42	818	1.13	(0.74,	1.74)
		CG	37	817			
Karinkanta, 2015[109]	60	IG	0	37	0.47	(0.02,	13.7)
		CG	1	35			
Luukinen, 2007[102]	16	IG	31	217	0.90	(0.58,	1.40)
		CG	35	220			
Ng, 2015[118]	12	IG	0	48	0.52	(0.02,	15.2)
		CG	1	50			
Robertson, 2001[101]	12	IG	1	121	0.16	(0.02,	1.34)
		CG	6	119			
Sherrington, 2014[112]	12	IG	10	171	1.10	(0.16,	2.63)
		CG	9	169			
Trombetti, 2011[116]	12	IG	1	66	1.03	(0.07,	16.1)
		CG	1	68			
Uusi-Rasi, 2015[108]	24	IG	0	103	0.25	(0.01,	5.42)
		CG	2	102			

Abbreviations: CG = control group; CI = confidence interval; IG = intervention group; RR = relative risk

† Calculated

Table 25. Institutionalization, for exercise interventions, by author

Author, Year	Time	Group	Events	N analyzed	Percent	RR†	(95% CI)	
Kovacs, 2013[114]	6	IG	0	36	0	0.50	(0.02,	14.4)
		CG	1	36	2.8			
Trombetti, 2011[116]	12	IG	0	66	0	0.52	(0.02,	15.1)
		CG	1	68	1.5			

Abbreviations: CG = control group; CI = confidence interval; IG = intervention group; RR = relative risk

† Calculated

Table 26. Hospitalization, for exercise interventions, by author

Author, Year	Time, months	Group	Events	N analyzed	Percent	RR†	(95% CI)	
Ng, 2015[118]	6	IG	1	48	2.1	0.52	(0.05,	5.56)
		CG	2	50	4.0			
	12	IG	3	48	6.3	1.56	(0.27,	8.95)
		CG	2	50	4.0			

Abbreviations: CG = control group; CI = confidence interval; IG = intervention group; RR = relative risk

† Calculated

Table 27. ADL, IADL, QOL, for exercise interventions, by author

Outcome	Author, year	Instrument (range)**	Time, months	Group	n analyzed	Mean (SD)	Mean change from baseline (SD)
IADL	Buchner, 1997[100]	Lawton and Brody, modified (0-5)	0	IG	24	4.6 (1.0)	NA
				CG	29	4.6 (0.7)	
			6	IG	24	NR	0.1 (0.4)
				CG	29	NR	0.2 (0.7)
	Campbell, 1997[105]	Lawton and Brody	12	IG	103	NR	No differences between the group scores at BL or 1 year
				CG	109	NR	
	Ng, 2015[118]	Lawton and Brody, modified (IADL-ADL dependency)	6	IG	48	4 (8.3)*	NR
				CG	50	2 (4.0)*	
			12	IG	48	4 (8.3)*	
				CG	50	3 (6.0)*	
QOL	Gawler, 2016[113]	EuroQol EQ-5D (0-1)	0	IG	399	0.675 (0.088)	NR
				CG	450	0.675 (0.082)	
			6	IG	258	0.705 (0.071)	
				CG	296	0.700 (0.074)	
	Sherrington, 2014[112]	SF-12 Mental Component (0-100)	0	IG	171	54.7 (6.5)	Mean difference between IG and CG (95% CI): 0.70 (-0.59, 1.99)
				CG	169	54.7 (6.8)	
			12	IG	157	55.9 (5.0)	
				CG	155	55.2 (7.1)	
		SF-12 Physical Component (0-100)	0	IG	171	37.4 (8.9)	Mean difference between IG and CG (95% CI): 1.45 (-0.24, 3.14)
				CG	169	38.2 (8.4)	
			12	IG	157	40.4 (8.3)	
				CG	155	39.3 (9.3)	
	Voukelatos, 2015[111]	Australian Quality of Life (0-1)	0	IG	191	0.81 (0.79, 0.83)†	NR
				CG	194	0.81 (0.79, 0.83)†	
			6	IG	144	0.84 (0.82, 0.86)†	
				CG	169	0.83 (0.81, 0.85)†	

Abbreviations: ADL = activities of daily living; BL = baseline; CG = control group; CI = confidence interval; IADL = instrumental activities of daily living; IG = intervention group; EQ5D = EuroQol five dimensions questionnaire; EuroQol = European quality of Life; NA = not applicable; NR = not reported; SD = standard deviation; SF = short form

** Higher scores indicate better function for all instruments
* N (%)
† 95% CI

Table 29. Population characteristics, for vitamin D interventions, by author

Author, Year	Quality	Aim	Country	Target Population	Recruitment Setting	Inclusion/Exclusion Criteria
Bischoff-Ferrari, 2006[146]	Good	To investigate a person's risk of falling given long-term supplementation with cholecalciferol-calcium	USA	Community-dwelling ambulatory adults aged 65 years of older	Community-based	Inclusion: Healthy; ambulatory; aged 65 years or older; community-dwelling Exclusion: Current cancer or hyperparathyroidism; kidney stone in past 5 years; renal disease or renal stone in past 5 years; bilateral hip surgery; therapy with a bisphosphonate, calcitonin, estrogen, tamoxifen, or testosterone in the past 6 months or fluoride in the past 2 years; femoral-neck bone mineral density more than 2 standard deviations below the mean for subjects of the same age and sex; dietary calcium intake exceeding 1500 mg per day; laboratory evidence of kidney or liver disease
Dukas, 2004[143]	Fair	To study the effect of alfacalcidol on fall risk in community-dwelling elderly men and women.	Switzerland	Community-dwelling persons aged 70 years or older	Community-based	Inclusion: Community-dwelling; aged 70 years or older; mobile; independent life style; participating in the Basel cohort study Exclusion: Persons with primary hyperparathyroidism; polyarthritis or inability to walk; calcium intake by supplement of more than 500 mg per day; vitamin D intake of more than 200 IU per day; active kidney stone disease; history of hypercalcuria or cancer or other incurable diseases; dementia; elective surgery within the next 3 months; severe renal insufficiency (creatinine clearance <20 mL/min); fracture or stroke within the last 3 months
Gallagher, 2001[144]	Fair	To examine the effect of estrogen and 1,25-dihydroxyvitamin D therapy given individually or in combination on bone loss in elderly women	USA	Women aged 65 years or older with normal bone density for their age	Population-based register	Inclusion: Women; aged 65 years or older; normal bone density for their age Exclusion: Severe chronic illness; primary hyperparathyroidism; active renal stone disease; on certain medications, such as bisphosphonates, anticonvulsants, estrogen, fluoride, or thiazide diuretics in the previous 6 month
Glendenning, 2012[147]	Good	To examine the effects of supervised oral 3-monthly vitamin D therapy on falls, muscle strength, and mobility	Australia	Community-dwelling, ambulatory women aged 70 years or older	Clinic, Population-based register	Inclusion: Community-dwelling; ambulatory; women; aged 70 years or older; registration with a GP; likelihood or attending 4 visits over 9 months Exclusion: Consumption of vitamin D either in isolation or as part of a combination treatment; cognitive impairment (MMSE <24); investigators' opinion would not be suitable for the study

Table 29. Population characteristics, for vitamin D interventions, by author

Author, Year	Quality	Aim	Country	Target Population	Recruitment Setting	Inclusion/Exclusion Criteria
Porthouse, 2005[145]	Fair	To assess whether supplementation with calcium and cholecaliferol (vitamin D3) reduces the risk of fracture in women with one or more risk factors for fracture of the hip	UK	Women; aged 70 and over; one or more risk factors for hip fracture (any previous fracture, low body weight (<58 kg), smoker, family history of hip fracture, or fair or poor self-reported health)	Clinic	Inclusion: Older women aged 70 and over with one or more risk factors for hip fracture: any previous fracture, low body weight (<58 kg), smoker, family history of hip fracture, or fair or poor self-reported health Exclusion: Could not give written consent; receiving calcium supplementation of more than 500 mg per day; history of kidney or bladder stones, renal failure, or hypercalcemia; cognitive impairment; life expectancy of less than six months
Sanders, 2010[148]	Good	To determine whether a single annual dose of 500,000 IU of cholecalciferol administered orally to older women in autumn or winter would improve adherence and reduce the risk of falls and fracture	Australia	Community-dwelling women aged 70 years or older at high risk of fracture	Population-based register	Inclusion: Community-dwelling; women; aged 70 years or older; at high risk of fracture, defined by criteria such as maternal hip fracture, past fracture, or self-reported faller Exclusion: Could not provide informed consent or information about falls or fractures; permanently resided at a high-level care facility; albumin-corrected calcium level higher than 2.65 mmol/L; creatinine level higher than 150 µmol/L; currently took vitamin D doses of 400 IU or more, calcitriol, or antifracture therapy
Uusi-Rasi, 2015[108]	Good	To determine the effectiveness of targeted exercise training and vitamin D supplementation in reducing falls and injurious falls among older women	Finland	Home-dwelling; women; aged 70 to 80 years old; history of at least one fall during the last 12 months; no regular use of vitamin D supplements	Population-based register	Inclusion: Home-dwelling; women; aged 70 to 80 years old; history of at least one fall during the last 12 months; no regular use of vitamin D supplements Exclusion: Moderate to vigorous exercise more than 2 hours per week; regular use of vitamin D or calcium plus vitamin D supplements, a recent fracture (during prior 12 months); contraindication or inability to participate in the exercise program; marked decline in the basic activities of daily living (ADL); cognitive impairments; primary hyperthyroidism; degenerative conditions such as Parkinson's disease

Abbreviations: ADL = activities of daily living; IU = international unit(s); min = minute(s); mg = milligram(s); MMSE = Mini-Mental State Examination; ms = milliseconds; NR = not reported; UK = United Kingdom; USA = United States of America

Table 29. Population characteristics, for vitamin D interventions, by author

Author, Year	N randomized	Mean age	Female, %	SES	White, %	Definition of fall risk*	At risk of falling,* %	Baseline health or functional status	Mean serum 25-hydroxyvitamin D level at baseline, ng/ml
Bischoff-Ferrari, 2006[146]	445 IG: 219 CG: 226	71	55.3	NR	96.6	NA	NR	NR	29.5
Dukas, 2004[143]	378 IG: 192 CG: 186	75	51	NR	NR	NR	NR	1 fall in previous 3 months: 9.2% 2+ falls in previous 3 months: 1.9%	29.1
Gallagher, 2001[144]	246 IG: 123 CG: 123	71	100	NR	98 [total, including HRT groups]	NR	NR	NR	31.8
Glendenning, 2012[147]	686 IG: 353 CG: 333	76.7	100	NR	96.5	NA	NR	MMSE, mean: 29.0 1+ fall in the previous 12 months: 29.1%	26.4†
Porthouse, 2005[145]	3314 IG: 1321 CG: 1993	76.8	100	NR	NR	≥1 risk factors for a hip fracture (any previous fracture, weight <58 kg, smoker, family history of hip fracture, or fair/ poor self-reported health)	100	Fall in previous 12 months: 34% Self-reported poor/fair health: 38%	NR
Sanders, 2010[148]	2258 IG: 1131 CG: 1127	NR (76 median)	100	NR	NR	Higher risk of hip fracture (maternal hip fracture, past fracture, or self reported faller)	100	Self- or physician-reported high risk of falling: 39%	IG: 21** CG: 18**
Uusi-Rasi, 2015[108]	204 (205 randomized to other groups) IG: 102 CG: 102	74.0	100	NR	NR	Fallen at least once in the previous 12 months (from inclusion)	100	ADL (range 6-36, lower scores indicate better functioning): 6.9 IADL (range 8-48, lower scores indicate better functioning): 10.3	26.8

Abbreviations: CG = control group; HRT = hormone replacement therapy; IG = intervention group; kg = kilograms; MMSE = Mini Mental State Examination; NA = not applicable; NR = not reported.
* As defined by study authors
† Among 40 participants that were randomly selected from the IG and CG
** Median

Table 30. Intervention details, for vitamin D interventions, by author

Author, Year	IG Description	CG Description	Vit D formulation and dose	Duration, months
Bischoff-Ferrari, 2006[146]	Participants received cholecalciferol (700 IU/day) AND calcium citrate malate (500 mg/day). Participants were asked to terminate any additional calcium or cholecalciferol supplements 2 months before the start of the study and throughout.	Placebo; tablets had identical appearance to the vitamin D pill and were taken once daily at bedtime	Cholecalciferol 700 IU PO q.d.	36
Dukas, 2004[143]	This was a 36-week double-blind, placebo-controlled, randomized trial. Participants were randomly assigned to 1 ug alfacalcidol (Alpha D3 TEVA) or matching placebo once daily. Calcium supplementation was not part of the intervention. None of the participants was receiving physical therapy or participating in training programs at study entry, and no attempt was made to alter subjects' diet or physical activity during the study.	Matching placebo	Alpha D3 TEVA (1-hydroxycholecalciferol) 1ug PO q.d.	9
Gallagher, 2001[144]	Subjects were randomized to one of four groups: conjugated estrogens to women without a uterus (estrogen replacement therapy) plus medroxyprogesterone acetate to women with a uterus (hormone replacement therapy), calcitriol, and a combination of HRT/ERTplus calcitriol, or placebos.	Matching placebo	Calcitriol (Rocaltrol) 0.25 µg twice a day	36
Glendenning, 2012[147]	Cholecalciferol therapy.	Identical placebo. Both groups received written lifestyle advice on maintaining physical activity (optimally 30 minutes per day outside) and consuming 1300 mg calcium per day using diet and/or supplements.	Cholecalciferol 150,000 IU PO q 3 mo	9
Porthouse, 2005[145]	Participants received general lifestyle advice on how to reduce their risk of fracture and a six month supply of 800 IU of cholecalciferol (vitamin D3) AND 1000 mg of calcium (calcium carbonate) as two tablets daily. Participants were recalled to see the practice nurse after six months and given a further supply of supplements if they wanted to continue with the study.	Usual care; the control group participants were sent a leaflet with general advice on prevention of falls and on how to consume adequate calcium and vitamin D from dietary sources.	Cholecalciferol 800 IU PO q.d.	18
Sanders, 2010[148]	Single oral dose of cholecalciferol (500,000 IU) annually	Matching placebo	Cholecalciferol 500,000 IU PO q year	36-60
Uusi-Rasi, 2015[108]	Participants received one daily pill containing 800 IU (20 µg) of vitamin D3 for 24 months. All tablets were provided by Oy Verman Ab (Kerava, Finland) and were similar in size, appearance, and taste (compared to placebo tablets). Each participant received a pack of pills for 6 months at a time.	Placebo	Cholecalciferol 800 IU (20µg) PO q.d.	24

Abbreviations: b.i.d. = twice a day; CG = control group; CI = confidence interval; ERT = estrogen replacement therapy; HRT = hormone replacement therapy; IG = intervention group; IU = international unit; IRR = incident rate ratio; mg = milligram(s); mo = month; PO = by mouth; q = once; q.d. = once a day; ug = micrograms

Table 31. Falls, for vitamin D interventions, by author

Author, Year	Time, months	Group	Falls	N analyzed	Event rate, per person-year	IRR†	(95% CI)	
Bischoff-Ferrari, 2006[146]	36	IG	274	219	0.42	1.12	(0.95,	1.33)
		CG	252	226	0.37			
Dukas, 2004[143]	9	IG	46	192	0.32	0.87	(0.59,	1.30)
		CG	51	186	0.37			
Gallagher, 2001[144]	36	IG	NR	101	0.27*	0.63	(0.47,	0.84)
		CG	NR	112	0.43*			
Sanders, 2010[148]	36	IG	2892	1131	0.85	1.16**	(1.03,	1.31)
		CG	2512	1125	0.74			
Uusi-Rasi, 2015[108]	24	IG	NR	102	1.32*	1.08**	(0.78,	1.52)
		CG	NR	102	1.18*			

Abbreviations: CG = control group; CI = confidence interval; IG = intervention group; IRR = incidence rate ratio; NR = not reported

† Calculated

* Author reported, unadjusted or adjustment not reported

** Author reported event rate or IRR, adjusted

Table 32. Injurious falls and fracture, for vitamin D interventions, by author

Outcome category	Author, year	Outcome description	Time, months	Group	Events	N analyzed	Event rate, per person-year	IRR†	(95% CI)	
Injuries	Sanders, 2010[148]	Falls with soft tissue injury	36	IG	1710	1131	0.50	1.15*	(1.02,	1.29)
				CG	1488	1125	0.44			
	Uusi-Rasi, 2015[108]	Injurious falls	24	IG	NR	102	0.129	0.84**	(0.45,	1.57)
				CG	NR	102	0.132			
Fractures	Sanders, 2010[148]	Falls resulting in fracture	36	IG	137	1131	0.040	1.25	(0.97,	1.61)
				CG	109	1125	0.032			

Abbreviations: CG = control group; CI = confidence interval; IG = intervention group; IRR = incidence rate ratio; NR = not reported

* Author reported, unadjusted or adjustment not reported

** Author reported, adjusted

† Calculated

Table 33. People experiencing a fall, for vitamin D interventions, by author

Author, Year	Time, months	Number of falls per person	Group	People experiencing a fall, n	n analyzed	Percent	RR†	(95% CI)	
Bischoff-Ferrari, 2006[146]	36	≥1	IG	107	219	48.9	0.89	(0.74,	1.07)
			CG	124	226	54.9			
Dukas, 2004[143]	9	≥1	IG	40	192	20.8	0.84	(0.58,	1.22)
			CG	46	186	24.7			
Gallagher, 2001[144, 150]	36	≥1	IG	50	101	49.5	0.77	(0.61,	0.98)
			CG	72	112	64.3			
		≥2	IG	25	101	24.8	0.77	(0.50,	1.19)
			CG	32	112	32.1			
		≥3	IG	11	101	10.9	0.68	(0.34,	1.36)
			CG	18	112	16.1			
Glendenning, 2012[147]	9	≥1	IG	102	353	28.9	1.08	(0.85,	1.38)
			CG	89	333	26.7			
		≥2	IG	26	353	7.4	1.53	(0.84,	2.81)
			CG	16	333	4.8			
Porthouse, 2005[145]	12	≥1	IG	283	914	31.0	1.01	(0.90,	1.14)
			CG	498	1627	30.6			
Sanders, 2010[148]	36	≥1	IG	837	1131	74.0	1.08	(1.03,	1.14)
			CG	769	1125	68.4			
		≥2	IG	558	1131	49.3	1.06	(0.97,	1.16)
			CG	523	1125	46.5			

Abbreviations: CG = control group; CI = confidence interval; IG = intervention group; RR = relative risk

† Calculated

Table 34. Person experiencing a fracture, for vitamin D interventions, by author

Author, year	Outcome	Time, months	Group	Events	N analyzed	RR†	(95% CI)	
Bischoff-Ferrari, 2006[146, 149]	Person with nonvertebral fracture (1+)	36	IG	11	187	0.46	(0.23,	0.90)
			CG	26	202			
	Person with hip fracture	36	IG	0	187	0.54	(0.02,	16.0)
			CG	1	202			
Glendenning, 2012[147]	Person with fracture (1+)	9	IG	10	353	0.94	(0.40,	2.24)
			CG	10	333			
Porthouse, 2005[145]	Physician-confirmed persons with hip fractures	25	IG	3	714	0.39	(0.11,	1.34)
			CG	15	1391			
Sanders, 2010[148]	Person with nonvertebral fracture (1+)	36	IG	124	1131	1.22	(0.95,	1.57)
			CG	101	1125			

Abbreviations: CG = control group; CI = confidence interval; IG = intervention group; N = number; RR = relative risk
† Calculated

Table 35. Mortality, for vitamin D interventions, by author

Author, year	Time, months	Group	Deaths	N analyzed	RR†	(95% CI)	
Dukas, 2004[143]	9	IG	1	192	0.97	(0.06,	15.38)
		CG	1	186			
Gallagher, 2001[144]	36	IG	1	123	1.00	(0.06,	15.8)
		CG	1	123			
Glendenning, 2012[147]	9	IG	2	353	3.77	(0.2,	73.4)
		CG	0	333			
Porthouse, 2005[145]	18	IG	57	1321	1.26	(0.90,	1.79)
		CG	68	1993			
Sanders, 2010[148]	36	IG	40	1131	0.85	(0.56,	1.28)
		CG	47	1125			
Uusi-Rasi, 2015[108]	24	IG	2	102	1.00	(0.14,	6.96)
		CG	2	102			

Abbreviations: CG = control group; CI = confidence interval; IG = intervention group; N = number; RR = relative risk
† Calculated

Table 36. ADL, IADL, QOL, for vitamin D interventions, by author

Outcome	Author, year	Instrument (range)**	Time, months	Group	n analyzed	Mean (SD)	Mean difference between IG and CG (95% CI)
QOL	Porthouse, 2005[145]	SF-12 Mental Component (0-100)	0	IG	1321	51.4 (9.8)	NR
				CG	1993	51.2 (9.7)	
			12	IG	1321	52.0 (9.2)	0.03 (-0.04, 0.97)
				CG	1993	51.9 (9.2)	
		SF-12 Physical Component (0-100)	0	IG	1321	40.1 (12.0)	NR
				CG	1993	40.29 (12.2)	
			12	IG	1321	41.66 (11.7)	-0.152 (-0.10, 0.7)
				CG	1993	41.20 (11.9)	

Abbreviations: CG = control group; CI = confidence interval; IG = intervention group; n = number; NR = not reported; QOL = quality of life; SD = standard deviation; SF = short form

** Higher scores indicate better function for all instruments

Table 37. Harms, for vitamin D interventions, by author

Author, Year	Outcome	Time	Group	Events	N analyzed	RR†	(95% CI)	
Bischoff-Ferrari, 2006[146, 149]	Epigastric distress	36	IG	1	187	0.54	(0.049,	5.91)
			CG	2	202			
	Flank pain	36	IG	0	187	0.54	(0.018,	16.0)
			CG	1	202			
	Constipation	36	IG	3	187	6.48	(0.33,	128.5)
			CG	0	202			
	Sweating	36	IG	1	187	2.16	(0.073,	64.0)
			CG	0	202			
	Hypercalciuria	36	IG	1	187	2.16	(0.073,	64.0)
			CG	0	202			
Dukas, 2004[143]	Itching	9	IG	22	192	0.93	(0.54,	1.60)
			CG	23	186			
	Major diseases	9	IG			No differences observed in the frequency of major diseases between IG and CG		
	Serious adverse events	9	IG			No cases of serious AE attributable to treatment		
	Side effects	9	IG	75	192	0.89	(0.70,	1.13)
			CG	82	186			
	Skin eruption	9	IG	15	192	1.32	(0.62,	2.80)
			CG	11	186			
	Transient hypercalcemia	9	IG	5	192	4.84	(0.57,	41.1)
			CG	1	186			
Gallagher, 2001[144]	Cardiovascular event	36	IG	4	123	1.33	(0.30,	5.83)
			CG	3	123			
	Cerebrovascular accident	36	IG	4	123	1.33	(0.30,	5.83)
			CG	3	123			
	Deep vein thrombosis	36	IG	0	123	0.50	(0.02,	14.77)
			CG	1	123			
	Gallbladder major adverse event	36	IG	3	123	6.00	(0.30,	118.54)
			CG	0	123			
	Gastrointestinal major adverse event	36	IG	20	123	0.91	(0.52,	1.58)
			CG	22	123			
	Hypercalciuria	36	IG	32	123	3.20	(1.65,	6.22)
			CG	10	123			
	Incident cancer	36	IG	6	123	1.20	(0.38,	3.83)
			CG	5	123			
	Kidney stone	36	IG	0	123	0.50	(0.02,	14.77)
			CG	1	123			
	Psychiatric major adverse event	36	IG	7	123	1.75	(0.53,	5.83)
			CG	4	123			

Table 37. Harms, for vitamin D interventions, by author

Author, Year	Outcome	Time	Group	Events	N analyzed	RR†	(95% CI)	
Glendenning, 2012[147]	Incident cancer	9	IG	19	353	1.19	(0.62,	2.31)
			CG	15	333			
	Ischemic heart disease	9	IG	2	353	0.47	(0.09,	2.56)
			CG	4	333			
	Person with fracture	9	IG	10	353	0.94	(0.40,	2.24)
			CG	10	333			
	Stroke	9	IG	3	353	1.42	(0.24,	8.42)
			CG	2	333			
	Type 2 diabetes	9	IG	1	353	0.47	(0.04,	5.18)
			CG	2	333			
Sanders, 2010 [148]	Cardiovascular event	36	IG	17	1131	1.30	(0.63,	2.67)
			CG	13	1125			
	Incident cancer	36	IG	7	1131	0.70	(0.27,	1.82)
			CG	10	1125			
	Serious adverse events	36	IG	244	1131	1.17	(0.99,	1.38)
			CG	207	1125			
	Number of Fractures	36	IG	171	1131	1.25*	(0.99	1.58)
			CG	135	1125			

Abbreviations: AE = adverse event; CI = confidence interval; CG = control group; IG = intervention group; N = number; RR = relative risk

* IRR

† Calculated

Table 38. Study characteristics, for environment interventions, by author

Author, Year	Quality	Aim	Country	Target Population	Recruitment Setting	Inclusion/Exclusion Criteria
Fitzharris, 2010[117]	Fair	To examine the effectiveness of the Whitehorse NoFalls trial on all falls, falls resulting in injury and falls requiring medical care	Australia	Community-dwelling people aged 70 years or older	Population-based register	Inclusion: Community-dwelling; aged 70 years or older; living in the City of Whitehorse local government area; living in one's own home or apartment, or leasing similar accommodations and permitted to make modifications Exclusion: Did not expect to remain in the area 2 two years (except for short absences); participated in regular to moderate physical activity with a balance improvement component in the previous two months; could not walk 10-20 meters without rest, help, or having angina; severe respiratory or cardiac disease; psychiatric illness prohibiting participation; dysphasia; had recent major home modifications; had an education and language adjusted score > 4 on the short portable mental status questionnaire; did not have the approval of their general practitioner
Pighills, 2011[157]	Good	To assess the effectiveness of an environmental fall-prevention intervention delivered by qualified occupational therapists or unqualified trained assessors	UK	Community-dwelling adults aged 70 and older with a history of falls in the previous year	Clinic	Inclusion: Community-dwelling; aged 70 and older; residing in the catchment area; experienced one or more falls in the preceding year Exclusion: Living in nursing or residential homes; currently receiving occupational therapy; had received a fall-specific occupational therapy intervention in the preceding year
Stevens, 2001[156]	Fair	To evaluate the outcome of an intervention to reduce hazards in the home on the rate of falls in seniors	Australia	People aged 70 years and older living independently	Population-based register	Inclusion: 70 years and older; living independently; able to follow the study protocol; able to speak and write in English; could contribute substantial person-time to the study (at least 10 months); could make changes to the environment inside the home; had not modified their home by the fitting of ramps or grab rails Exclusion: Living in an institutional setting

Abbreviations: UK = United Kingdom

Table 39. Population characteristics, for environment interventions, by author

Author, Year	N randomized	Mean age	Female, %	SES	White, %	Definition of fall risk*	At risk of falling,* %	Baseline health or functional status
Fitzharris, 2010[117]	1090 (some randomized to other groups) IG: 136 CG: 137	76.1 (total)	60 (total)	NR	NR	NA	NR	Living alone: 54% Fall in past month: 6% Mean ADL (IADL plus bathing): 5.3 Mean number of medications: 3.4
Pighills, 2011[157]	238 (73 randomized to another group) IG: 87 CG: 78	79	69	NR	NR	One or more falls in the preceding year (from inclusion)	100	Mean baseline falls: 3 Mean Barthel index: 18
Stevens, 2011[156]	1879 IG: 635 CG: 1244	76	52.3	NR	NR	NA	NR	Fell in past year: 27%

Abbreviations: ADL = activities of daily living; CG = control group; IADL = instrumental activities of daily living; IG = intervention group; NA = not applicable; NR = not reported; SES = socioeconomic status

* As defined by study authors

Table 40. Intervention details, for environment interventions, by author

Author, Year	IG	CG	Format	Delivered By	Duration
Fitzharris, 2010[117]	The home hazard intervention involved the removal or modification of hazards, both inside the home and at the entry points, identified in the initial risk factor assessment. Home hazard reduction was undertaken either by the participants or via the City of Whitehorse's home maintenance service. Home maintenance staff visited the home, providing a quotation for the work, including free labor and materials up to the value of $54. (Unclear who is conducting the home hazards risk assessment)	Usual care; the control group received a delayed intervention	Individual	NR, Home maintenance service	Single assessment
Pighills, 2011[157]	Occupational therapist led environmental assessment (modification of the home environment). The Westmead Home Safety Assessment (WeHSA) was used to guide the intervention, which represents a systematic approach to identifying home hazards. An accompanying manual provides background to different types of hazards and potential risks and describes the relationship between hazards and the evaluation of the person. The intervention consisted of assessment of participants in their home environment using the WeHSA to identify personal risk from environmental and behavioral perspectives. The assessor and participant moved through the house together to enable functional evaluation and participant involvement in hazard identification. The assessments were conducted during a single visit lasting 1.5 to 2 hours. A follow-up telephone contact was made after 4 weeks to determine whether the recommendations had been followed. Another telephone contact was made after 12 months to establish the level of adherence to recommendations and reasons for non-adherence.	Usual care; CG remained under the care of their general practitioner and were referred for services as required.	Individual	Occupational therapists	Single assessment + follow-up phone calls
Stevens, 2001[156]	A trained research nurse conducted a home visit that followed a structured protocol, consisting of obtaining consent and educating participants on how to recognize a fall and complete the daily calendar; the intervention consisted of three strategies including home hazard assessment, installation of free safety devices, and an educational strategy to empower seniors to remove or modify home hazards	The control group did not receive safety devices or information on home hazard reduction	Individual	Research nurse	Single assessment

Abbreviations: CG = control group; IG = intervention group; NR = not reported

Table 41. Falls, for remaining interventions, by author

Intervention Type	Author, Year	Time, months	Group	Falls	N analyzed	Event rate, per person-year†	IRR†	(95% CI)	
Environment	Fitzharris, 2010[117]	18	IG	212	136	1.2*	0.98	(0.81,	1.19)
			CG	211	137	1.2*			
	Pighills, 2011[157]	12	IG	175	87	2.01	0.54*	(0.36	0.83)
			CG	290	78	3.72			
	Stevens, 2001[156]	12	IG	NR	NR	0.69*	1.02**	(0.83	1.27)
			CG	NR	NR	0.72*			
Medical management	Blalock, 2010[158]	12	IG	151	322	2.2*	1.01	(0.81,	1.26)
			CG	171	322	2.1*			
Psychological	Dorresteijn, 2016	12	IG	362	166	2.18	0.86**	(0.65,	1.13)
			CG	429	180	2.38			
	Zijlstra, 2009[161]	14	IG	302	280	0.92	0.86**	(0.65	1.14)
			CG	381	260	1.26			
Multiple	Clemson, 2004[166]	14	IG	179	157	0.98	0.68	(0.57,	0.83)
			CG	255	153	1.43			
	Fitzharris, 2010[117]	18	IG	162	135	0.96*	0.80	(0.65,	0.98)
			CG	211	137	1.2*			
	Freiberger, 2012[115]	24	IG	90	73	0.62	0.94**	(0.58	1.53)
			CG	82	80	0.51			
	Shumway-Cook, 2007[167]	12	IG	297	226	1.33*	0.75*	(0.52	1.09)
			CG	398	227	1.77*			
	Siegrist, 2016[168]	12	IG	291	222	1.3	0.54**	(0.35,	0.84)
			CG	367	156	2.4			
	Uusi-Rasi, 2015[108]	24	IG	NR	102	1.13*	0.99**	(0.72	1.39)
			CG	NR	102	1.18*			

Abbreviations: CG = control group; CI = confidence interval; IG = intervention groups; IRR = incidence rate ratio; N = number; NR = not reported; RR = relative risk

† Calculated

* Author reported event rate or IRR, no adjustment or adjustment not reported

** Author reported event rate or IRR, adjusted

Table 42. Injurious falls, for other interventions, by author

Intervention type	Author, year	Outcome	Detailed outcome	Time, months	Group	Events	N analyzed	Event rate, per person-year[†]	IRR[†]	(95% CI)	
Environment	Fitzharris, 2010[117]	Injurious falls	A cut, scrape, gash, bruise or fracture was sustained; a head injury resulted or where the fall resulted in hospitalization.	18	IG	114	136	0.635*	0.97	(0.75,	1.26)
					CG	115	137	0.654*			
		Falls with injuries resulting in health care	NA	18	IG	27	136	0.15*	1.47	(0.81,	2.67)
					CG	18	137	0.102*			
Medication management	Blalock, 2010[158]	Injurious falls	Any reported injury, irrespective of the severity.	12	IG	55	93	0.59	0.87	(0.62,	1.24)
					CG	72	93	0.77			
Psychological	Dorresteijn, 2016[162]	Falls resulting in medical care	NA	12	IG	106	166	0.64	1.42**	(0.96,	2.10)
					CG	87	180	0.48			
	Zijlstra, 2009[161]	Fall-induced injuries resulting in health care	NA	14	IG	75	280	0.23	0.78**	(0.45,	1.34)
					CG	102	260	0.34			
Multiple	Fitzharris, 2010[117]	Injurious falls	A cut, scrape, gash, bruise or fracture was sustained; a head injury resulted; or where the fall resulted in hospitalization.	18	IG	88	135	0.52*	0.80	(0.60,	1.05)
					CG	115	137	0.654*			
		Falls with injuries resulting in health care	NA	18	IG	14	135	8.3	0.81	(0.40,	1.64)
					CG	18	137	10.2			
	Freiberger, 2012[115]	Injurious falls	NR	24	IG	42	73	0.29	1.02**	(0.54,	1.95)
					CG	35	80	0.22			
	Shumway-Cook, 2007[167]	Falls resulting in medical care	NA	12	IG	NR	226	0.18*	0.72**	(0.45,	1.15)
					CG	NR	227	0.21*			
	Siegrist, 2016[168]	Fall-induced injuries	NR	12	IG	NR	222	NR	0.79**	(0.49,	1.33)
					CG	NR	156	NR			
	Uusi-Rasi, 2015[108]	Injurious falls	Injurious falls were those for which participants sought medical care (nurse, physician, or hospital) and included injuries	24	IG	NR	102	0.05*	0.38**	(0.17,	0.81)
					CG	NR	102	0.132*			

Table 42. Injurious falls, for other interventions, by author

Intervention type	Author, year	Outcome	Detailed outcome	Time, months	Group	Events	N analyzed	Event rate, per person-year†	IRR†	(95% CI)	
			such as bruises, abrasions, contusions, sprains, fractures, and head injuries.								

Abbreviations: CG = control group; CI = confidence interval; IG = intervention group; IRR = incidence rate ratio; N = number; NA = not applicable; NR = not reported
† Calculated
** Author reported, adjusted

Table 43. People experiencing a fall, for other interventions, by author

Intervention Type	Author, Year	Time, months	Number of falls per person	Group	People experiencing a fall, n	n analyzed	Percent	RR†	(95% CI)	
Environment	Fitzharris, 2010[117]	18	≥1	IG	78	136	57.4	0.92**	(0.78	1.08)
				CG	87	137	63.5			
			≥2	IG	42	136	30.9	0.94	(0.66,	1.33)
				CG	45	137	32.8			
	Pighills, 2011[157]	12	≥1	IG	50	87	57.5	0.83	(0.66,	1.05)
				CG	54	78	69.2			
	Stevens, 2001[156]	12	≥1	IG/CG	NR	570	NR	0.93‡	(0.75,	1.15)
Medication management	Blalock, 2010[158]	12	≥1	IG	53	93	57.0	1.02	(0.79,	1.31)
				CG	52	93	55.9			
			≥2	IG	NR	NR	NR	0.96	(0.65,	1.40)
				CG	NR	NR	NR			
	Mott, 2016[159]	6	≥1	IG	11	39	28.2	1.16	(0.55,	2.41)
				CG	10	41	24.4			
			≥2	IG	6	39	15.4	2.10	(0.56,	7.83)
				CG	3	41	7.3			
			≥3	IG	2	39	5.1	1.05	(0.16,	7.10)
				CG	2	41	4.9			
Psychological	Dorresteijn, 2016 [162]	12	≥1	IG	94	166	56.6	0.96	(0.80,	1.15)
				CG	106	180	58.9			
			≥2	IG	55	166	33.1	0.89	(0.67,	1.19)
				CG	67	180	37.2			
	Zijlstra, 2009[161]	8	≥1	IG	80	280	28.6	0.74‡	(0.35,	1.60)
				CG	95	260	36.5			
			≥2	IG	35	280	12.5	0.48‡	(0.20,	1.12)
				CG	53	260	20.4			
		14	≥1	IG	91	280	32.5	0.50‡	(0.23,	1.08)
				CG	117	260	45.0			
			≥2	IG	48	280	17.1	0.38‡	(0.17,	0.84)
				CG	76	260	29.2			
Multiple	Clemson, 2004[166]	14	≥1	IG	82	157	52.2	0.90	(0.73,	1.10)
				CG	89	153	58.2			
			≥2	IG	40	157	25.5	0.74	(0.52,	1.04)
				CG	53	153	34.6			
	Fitzharris, 2010[117]	18	≥1	IG	65	135	48.1	0.67**	(0.51,	0.88)
				CG	87	137	63.5			
			≥2	IG	31	135	23.0	0.70	(0.47,	1.03)
				CG	45	137	32.8			
			≥3	IG	22	135	16.3	0.89	(0.53,	1.50)
				CG	25	137	18.2			

Table 43. People experiencing a fall, for other interventions, by author

Intervention Type	Author, Year	Time, months	Number of falls per person	Group	People experiencing a fall, n	n analyzed	Percent	RR†	(95% CI)	
	Shumway-Cook, 2007[167]	12	≥1	IG	124	226	54.9	0.96**	(0.82,	1.13)
				CG	130	227	57.3			
	Siegrist, 2016[168]	12	≥1	IG	93	222	41.9	0.85	(0.68,	1.06)
				CG	77	156	49.4			

Abbreviations: CG = control group; CI = confidence interval; IG = intervention group; NA = not applicable; NR = not reported; RR = relative risk

† Calculated

** Author reported RR, adjusted

‡ Author reported OR, adjusted

NOTE: Stevens, 2001 not in figure (Figure 20)

Table 43. People experiencing a fall, for other interventions, by author

Intervention type	Outcome	Author, year	Instrument (range)**	Time, months	Group	n analyzed	Mean (SD)	Mean difference between IG and CG (95% CI)
Environment	ADL	Pighills, 2011[157]	Barthel (0-20)	0	IG	87	18 (3)	NR
					CG	78	18 (3)	
				12	IG	87	18.4 (18.1, 18.7)*	NR
					CG	78	18.4 (18.1, 18.7)*	
	QOL	Pighills, 2011[157]	EuroQol (0-1)	0	IG	87	0.6 (0.3)	NR
					CG	78	0.6 (0.3)	
				12	IG	87	0.58 (0.55, 0.62)	NR
					CG	78	0.56 (0.53, 0.60)	
			SF-12 Mental Component (0-100)	0	IG	87	49 (11)	NR
					CG	78	47 (11)	
				12	IG	87	50 (48, 51)	NR
					CG	78	49 (48, 50)	
			SF-12 Physical Component (0-100)	0	IG	87	33 (14)	NR
					CG	78	33 (12)	
				12	IG	87	35 (34, 37)	NR
					CG	78	34 (32, 36)	
Psychological	ADL	Dorresteijn, 2016[162]	Groningen Activity Restriction Scale (11-44)	0	IG	141	18.5 (4.9)	NR
					CG	171	18.7 (4.9)	
				12	IG	141	17.6 (4.9)	-0.83 (-∞, -0.24)†
					CG	171	18.7 (4.8)	
	IADL	Dorresteijn, 2016[162]	Groningen Activity Restriction Scale (7-28)	0	IG	141	15.6 (5.1)	NR
					CG	171	15.0 (15.4)	
				12	IG	141	14.8 (5.0)	-1.01 (-∞, -0.41)†
					CG	171	15.4 (5.1)	
		Zijlstra, 2009[161]	Frenchay Activities Index (15-60)	0	IG	280	39.5 (7.2)	NR
					CG	260	38.2 (7.2)	
				8	IG	280	40.3 (6.9)	0.9 (0.1, 1.7)
					CG	260	38.0 (7.4)	
				14	IG	280	39.6 (7.4)	0.5 (-0.4, 1.4)
					CG	260	37.7 (7.6)	
	ADL/IADL	Dorresteijn, 2016[162]	Groningen Activity Restriction Scale (18-72)	0	IG	141	34.1 (9.4)	NR
					CG	171	33.7 (9.3)	
				12	IG	141	32.4 (9.4)	-1.81 (-∞, -0.77)†
					CG	171	34.0 (9.3)	
Multiple	QOL	Clemson, 2004[166]	SF-36 Mental Component (0-100)	0	IG	157	53.2 (11.1)	NR
					CG	153	54.3 (10.3)	
				14	IG	133	NR	0.5 (-3.0, 1.9)
					CG	125	NR	
			SF-36 Physical Component (0-100)	0	IG	157	38.4 (10.8)	NR
					CG	153	38.8 (10.7)	
				14	IG	133	NR	0.7 (-2.9, 1.9)

Table 43. People experiencing a fall, for other interventions, by author

Intervention type	Outcome	Author, year	Instrument (range)**	Time, months	Group	n analyzed	Mean (SD)	Mean difference between IG and CG (95% CI)
					CG	125	NR	

Abbreviations: ADL = activities of daily living; CG = control group; CI = confidence interval; IADL = instrumental activities of daily living; IG = intervention group; EQ5D = EuroQol five dimensions questionnaire; EuroQol = European quality of Life; NA = not applicable; NR = not reported; SD = standard deviation; SF = short form; VAS = visual analogue scale

* 95% CI
** Higher scores indicate better function for all instruments, with the exception of the Groningen Activity Restriction Scale where lower scores indicate better function
† Adjusted

Table 45. Study characteristics, for medication management interventions

Author, Year	Quality	Aim	Country	Target Population	Recruitment Setting	Inclusion/Exclusion Criteria
Blalock, 2010[158]	Fair	To assess the effects of a community pharmacy-based fall-prevention program targeting high-risk older adults on the rates of recurrent falls, injurious falls, and filling prescriptions for medications that have been associated with an increased risk of falling	US	Individuals at high risk for falling, specifically those ≥65 years of age	Central electronic database of prescription records maintained by Kerr Drug	Inclusion: High risk for falling; ≥65 years of age; ≥1 fall not attributable to syncope within the 1-year period preceding randomization; taking ≥4 different chronic prescription medications, ≥1 of which was a CNS-active medication Exclusion: Residing in a long-term care facility; housebound; not able to read and write English; exhibited significant cognitive impairment (3 or more errors on a 6-item screening derived from the MMSE)
Mott, 2016[159]	Fair	To examine the preliminary effects of the targeted medication therapy management intervention on the rate of discontinuing falls risk-increasing drugs and the risk and rate of falling.	US	Older adults who completed a fall prevention workshop	Community-based	Inclusion: English speaking participants; 65 years and older; fallen in the past 12 months or have a fear of falling; complete at least four of the seven curriculum classes in the Stepping On workshop; capable of providing their own consent Exclusion: NR

Abbreviations: CNS = central nervous system; MMSE = Mini Mental State Examination; NR = not reported; US = United States

Table 46. Population characteristics, medication management interventions

Author, Year	N randomized	Mean age	Females, %	SES	White, %	Definition of fall risk*	At risk of falling,* %	Baseline health or functional status
Blalock, 2010[158]	186 IG: 93 CG: 93	74.8	71.0	24.2% (high school education or less)	88.7	Had experienced ≥1 fall not attributable to syncope within the 1-year period preceding randomization and were taking ≥4 different chronic prescription medications, ≥1 of which was a CNS-active medication	100	Mean number of high-risk conditions: 1.62 ≥2 falls during previous year: 48.9% Mean number of prescriptions for high-risk medications filled during previous year: 14.2
Mott, 2016[159]	80 IG: 39 CG: 41	75.6	78.8	HS or less education: 28.8%	98.8	Fallen in the past 12 months or had a fear of falling	100	Self-reported health (good/very good/excellent): 87.5% Very afraid of falling: 22.5% Fallen in past 6 months: 40%

Abbreviations: CG = control group; CI = confidence interval; CNS = central nervous system; IG = intervention group; SES = socioeconomic status
* As defined by study authors

Table 47. Intervention details, for medication management interventions

Author, Year	IG	CG	Format	Delivered by	Duration
Blalock, 2010[158]	Participants assigned to the intervention group received an invitation by telephone to participate in a free, face-to-face medication consultation conducted by a community pharmacy resident at the Kerr Health Care Center nearest their home. During the consultation sessions, the pharmacist reviewed the patient's medications and identified potential problems in their drug therapy. Special attention was given to medications that have been found to increase the risk of falling, with an emphasis on CNS-active medications. To standardize delivery of the intervention, structured algorithms for addressing medications associated with a high risk of falling were created by two of the study investigators. When a drug therapy problem was identified, the pharmacist discussed the problem and potential solutions with the patient. If patients expressed interest in making a change in their medication regimen, the pharmacist contacted their prescribing physician to inform them of the potential drug therapy problem(s) and seek prescriber approval of the recommended changes. Participants also received a packet containing 2 brochures on the prevention of falls developed by the Centers for Disease Control and Prevention as well as a refrigerator magnet designed for this project, containing contact information for study personnel.	Usual care; participants assigned to the control group received no medication consultation but did receive a packet containing two brochures on the prevention of falls developed by the Centers for Disease Control and Prevention	Individual	Pharmacists	52 weeks 45 min session 1 time
Mott, 2016[159]	60-minute face-to-face targeted medication review with a community pharmacist with the goal of identifying and modifying falls risk-increasing drug use. Clinical algorithms for five therapeutic categories of drugs (e.g., antidepressants, antihypertensives, benzodiazepines, neuroleptics, sedatives, hypnotics) and certain additional drugs with high anticholinergic properties (e.g., sedating antihistamines, oxybutynin) with good literature support showing association with falls among persons 65 years and older3-6 were developed by a geriatric pharmacotherapy expert to standardize the process of reviewing and modifying falls risk-increasing drug use. The community pharmacist developed a medication-related action plan (MAP) that included recommendations to modify falls risk-increasing drug use. The community pharmacist discussed the recommendations with the subject and provided the MAP to the subject. If needed, the pharmacist communicated recommendations and supplemental information to corresponding prescribers via either fax or telephone. The community pharmacist documented and followed up on all recommendations to determine whether they were accepted or rejected. Immediately after the medication review, the community pharmacist gave the subject a packet containing a commercially available pamphlet describing the role of medications in falls.	Usual care and a mailed pamphlet describing medication use and falls.	Individual	Pharmacists	12 weeks 2 sessions (60 minutes for first session, NR for the second)

Abbreviations: CG = control group; CI = confidence interval; CNS = central nervous system; IG = intervention group; SES = socioeconomic status

Table 48. Mortality, for other interventions, by author

Intervention Type	Author, year	Time, months	Group	Deaths	N analyzed	RR†	(95% CI)	
Medication management	Blalock, 2010[158]	12	IG	3	93	1.50	(0.26,	8.77)
			CG	2	93			
Psychological	Dorresteijn, 2016[162]	12	IG	7	194	1.01	(0.36,	2.81)
			CG	7	195			
	Zijlstra, 2009[161]	14	IG	6	280	0.93	(0.30,	2.84)
			CG	6	260			
		84	IG	90	280	0.98	(0.77,	1.25)
			CG	85	259			
Multiple	Shumway-Cook, 2007[167]	12	IG	2	226	0.67	(0.11,	3.97)
			CG	3	227			
	Siegrist, 2016[168]	12	IG	8	222	0.56	(0.23,	1.39)
			CG	10	156			
	Uusi-Rasi, 2015[108]	24	IG	0	102	0.25	(0.01,	5.48)
			CG	2	102			

Abbreviations: CG = control group; CI = confidence interval; IG = intervention group; NA = not applicable; NR = not reported; RR = relative risk
† Calculated

Table 49. Study characteristics, for psychological interventions

Author, Year	Quality	Aim	Country	Target Population	Recruitment Setting	Inclusion/Exclusion Criteria
Dorresteijn, 2016[162]	Fair	To assess the effectiveness of a home-based cognitive behavioral program on concerns about falls in frail, older people living in the community	The Netherlands	Frail community-dwelling older adults with some concerns about falls and related activity avoidance	Population-based register	Inclusion: At least some concerns about falls; at least some associated avoidance of activity; perceived their general health as fair or poor; they lived in the community; they were 70 years of age or older; willing to participate (signed informed consent form) Exclusion: Confined to bed; restricted by the permanent use of a wheelchair; were waiting for a nursing home admission; experienced substantial hearing or vision impairments or they failed the shortened version of the Abbreviated Mental Test and, subsequently, the Telephone Interview Cognitive Status; spouse was included in the study
Zijlstra, 2009[161]	Fair	To evaluate the effects of a multicomponent cognitive behavioral intervention on fear of falling and activity avoidance in older adults	The Netherlands	Adults aged 70 and older who reported fear of falling and fear-induced activity avoidance	Population-based register	Inclusion: Community-dwelling; aged 70 and older; reported at least some fear of falling and at least some activity avoidance due to fear of falling Exclusion: Confined to bed; restricted by permanent use of wheelchair; waiting for nursing home admission; participating in other intervention studies

Table 50. Population characteristics, for psychological interventions

Author, Year	N randomized	Mean age	Females, %	SES	White, %	Definition of fall risk*	At risk of falling,* %	Baseline health or functional status
Dorresteijn, 2016[162]	389 IG: 194 CG: 195	78.3	70.2	High education level: 12.6%	NR	Reported at least some concerns about falls; reported at least some associated avoidance of activity; and perceived their general health as fair or poor	100	Perceived general health as poor: 12.6% Fell in past 6 months: 61.4% Often/Very often concerned about falls: 26.0% Often/Very often avoids activities: 22.6%
Zijlstra, 2009[161]	540 IG: 280 CG: 260	77.9	71.9	1.0 (median edu level)	NR	Some fear of falling and at least some activity avoidance due to fear of falling (from inclusion criteria)	100	Median perceived general health: 2 Living alone: 55% Fear of falling: 42% Mean daily activity: 38.9 (range 15-60, 60 is favorable) Other characteristics: Fallen in the past 6 months (categorical, median); avoidance of activity due to fear of falling; concerns about falling

Abbreviations: CG = control group; CI = confidence interval; CNS = central nervous system; edu = education; IG = intervention group; NR = not reported; SES = socioeconomic status

* As defined by study authors

Table 51. Intervention details, for psychological interventions

Author, Year	IG	CG	Format	Delivered by	Duration
Dorresteijn, 2016[162]	The purpose was to shift maladaptive to adaptive cognitions with respect to falling and concerns about falls. The program aimed to instill a realistic view of fall risk, increasing self-efficacy beliefs and feelings of control, and changing behavior. To achieve these goals the following strategies were applied: 1) identifying and restructuring misconceptions about falls and fall risk; 2) setting realistic personal goals for increasing activity levels and safe behavior; and 3) promoting the uptake of old and new daily life activities that were avoided due to concerns about falls. The 'A Matter of Balance' (AMB)-Home program consists of seven individual sessions, including three home-visits (60, 60 and 75 min, respectively) and four telephone contacts (35 min each). The seven pre-defined themes of the program were concerns about falls; thoughts about falling; physical exercise; asserting oneself; overcoming personal barriers; safe behavior; and managing concerns about falls. Each session was similarly structured with a review of the previous session (except the first session), a discussion of the main theme, and the formulation of a personalized action plan related to the discussed theme. Session 5 differed slightly from the other sessions in that participants were guided to safely execute a daily activity they were afraid to perform independently ('exposure in vivo'). Examples of activities selected by participants included walking down the stairs or crossing a street. The participants received homework assignments between the sessions, including reading informative leaflets, filling in checklists to become aware of their beliefs about falls, and executing personal action plans. In addition, a DVD was used to show how peers address concerns about falls.	The control group received care as usual. Whereas no standard treatment for concerns about falls was available during the study period, it is likely they received no treatment.	Individual	Nursing Professional	16 weeks 3 in-person sessions 60-75 minutes, 4 phone sessions 35 minutes
Zijlstra, 2009[161]	Multicomponent cognitive behavioral group intervention; the intervention consisted of four strategies including restructuring misconceptions to promote a view of fall risk and fear of falling as controllable, setting realistic goals for increasing activity in a safe manner (taking personal capabilities into account), changing the home environment to reduce fall risk, and promoting physical exercise to increase strength and balance. The cognitive behavioral approach was applied in all intervention sessions. A variety of techniques and materials were used, including lectures, videos, group discussions, mutual problem solving, and assertiveness training. Sessions 3 to 8 included 15 minutes of low-intensity physical exercises. These exercises were included in the context of cognitive restructuring (as a way to address maladaptive beliefs about avoiding activities as a means to reduce fall risk) and to increase physical self-efficacy to decrease fear of falling. The exercises included stretching and flexing exercises and strength exercises using a resistance band. Behavioral contracts and goal setting were included to individualize the intervention. Participants received assignments, including the physical exercises, after each session.	Usual care	Group	Nursing Professional	8 weeks 2-hour sessions 1 time per week

Abbreviations: CG = control group; hr = hour; IG = intervention group

Table 52. Study characteristics, for multiple interventions, by author

Author, Year	Quality	Aim	Country	Target Population	Recruitment Setting	Inclusion/Exclusion Criteria
Clemson, 2004[166] Knowledge + environment	Fair	To test whether a multifaceted community-based program using a small-group learning environment is effective in reducing falls in at-risk people living at home.	Australia	Community residents aged 70 and older who had a fall in the previous 12 months or were concerned about falling	Community-based	Inclusion: Community-dwelling; aged 70 years and older; fallen in the previous year or were concerned about falling Exclusion: Cognitive problems associated with dementia (measured using three or more errors on the Short Portable Mental Status Questionnaire); homebound and unable to independently leave home; unable to have conversational English
Fitzharris, 2010[117] Exercise + environment + vision	Fair	To examine the effectiveness of the Whitehorse NoFalls trial on all falls, falls resulting in injury and falls requiring medical care	Australia	Community-dwelling people aged 70 years or older	Population-based register	Inclusion: Community-dwelling; aged 70 years or older; living in the City of Whitehorse local government area; living in one's own home or apartment, or leasing similar accommodations and permitted to make modifications Exclusion: Did not expect to remain in the area for 2 years (except for short absences); participated in regular to moderate physical activity with a balance improvement component in the previous 2 months; could not walk 10-20 meters without rest, help, or having angina; severe respiratory or cardiac disease; psychiatric illness prohibiting participation; dysphasia; had recent major home modifications; had an education and language adjusted score >4 on the short portable mental status questionnaire; did not have the approval of their general practitioner
Freiberger, 2012[115] Exercise + psychological	Good	To determine the long-term effects of three strength and balance exercise interventions on physical performance, fall-related psychological outcomes, and falls in older people	Germany	Community-dwelling adults aged 70 to 90 years who had fallen in the past 6 months or reported fear of falling	Health insurance company membership database	Inclusion: Community-dwelling; aged 70 years or older; fallen in the past 6 months or reported fear of falling; provided signed informed consent; completed baseline assessment Exclusion: Unable to ambulate independently; cognitive impairment (as noted by a score <25 on the Digit Symbol Substitution Test)
Shumway-Cook, 2007[167] Exercise + knowledge + falls risk assessment	Good	To evaluate the effectiveness of a 12-month community-based intervention on falls and risk factors (balance, lower extremity strength, and mobility) in community-living older adults	USA	Community-dwelling adults aged 65 years or older	Community-based	Inclusion: Aged 65 years or older; community-dwelling; English-speaking; saw a primary care physician within the previous 3 years; independent ambulators; willing to participate in group exercise classes for at least 6 months; access to transportation; minimal hearing and vision impairments; no regular exercise in the previous 3 months; able to complete a 10-foot Timed Up and Go Test in <30 seconds; pass the Pfeiffer Short Portable Mental Status Questionnaire with fewer than five errors Exclusion: NR

Table 52. Study characteristics, for multiple interventions, by author

Author, Year	Quality	Aim	Country	Target Population	Recruitment Setting	Inclusion/Exclusion Criteria
Siegrist, 2016[168] Exercise + psychological	Fair	To investigate whether the implementation of an exercise-based fall prevention program in the German primary care setting (general practitioners), consisting of 16 weeks of group exercise in combination with an individualized homebased training program, can significantly reduce the number of falls per individual in community-dwelling older people at high risk of falls compared to those receiving usual care	Germany	Community-dwelling older adults at high risk of falls	Clinic	Inclusion: Patient of selected general practitioners in southern Germany; community-dwelling senior citizens; aged ≥ 65 years; increased physical fall risk into the trial (defined as one or more falls in the past 12 months, low physical function [Timed-up-and-Go-Test or Chair-Stand-Test >10 seconds] or subjective or objective balance deficits or fear of falling Exclusion: Not living independently; suffering from physical or mental restrictions that interfere with the assessment of physical fall risk or participation in an exercise program
Uusi-Rasi, 2015[108] Exercise + vitamin D	Good	To determine the effectiveness of targeted exercise training and vitamin D supplementation in reducing falls and injurious falls among older women	Finland	Home-dwelling; women; aged 70 to 80 years old; history of at least one fall during the last 12 months; no regular use of vitamin D supplements	Population-based register	Inclusion: Home-dwelling; women; aged 70 to 80 years old; history of at least one fall during the last 12 months; no regular use of vitamin D supplements Exclusion: Moderate to vigorous exercise more than 2 hours per week; regular use of vitamin D or calcium plus vitamin D supplements, a recent fracture (during preceding 12 months); contraindication or inability to participate in the exercise program; marked decline in the basic activities of daily living (ADL); cognitive impairments; primary hyperthyroidism; degenerative conditions such as Parkinson's disease

Abbreviations: ADL = activities of daily living; USA = United States of America

Table 53. Population characteristics, for multiple interventions, by author

Author, Year	N randomized	Mean age	Female, %	SES	White, %	Definition of fall risk*	At risk of falling,* %	Baseline health or functional status
Clemson, 2004[166]	310 IG: 157 CG: 153	78.4	74.2	NR	NR	Fallen in the previous year or concerned about falling (from inclusion)	100	Other characteristics: falls in previous 12 mo (0, 1, 2+), history of stroke, history of knee arthritis, history of hip fracture, use of psychotropic drugs, # people in household, # of medications, falls efficacy scale, mobility efficacy score, worry scale, SF-36 PCS, SF-36 MCS
Fitzharris, 2010[117]	1090 (some randomized to other groups) IG: 135 CG: 137	76.1 (total)	60 (total)	NR	NR	NA	NR	Living alone: 54% Fall in past month: 6% Mean ADL (IADL plus bathing): 5.3 Mean number of medications: 3.4
Frieberger, 2012[115]	280 (some randomized to other groups) IG: 73 CG: 80	76.2	45.1	35.4% (low ed); 25.7% (low income)	NR	Fallen in the previous 6 months or fear of falling (inclusion)	100	Living alone: 42% (multiple) Fallen in past 6 months: 25% (multiple) Fear of falling: 56% (multiple)
Shumway-Cook, 2007[167]	453 IG: 226 CG: 227	75.6	76.8	NR	95	NA	NR	Fall in previous 3 months: 27% Other: 1+ alcoholic drinks per day, 2+ chronic conditions, heart disease, high or low BP, sensory impairment, taking 4+ medications, use of a walking aid, Berg balance score, TUG, chair stand
Siegrist, 2016[168]	378 IG: 222 CG: 156	78	75.4	NR	NR	One or more falls in the past 12 months, low physical function (Timed-up-and-Go-Test or Chair-Stand-Test >10 seconds), or subjective or objective balance deficits or fear of falling	100	Living alone: 41.8%
Uusi-Rasi, 2015[108]	409 (some randomized to other groups) IG: 102 CG: 102	74.0	100	NR	NR	Fallen at least once in the previous 12 months (from inclusion)	100	ADL (range 6-36, lower scores indicate better functioning): 6.8 IADL (range 8-48, lower scores indicate better functioning): 10.1

Abbreviations: ADL = activities of daily living; BMI = body mass index; CG = control group; GP = general practitioner; IADL = instrumental activities of daily living; IG = intervention group; MMSE = Mini-Mental State Examination; mo = month; NA = not applicable; NR = not reported; PD = Parkinson's Disease; SES = socioeconomic status; SF = short form; SPPB = short physical performance battery; TUG = Timed Up-and-Go

* As defined by study authors

Table 54. Intervention details, for multiple interventions, by author

Author, Year	IG	CG	Format	Delivered by	Duration
Clemson, 2004[166] Knowledge + environment	Stepping On is a multifaceted community-based program using a small-group learning environment to improve fall self-efficacy, encourage behavioral change, and reduce falls. The program included lower-limb balance and strength exercises known to be effective in fall prevention, coping with visual loss and regular visual screening, medication management, environmental and behavioral home safety, and community safety. Information was also shared and reinforced within the context of the group. Each session provided time for reflection and sharing accomplishments and ended in planning action and homework for the next week. Each session also included practicing or reviewing some of the exercises, and one session included a community mastery experience during which community mobility and discrete skills (e.g., negotiating grass or curb ramps) were practiced. A follow-up home visit took place within 6 weeks of the final program session. A booster session, conducted 3 months after session seven, lasting 1.5 hours, occurred at the program venue.	Usual care; the CG received up to two social visits from an occupational therapy student (as part of an aging-at-home fieldwork project); these visits were conducted during the same time as the program. Students were instructed not to discuss falls or falls prevention with the subjects.	Group	Occupational therapists	7 weeks 2-hour sessions (8 total) 1 time per week; follow up home visit within 6 weeks of final session and a booster session 3 months after final session
Fitzharris, 2010[117] Exercise + environment + vision	The exercise intervention was a weekly strength and balance exercise class of 1-hr for 15 weeks, supplemented by daily home exercises. The home hazard intervention involved the removal or modification of hazards, both inside the home and at the entry points, identified in the initial risk factor assessment. Home hazard reduction was undertaken either by the participants or via the City of Whitehorse's home maintenance service. The vision intervention involved referral to the participant's usual eye-care provider, general practitioner or local optometrist, if their vision tested below predetermined criteria and if he or she was not already receiving treatment for the problem identified.	Usual care; the control group received a delayed intervention	Individual, group	Physical therapists, NR, home maintenance service, trained assessor	15 weeks (exercise component), NA (environment component) 1-hour sessions 1 time per week (exercise)

Table 54. Intervention details, for multiple interventions, by author

Author, Year	IG	CG	Format	Delivered by	Duration
Freiberger, 2012[115] Exercise + psychological	All interventions included strength and balance exercises but differed regarding their second feature, endurance training (fitness) or fall risk education (multiple). The interventions were progressive over time, and each session had the following structure: a 5-minute discussion to introduce the session and address participants' well-being and questions; a 10-minute warm-up exercise including stretching, walking, and culminating activities; a 30-minute program that included the session's main components; a 10 minute cool-down including activities such as stretching and relaxation; and a 5-minute discussion of the exercises and participants' experiences. The multifaceted intervention comprised fall risk education delivered through a multicomponent cognitive behavioral program called A Matter of Balance. Elements addressed included physiological changes with aging, attitudes about falls, thoughts and concerns about falling and their effects regarding feelings and behavior, and recognizing potential environmental fall hazards. The cognitive training included exercises on concentration, information processing speed, and short-term memory.	Usual care; no intervention	Group	Fall prevention instructors	16 weeks 1-hour sessions (32 total) 2 times per week
Shumway-Cook, 2007[167] Exercise + knowledge + falls risk assessment	Multifaceted intervention including a comprehensive falls- risk assessment, exercise, and education. A summary of the intervention group participants' fall risk assessment was mailed to their primary care physicians, with a copy of the Guideline for the Prevention of Falls in Older Persons. The exercise intervention used a community-based group exercise curriculum for seniors. Each exercise class used a standardized format that included 30 minutes of moderate-intensity aerobic conditioning, 20 minutes of progressive strength training, and 10 minutes of flexibility and balance exercises, exercises known to impact fall risk. Strength training involved progressive resistive exercises, using adjustable 1- to 10-pound ankle and wrist weights. A sequence of progressively more difficult exercises to improve static and dynamic balance was also performed. Although exercises could be done seated, the importance of doing exercises in a	Usual care; CG participants were given two fall-prevention brochures developed by the Centers for Disease Control and Prevention.	Group	Nursing professionals, Exercise instructor	52 weeks 1 hour (exercise); 1 hour (education) (162 total) 3 times per week (exercise); 1 time per month (education)

Table 54. Intervention details, for multiple interventions, by author

Author, Year	IG	CG	Format	Delivered by	Duration
	standing position to improve balance was stressed. The intervention education component, presented by a nurse, included six 1-hour classes presented once a month in each group exercise class. The education component topics included fall risk and prevention, exercising after illness or injury, home safety, medication safety, footwear and use of gait devices, and strategies for exercise adherence.				
Siegrist, 2016[168] Exercise + psychological	Physicians and one staff member from each participating general practice in both the intervention and the usual care group were trained in workshops lasting 3.5 hours including general information about falls and fall risk assessments. The intervention program on the patients' level consisted of a 16 week supervised exercise training program (1 hour/week) with strength and power training, challenging balance and gait training with increasing levels of difficulty, behavioral aspects, a self-management program and perceptual and functional training conducted by a fall prevention instructor (physical therapist or sports scientist). Given the importance of fear of falling, components of the "Matter of Balance" program were added to the intervention program to address not only physical but also psychological risk factors for falls. This cognitive behavioral program aimed to reduce fear of falling by increasing self-efficacy.	Usual care. No structured treatment to prevent falls due to a lack of guidelines for GPs apart from individual GPs experience.	Individual	Physical therapist or sports scientist (exercise)	16 weeks 1 hour (exercise)
Uusi-Rasi, 2015[108] Exercise + vitamin D	Participants received one daily pill containing 800 IU (20 µg) of vitamin D3 for 24 months and exercise classes. (The exercise program is the same as the one provided for the exercise only intervention group.)	Placebo; asked to maintain their pre-study level of physical activity.	Group	Physical therapists, Self-directed	104 weeks Length of sessions NR (78 total-exercise) 2 times per week (first 12 months); 1 time per week (next 12 months)

Abbreviations: CG = control group; h = hour(s); HR = heart rate; IG = intervention group; IU = international unit(s); kg = kilogram(s); min = minute(s); ng/mL = nanograms per milliliter; NA = not applicable; NR = not reported; ug = microgram(s)

Table 55. People experiencing an injurious fall, for multiple interventions, by author

Author, year	Outcome	Detailed outcome description	Time	Group	Person with injury	N analyzed	RR†	(95% CI)	
Siegrist, 2016[168]	Person with injurious fall	NR	12	IG	63	222	0.75	(0.56,	1.00)
				CG	59	156			

Abbreviations: CG = control group; CI = confidence interval; IG = intervention group; NR = not reported; RR = relative risk
† Calculated

Table 56. Total number of included studies and participants analyzed by intervention type and outcome

Intervention Type	Falls	People Experiencing a Fall	Injurious Falls	People Experiencing an Injurious Fall	Mortality	ADL	IADL	QOL	People Hospitalized	People Transitioning to Institutional Care	Harms
Multifactorial k=26	k=17 n=9,737	k=24 n=12,490	k=9 n=4,306	k=16 n=9,445	k=23 n=9,721	k=7 n=2,106	k=4 n=1,102	k=4 n=1,104	k=4 n=2,134	k=7 n=2,143	k=4 n=1,466
Exercise k=21	k=14 n=4,663	k=15 n=4,926	k=10 n=4,622	k=5 n=2,776	k=11 n=4,263	k=0 n=0	k=3 n=363	k=3 n=1,179	k=1 n=98	k=2 n=206	k=8 n=4,107
Vitamin D k=7	k=5 n=3,496	k=6 n=6,519	k=2 n=2,460	k=0 n=0	k=6 n=7,084	k=0 n=0	k=0 n=0	k=1 n=3,314	k=0 n=0	k=0 n=0	k=5 n=3,955
Environment k=3	k=3 n=2,175	k=2 n=438	k=1 n=273	k=0 n=0	k=0 n=0	k=1 n=165	k=0 n=0	k=1 n=165	k=0 n=0	k=0 n=0	k=0 n=0
Medication Management k=2	k=1 n=186	k=2 n=266	k=1 n=186	k=0 n=0	k=1 n=186	k=0 n=0	k=0 n=0	k=0 n=0	k=0 n=0	k=0 n=0	k=0 n=0
Psychological k=2	k=2 n=886	k=2 n=886	k=2 n=886	k=0 n=0	k=2 n=886	k=0 n=0	k=1 n=540	k=0 n=0	k=0 n=0	k=0 n=0	k=1 n=540
Multiple k=6	k=6 n=1,770	k=4 n=1,413	k=5 n=1,460	k=1 n=378	k=3 n=1,035	k=0 n=0	k=0 n=0	k=1 n=258	k=0 n=0	k=0 n=0	k=3 n=810

Abbreviations: ADL = activities of daily living; IADL = instrumental activities of daily living; k=number of studies; n=number of participants; QOL = quality of living

Table 57. Summary of evidence

Intervention Type No. of studies (k), No. of participants randomized (n)	Outcome	No. of RCTs (k), no. of obs. (n)	Summary of Findings by Outcome	Consistency/ Precision	Reporting Bias	EPC Assessment of Strength of Evidence	Study Quality	Body of Evidence Limitations	Applicability
KQ1									
Multifactorial k=26 (11 new studies), n=15,506	Falls	k=17, n=9,737	Pooled reduction in falls (IRR, 0.79 [95% CI, 0.68 to 0.91]; I^2=87.2%) with substantial heterogeneity. Exploratory analysis suggests that trials recruiting from emergency setting report greater benefit (than trials recruiting from clinic or a combination of clinic and emergency setting)	inconsistent, imprecise	Undetected	Low	Good: 7 Fair: 19	Heterogeneous populations as reflected by large variation in CG fall rate and percent fallers. Heterogeneous group of interventions. Cannot make conclusions about which components associated with greater falls-related benefit. Most studies report and designed to be powered for either falls or fallers outcomes..	Applicable to community-dwelling older adults. ¾ of trials in 'high risk' older adults where high risk is variably defined but often includes history of fall Difficult to identify set of effective components for implementation purposes
	People having a fall	k=24, n=12,490	No pooled effect (RR, 0.95 [95% CI, 0.89 to 1.01]; I^2=56.1%)	Reasonably consistent, imprecise	Undetected	Moderate			
	Injuries	Injurious falls: k=9, n=4,306 People having an injurious fall: k=16 n=9,445	No statistically significant difference seen in nearly all studies for number of injurious falls. Pooled estimate of people experiencing an injurious fall shows no effect (RR, 0.94 [95% CI, 0.85 to 1.03]; I^2=34.3%)	Reasonably consistent, imprecise	Undetected	Low			
	Mortality	k=23, n=9,721	No statistically significant pooled effect (RR, 0.96 [95% CI, 0.79 to 1.17]; I^2=0%)	Inconsistent, imprecise	Undetected	Low			
Exercise k=21 (12 new) n=7,297	Falls	k=14 n=4, 663	Nonsignificant reduction in falls (IRR, 0.87 [95% CI, 0.75 to 1.00]; I^2=57.3%)	inconsistent, imprecise	Undetected	Low	Good: 5 Fair: 16	Relatively small trials and less than half powered for falls or fallers; heterogeneous interventions;	Community-dwelling older adults Average to high risk for falling (55% of RCTs
	People having a fall	k=15, n=4,926	Pooled reduction in people experiencing a fall (RR, 0.89 [95% CI, 0.81 to 0.97]; I^2=43.9%)	Reasonably consistent, imprecise	Undetected	Low to Moderate			

Table 57. Summary of evidence

Intervention Type No. of studies (k), No. of participants randomized (n)	Outcome	No. of RCTs (k), no. of obs. (n)	Summary of Findings by Outcome	Consistency/ Precision	Reporting Bias	EPC Assessment of Strength of Evidence	Study Quality	Body of Evidence Limitations	Applicability
	Injuries	Injurious falls: k=10, n=4,622 People having an injurious fall: k=5 n=2,776	Pooled reduction in injurious falls (IRR, 0.81 [95% CI, 0.73 to 0.90] I^2=0.0%). Trend toward reduction in people experiencing an injurious fall in individual trials with IRR ranging from 0.61 to 0.90 but not statistically significant.	Reasonably consistent, imprecise	Undetected	Low to Moderate		small to moderate potential for reporting bias	recruited "high risk", often includes history of falls or physical impairment) Difficult to identify set of effective components for implementation purposes
	Mortality	k=11 n=4,263	No statistically significant pooled effect (RR, 0.93 [95% CI, 0.71 to 1.22]; I^2=0%)	inconsistent, imprecise	Undetected	Low			
Vitamin D K= 7 (3 new) n=7,531	Falls	k=5, n=3,496	Mixed results: 1 trial of calcitriol showed statistically significant reduction in falls (IRR, 0.63 [95% CI, 0.47 to 0.84]) and 1 trial of 1-hydroxycholecalciferol showed non stat sig reduction in falls (0.87 [0.59-1.30]) The high dose cholecalciferol (500,000 IU annually) showed increase in falls in vitamin D group at 36 months (IRR 1.16 [1.03-1.31]) while 2 other trials of cholecalciferol 700IU and 800IU daily showed nonstat significant point estimates just above 1 (IRRs 1.08 and 1.12). Pooled results show overall no effect on falls (IRR, 0.97 [95% CI, 0.79 to 1.20]; I^2=75.8%)	Inconsistent, imprecise	Undetected	Low	Fair: 3 Good: 4	Heterogeneity in formulations, dosing schedules, control group fall rates (reflecting heterogeneous baseline risk)	Applicable to unselected older populations of US community-dwelling adults

Table 57. Summary of evidence

Intervention Type No. of studies (k), No. of participants randomized (n)	Outcome	No. of RCTs (k), no. of obs. (n)	Summary of Findings by Outcome	Consistency/ Precision	Reporting Bias	EPC Assessment of Strength of Evidence	Study Quality	Body of Evidence Limitations	Applicability
	People having a fall	k=6, n=6,519	Mixed results: 1 trial calcitriol showed stat sig reduction in fallers (RR 0.77 [0.61-0.98]) while 1 trial of 1-hydroxy-cholecalciferol showed nonstat significant reduction (0.84 [0.58-1.22]). 2 trials of cholecalciferol 800IU daily and 150,000IU every 3 months with RRs near 1 (1.01 and 1.08). The high dose vitamin D 500,000IU annually showed statistically significant increase in fallers (RR 1.08 [1.03-1.14]). Pooled analysis shows no effect on people experiencing a fall (RR, 0.97 [95% CI, 0.88 to 1.08]; I^2= 60.3%)	Inconsistent, imprecise	Undetected	Low			
	Injuries	Injurious falls: k=2, n=2,460 People having an injurious fall: k=0	Mixed results: Annual high dose (500,000 IU) vitamin D showed increase in injurious falls in vitamin D group at 36 months (IRR, 1.15 [95% CI, 1.02 to 1.29]) while 1 trial (800IU daily) showed no difference at 24 months (IRR, 0.84 [95% CI, 0.45 to 1.57]).	Inconsistent, imprecise	Undetected	Low			
	Mortality	k=6, n=7,084	No statistically significant difference in mortality (RR, 1.08 [95% CI, 0.83 to 1.40]; I2=0%)	Inconsistent, imprecise	Undetected	Low			

Table 57. Summary of evidence

Intervention Type No. of studies (k), No. of participants randomized (n)	Outcome	No. of RCTs (k), no. of obs. (n)	Summary of Findings by Outcome	Consistency/ Precision	Reporting Bias	EPC Assessment of Strength of Evidence	Study Quality	Body of Evidence Limitations	Applicability
Environment K=3 (2 new) N=2,175	Falls	k=3, n=2,175	Mixed results: 1 trial reported a significant reduction in falls for the IG vs CG (IRR, 0.54 [95% CI, 0.36 to 0.83]). The other 2 trials showed no effect (IRRs 0.98 and 1.02).	Inconsistent and imprecise	Undetected	Low	Good: 1 Fair: 2	Small group of studies showing no consistent effect on falls or fallers.	Conducted outside the US; one trial had a social services program conduct repairs that would likely not be available in the US
	People having a fall	k=2, n=438	No statistically significant difference in fallers in any trial at 12 and 18 months (RR/OR ranging from 0.83-0.93)	Reasonably consistent but only 2 trials and imprecise	Undetected	Low			
	Injuries	k=1, n=273	No difference between IG and CG	NA	NA	Insufficient			
	Mortality	k=0	NA	NA	NA	Insufficient			
KQ2									
Multifactorial	Harms	k=4, n=1,466	Harms were generally minor, rare musculo-skeletal complaints related to the exercise component of the MF intervention.	Reasonably consistent, imprecise	Suspected	Low	Good: 2 Fair: 2	Conclusions are limited by few studies and incomplete adverse event reporting	Studies of high-risk older adults
Exercise	Harms	k=8, n=4,107	No difference in serious injuries observed in 2 studies with CG comparison; several studies reported minor pain and/or bruising associated with exercise. 1 of these trials reported low rate of serious injurious falls during exercise sessions (2.6/100,000 sessions).	Reasonably consistent, imprecise	Suspected	Low	Good: 3 Fair: 5	75% did not report harms for CG	Community-dwelling; average to high risk for falling

Table 57. Summary of evidence

Intervention Type No. of studies (k), No. of participants randomized (n)	Outcome	No. of RCTs (k), no. of obs. (n)	Summary of Findings by Outcome	Consistency/ Precision	Reporting Bias	EPC Assessment of Strength of Evidence	Study Quality	Body of Evidence Limitations	Applicability
Vitamin D	Harms	k=5, n=3,955	As noted above, there may be an increase in falls, people experiencing a fall, and injuries associated with the highest annual dose of vitamin D. No difference between IG and CG in other adverse events attributable to treatment.	Inconsistent, imprecise	Suspected	Low	Good: 3 Fair: 2	Conclusions limited by rare events and incomplete reporting	Most studies of average risk older adults
Environment	Harms	k=0	NA	NA	NA	Insufficient	NA	NA	NA

Abbreviations: CG = control group; CI = confidence interval; EPC = Evidence-based Practice Center; IG = intervention group; IRR = incidence rate ratio; IU = international unit(s); k = number of studies; n = number of participants; NA = not applicable; NR = not reported; RCT = randomized controlled trial; RR = relative risk; sig = significant; stat = statistically; US = United States

Other intervention types included in this review:

Medication management: Two fair quality trials (n=266) of participants at high risk for falls showed no difference in falls, people experiencing a fall, injuries or mortality (insufficient)

Psychological: Two fair quality trials (n=886) showed nonstatistically significant reductions in falls and people experiencing a fall. Trial results on injurious falls was mixed, and there was no difference in mortality. (Insufficient)

Multiple: Six fair to good quality individual trials each studying different combination of intervention types: Exercise + Environment + Vision (n=272), Exercise + Psychological (k=2, n=531), Exercise + Knowledge + Fall risk assessment (n=453), Exercise + Vitamin D (n=204), Knowledge + Environment (n=310). Trials show mixed results on falls, fallers, injuries with the only the exercise+environonment+vision trial showing a statistically significant reduction in both falls and fallers. (Insufficient)

Appendix A. Recommendations on falls prevention

Society or Professional Organization	Year	Age, years	Recommendation
U.S. Preventive Services Task Force[52]	2012	≥65	Recommends exercise or physical therapy and vitamin D supplementation to prevent falls in community-dwelling adults who are at increased risk for falls. Does not recommend automatically performing an in-depth multifactorial risk assessment in conjunction with comprehensive management of identified risks to prevent falls in community-dwelling adults aged 65 years or older because the likelihood of benefit is small.
CDC[29]	2013	≥65	Recommends screening questionnaire followed by functional gait/balance assessment for those who screen positive to initial questionnaire. Recommends all older adults receive education, vitamin D +/- calcium, and referral to gait/balance exercises. Patients categorized into low, moderate, high fall risk and treatment recommendations for physical therapy/exercise, multifactorial interventions customized based on risk category.
National Institute for Health and Care Excellence[201]	2015	≥65	Older adults in contact with health professionals should be asked routinely whether they have fallen in the past year and asked about the frequency, context, and characteristics of the fall(s). Older people at risk of falling should be observed for balance and gait defects and considered for their ability to benefit from interventions to improve strength and balance. Older adults who present for medical attention because of a fall, or report recurrent falls in the past year, or demonstrate abnormalities of gait and/or balance should be offered a multifactorial falls risk assessment. Recommended interventions: Multifactorial interventions; strength and balance training; exercise in extended care settings; home hazard and safety intervention; psychotropic medication review; cardiac pacing.
Royal Australian College of General Practitioners[202]	2012	≥65	Recommend assessing risk of falls and if indicated by the screening questions, determine multifactorial fall risk and obtain relevant medical history, conduct a complete physical examination, and perform cognitive and functional assessments. Recommended interventions: exercise programs; medication review; vitamin D supplementation; podiatry intervention if indication; discuss dangers of bifocal and multifocal glasses when walking outdoors and recommend single lens glasses when outdoors; identify cataracts; occupational therapy home assessment (if history of recent falls)
American Geriatrics Society/British Geriatrics Society[203]	2010	NR	Recommend a multifactorial fall risk assessment for all older adults who present with a fall or who have gait and balance problems. Also recommend a multifactorial falls risk assessment for individuals who simply report difficulties with gait or balance. A falls risk assessment is not considered necessary for older persons reporting only a single fall without reported or demonstrated difficulty or unsteadiness. Recommend that assessments include examination of the feet and footwear, functional assessment (assessment of activity of daily living skills, including use of adaptive equipment and mobility aids, as appropriate); assessment of the individual's perceived functional ability and fear related to falling; and environmental assessment, including home safety. Recommended components of multifactorial interventions: exercise, specifically programs that include balance, gait, and strength training, such as tai chi or physical therapy, in group programs or as individual programs at home; environmental adaptation or modification; medication reduction or withdrawal; assessment and treatment of postural hypotension; cataract surgery on the first

Appendix A. Recommendations on falls prevention

Society or Professional Organization	Year	Age, years	Recommendation
			eye should be expedited in older persons in which the surgery is indicated; dual-chamber cardiac pacing when indicated; and vitamin D supplementation.

Abbreviations: NR = not reported.

Literature Search Strategies for Primary Literature

CENTRAL

#1 "accidental falls":kw
#2 falling:kw
#3 fall:ti
#4 falling:ti
#5 falls:ti
#6 (faller or fallers):ti,ab
#7 52-#6 Publication Year from 2010 to 2015, in Trials

CINAHL

S55 S11 OR S54

S54 S7 AND S52 (Limiters - Published Date: 20100101-20151231; English Language)

S53 S7 AND S52

S52 S48 OR S51

S51 S4 AND S49 AND S50

S50 TI injur* OR AB injur* OR MW injur*

S49 S23 OR S24 OR S25 OR S26 OR S27 OR S28 OR S29

S48 S43 AND S47

S47 S44 OR S45 OR S46

S46 TI "falls efficacy" OR AB "falls efficacy"

S45 TI "fear of falling" OR AB "fear of falling"

S44 TI adverse* OR AB adverse* OR MW adverse* OR TI harm* OR AB harm* OR MW harm*

S43 S41 OR S42

S42 MH "accidental falls" AND MW "prevention and control"

S41 S4 AND S40

S40 (S12 OR S13 OR S14 OR S15 OR S18 OR S19 OR S20 OR S21 OR S22 OR S23 OR S24 OR S25 OR S26 OR S27 OR S28 OR S29 OR S30 OR S31 OR S32 OR S33 OR S34 OR S35 OR S36 OR S37 OR S38 OR S39)

S39 TI "recurrent faller*" OR AB "recurrent faller*" OR TI "recurrent falls" OR AB "recurrent falls"

S38 TI (medication N3 (cessat* OR remov* OR stop OR withdraw*)) OR AB (medication N3 (cessat* OR remov* OR stop OR withdraw*))

S37 TI (medication N3 (modification or adjustment* or optim*)) OR AB (medication N3 (modification or adjustment* or optim*))

S36 TI (medication N2 review) OR AB (medication N2 review)

S35 TI "medical management" OR AB "medical management"

S34	TI "medication management" OR AB "medication management"
S33	TI (multivitamin* OR multimineral*) OR AB (multivitamin* OR multimineral*)
S32	TI ((vitamin* or mineral*) N5 (dietary or supplement*)) OR AB ((vitamin* or mineral*) N5 (dietary or supplement*))
S31	MH "Vitamins" OR MH "Minerals"
S30	MH "Calcium, Dietary" OR TI (dietary N3 calcium) OR AB (dietary N3 calcium) OR TI "calcium supplement*" OR AB "calcium supplement*"
S29	MH "muscle strengthening" OR TI "muscle strengthening" OR AB "muscle strengthening"
S28	TI "mobility training" OR AB "mobility training"
S27	TI "balance training" OR AB "balance training"
S26	MH "gait training" OR TI "gait training" OR AB "gait training"
S25	MH "tai chi" OR TI "tai chi" OR AB "tai chi"
S24	TI "exercise therapy" OR AB "exercise therapy" OR TI "physical therapy" OR AB "physical therapy"
S23	MH exercise OR MH "therapeutic exercise"
S22	(TI "hazard reduction" OR AB "hazard reduction") AND home
S21	(TI "home hazard*" OR TI "home safety" OR AB "home hazard*" OR AB "home safety") AND (TI modification* OR AB modification* OR TI program* OR AB program*)
S20	MH "home visits" OR TI "home visit*" OR AB "home visit*"
S19	MH counseling OR (TI counsel* OR AB counsel*) OR MH "cognitive therapy"
S18	S16 AND S17
S17	TI (assessment* or intervention*) OR AB (assessment* or intervention*)
S16	TI (multifactorial or multifaceted or multidimensional) OR AB (multifactorial or multifaceted or multidimensional)
S15	TI ("patient education" or "health education") OR AB ("patient education" or "health education")
S14	mh "patient education" or mh "health education"
S13	TI ("geriatric assessment" or "geriatric functional assessment") OR AB ("geriatric assessment" or "geriatric functional assessment")
S12	mh "geriatric assessment" or mh "geriatric functional assessment"
S11	S8 AND S9 (Limiters - Published Date: 20100101-20151231; Language: English)
S10	S8 AND S9

S9	(MH "Meta Analysis") OR (MH "Control Group") OR (MH "Single-Blind Studies") OR (MH "Double-Blind Studies") OR (MH "Triple-Blind Studies") OR (MH "Randomized Controlled Trials") OR (MH "Clinical Trials") OR (MH "Random Assignment") OR (AB clinical n1 trial*) OR (AB controlled n1 trial*) OR (TI clinical n1 trial*) OR (TI controlled n1 trial*) OR (PT Clinical trial) OR (PT randomized controlled trial)
S8	(S4 AND S7)
S7	S5 OR S6
S6	TI (geriatric* or older or senior* or elder* or aged) OR AB (geriatric* or older or senior* or elder* or aged)
S5	(MH "Frail Elderly") OR (MH "Aged") OR (MH "Aged, 80 and Over")
S4	S1 OR S2 OR S3
S3	TI (fall or falling)
S2	TI ((falls or faller or fallers)) OR AB ((falls or faller or fallers))
S1	mh "accidental falls"

Ovid MEDLINE, Ovid MEDLINE In-Process & Other Non-Indexed Citations, Ovid MEDLINE Daily Update

KQ1

1 Accidental Falls/
2 (falls or faller or fallers).ti,ab.
3 (fall or falling).ti.
4 1 or 2 or 3
5 aged/ or "aged, 80 and over"/ or frail elderly/
6 Geriatric Assessment/
7 Geriatrics/
8 Health Services for the Aged/
9 geriatric$.ti,ab.
10 older.ti,ab.
11 senior$.ti,ab.
12 elder$.ti,ab.
13 aged.ti,ab.
14 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13
15 4 and 14
16 clinical trials as topic/ or controlled clinical trials as topic/ or randomized controlled trials as topic/ or meta-analysis as topic/
17 (clinical trial or controlled clinical trial or meta analysis or randomized controlled trial).pt.
18 Random$.ti,ab.
19 control groups/ or double-blind method/ or single-blind method/
20 clinical trial$.ti,ab.
21 controlled trial$.ti,ab.
22 meta analy$.ti,ab.
23 16 or 17 or 18 or 19 or 20 or 21 or 22
24 15 and 23
25 limit 24 to english language
26 limit 25 to yr="2010 -Current"
27 remove duplicates from 26

KQ2

1 Accidental Falls/
2 (falls or faller or fallers).ti,ab.
3 (fall or falling).ti.
4 1 or 2 or 3
5 Geriatric Assessment/
6 (multifactorial or multifaceted or multidimensional).ti,ab. and (assessment$ or intervention$).ti,ab,hw.
7 geriatric assessment$.ti,ab.
8 Patient Education as Topic/
9 Patient education.ti,ab.
10 Health Education/
11 Health Education.ti,ab.
12 education$ intervention$.ti,ab.
13 Counseling/
14 Directive Counseling/
15 counsel$.ti,ab.
16 Cognitive Therapy/
17 House Calls/
18 home visit$.ti,ab.
19 ((home hazard$ or home safety) and (modification$ or program$)).ti,ab.
20 hazard reduction.ti,ab. and home.ti,ab,hw.
21 Exercise/
22 Exercise Therapy/
23 exercise therapy.ti,ab.
24 Physical Therapy.ti,ab.
25 Physical Therapy Modalities/
26 Exercise Movement Techniques/
27 exercise training.ti,ab.
28 tai chi.ti,ab.
29 Tai Ji/
30 gait training.ti,ab.
31 balance training.ti,ab.
32 mobility training.ti,ab.
33 muscle strengthening.ti,ab.
34 Calcium, dietary/
35 (diet$ adj3 calcium).ti,ab.
36 calcium supplement$.ti,ab.
37 Vitamins/
38 Minerals/
39 ((vitamin$ or mineral$) adj5 (dietary or supplement$)).ti,ab.
40 (multivitamin$ or multimineral$).ti,ab.
41 medication management.ti,ab.
42 medical management.ti,ab.
43 (medication adj2 review).ti,ab.
44 (medication adj3 (modification or adjustment$ or optim$)).ti,ab.
45 (medication adj3 (cessat$ or remov$ or stop$ or withdraw$)).ti,ab.
46 recurrent faller$.ti,ab.
47 recurrent falls.ti,ab.
48 or/5-47
49 (4 and 48) or Accidental Falls/pc
50 adverse effects.fs.
51 adverse$.ti,ab.
52 harm$.ti,ab.
53 psychology.fs.
54 fear of falling.ti,ab.
55 falls efficacy.ti,ab.

56 or/50-55
57 49 and 56
58 or/21-33
59 injuries.fs.
60 injur$.ti,ab.
61 59 or 60
62 4 and 58 and 61
63 57 or 62
64 aged/ or "aged, 80 and over"/ or frail elderly/
65 geriatric$.ti,ab.
66 older.ti,ab.
67 senior$.ti,ab.
68 elder$.ti,ab.
69 aged.ti,ab.
70 or/64-69
71 63 and 70
72 limit 71 to english language
73 limit 72 to yr="2010 -Current"
74 remove duplicates from 73

PUBMED, publisher-supplied records

#11 #10 AND publisher[sb] AND ("2010"[Date - Publication] : "3000"[Date - Publication]) AND English[Language]

#10 #4 OR #9

#9 #1 AND #2 AND #8

#8 #5 OR #6 OR #7

#7 “falls efficacy”[tiab]

#6 “fear of falling”[tiab]

#5 adverse*[tiab] OR harm*[tiab]

#4 #1 AND #2 AND #3

#3 trial*[tiab] OR random*[tiab]

#2 geriatric*[tiab] OR older[tiab] OR senior*[tiab] OR elder*[tiab] OR aged[tiab]

#1 falls[tiab] or faller[tiab] or fallers[tiab] or fall[ti] OR falling[ti]

Appendix B Table 1. Inclusion and exclusion criteria

Category	Included	Excluded
Aim	Trials with the primary or secondary aim of reducing falls or falls-related injuries	Comparative effectiveness trials of fall interventions
Population	Community-dwelling adults age ≥65 years (including those residing in independent living facilities). Includes older adults who are at average and high risk for falls; participants may be recruited from settings both within and outside of the community or primary care (e.g., community-dwelling adults recruited from emergency department visits for falls-related injuries).	• Trials conducted exclusively in populations living in special settings outside of the community (e.g., hospitals, nursing or care homes, rehabilitation centers, or other long-term care facilities) • Trials conducted exclusively in special populations (e.g., adults with neurocognitive disorders, such as moderate to severe dementia or Parkinson's disease; persons who are nonambulatory) in which interventions may be considered disease management • Trials conducted in adults age ≤65 years or with a mean study age of ≤65 years
Interventions	KQ 1: • Interventions that are primary care feasible or referable • Studies with a minimum followup of 6 months Categories of included interventions*: • Exercise (supervised or unsupervised, individual or group) • Medications (e.g., medical management, supplements [vitamin D, calcium]) • Psychological (individual or group) • Environmental/assistive technology (e.g., home hazard assessment and modification) • Knowledge (e.g., educational materials) • Social environment (e.g., caregiver training) Interventions may be delivered alone (single) or in combination (multifactorial, multiple). Multifactorial assessment and management is an included intervention.	KQs 1, 2: • Community interventions that are not generally accessible (e.g., senior residence program) • Social marketing (e.g., media campaign) • Policy (e.g., local and State public or health policy) • Institutional methods (e.g., use of restraints) • Surgery (e.g., cataract extraction, pacemaker placement, podiatry surgery) • Fluid or nutrition therapy • Management of urinary incontinence • Optical aids, hearing aids, and body-worn protective aids (e.g., hip protectors) • Interventions designed solely for persons with neurocognitive disorders • Interventions designed solely for persons who are nonambulatory
Comparators	KQ 1: Placebo, minimal control (i.e., provision of education via written materials, video, lecture), usual care	
Outcomes	KQ 1: • Falls • Mortality (all-cause and falls-related) • Falls-related morbidity, defined as: o Falls-related fracture injuries o Disability (activities of daily life and/or instrumental activities of daily life) o Quality of life (as measured on the 12-, 20-, or 36-item Short-form Health Survey; EuroQol; Sickness Impact Profile; Health Utilities Index; Dartmouth COOP Charts; Nottingham Health Profile) o Hospitalizations for falls-related injuries o Emergency department visits for falls-related injuries o Institutionalizations (e.g., transition from community dwelling to nursing or care homes, or other long-term care facilities) KQ 2: Harm outcomes as reported in studies, including psychological outcomes	KQ 1: • Falls-related injuries other than fractures that do not lead to an emergency department visit or hospitalization • Quality of life measures not listed in the inclusion criteria • Disability measures other than activities of daily life and/or instrumental activities of daily life • Falls Efficacy Scale • Function measures (e.g., Performance-Oriented Mobility Assessment, Timed Get Up & Go Test, 6-meter timed walk, Functional Reach Test, and Berg Balance Scale) KQ 2: Minor adverse events that are reported using nonvalidated, nongeneralizable measures

Appendix B Table 1. Inclusion and exclusion criteria

Category	Included	Excluded
Study Designs	KQ 1: Randomized, controlled trials KQ 2 (vitamin D): Systematic evidence reviews; randomized, controlled trials identified from KQ 1 KQ 2 (all other interventions): Randomized, controlled trials identified from KQ1	All KQs: Editorials, letters, nonsystematic reviews, opinions, comparative effectiveness trials KQ 1: Clinical controlled trials, case-control studies, cohort studies KQ 2: Convenience surveys, qualitative studies
Setting	Interventions conducted in primary care or that are referable from primary care	Interventions conducted in or recruited from settings that are not generalizable to primary care (e.g., worksites, university classrooms, institutional settings), in a population with pre-existing social ties (e.g., from the same worksite or church), in a setting with a population not comparable to a community-dwelling, primary care population (e.g., hospital, rehabilitation center, long-term care facility, emergency department), or in a setting where the intervention could not be reproduced in primary care or within a broader health system.
Country	Countries categorized as "Very High" on the 2014 Human Development Index (as defined by the United Nations Development Programme)	Countries not categorized as "Very High" on the 2014 Human Development Index
Language	English only	Non-English language publications
Quality	Fair or good, according to design-specific criteria	Poor, according to design-specific criteria

* Based on ProFaNE intervention descriptors (Lamb SE, Becker C, Gillespie LD, et al. Reporting of complex interventions in clinical trials: development of a taxonomy to classify and describe fall-prevention interventions. *Trials*. 2011;12:125).

† Included countries: all countries listed as "very high" or equivalent on human development on the 2014 Human Development Index (http://hdr.undp.org/en/statistics/): Andorra, Argentina, Australia, Austria, Bahrain, Belgium, Brunei Darussalam, Canada, Chile, Croatia, Cuba, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Kuwait, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Netherlands, New Zealand, Norway, Poland, Portugal, Qatar, Saudi Arabia, Singapore, Slovakia, Slovenia, Spain, Sweden, Switzerland, Taiwan, United Arab Emirates, United Kingdom, United States

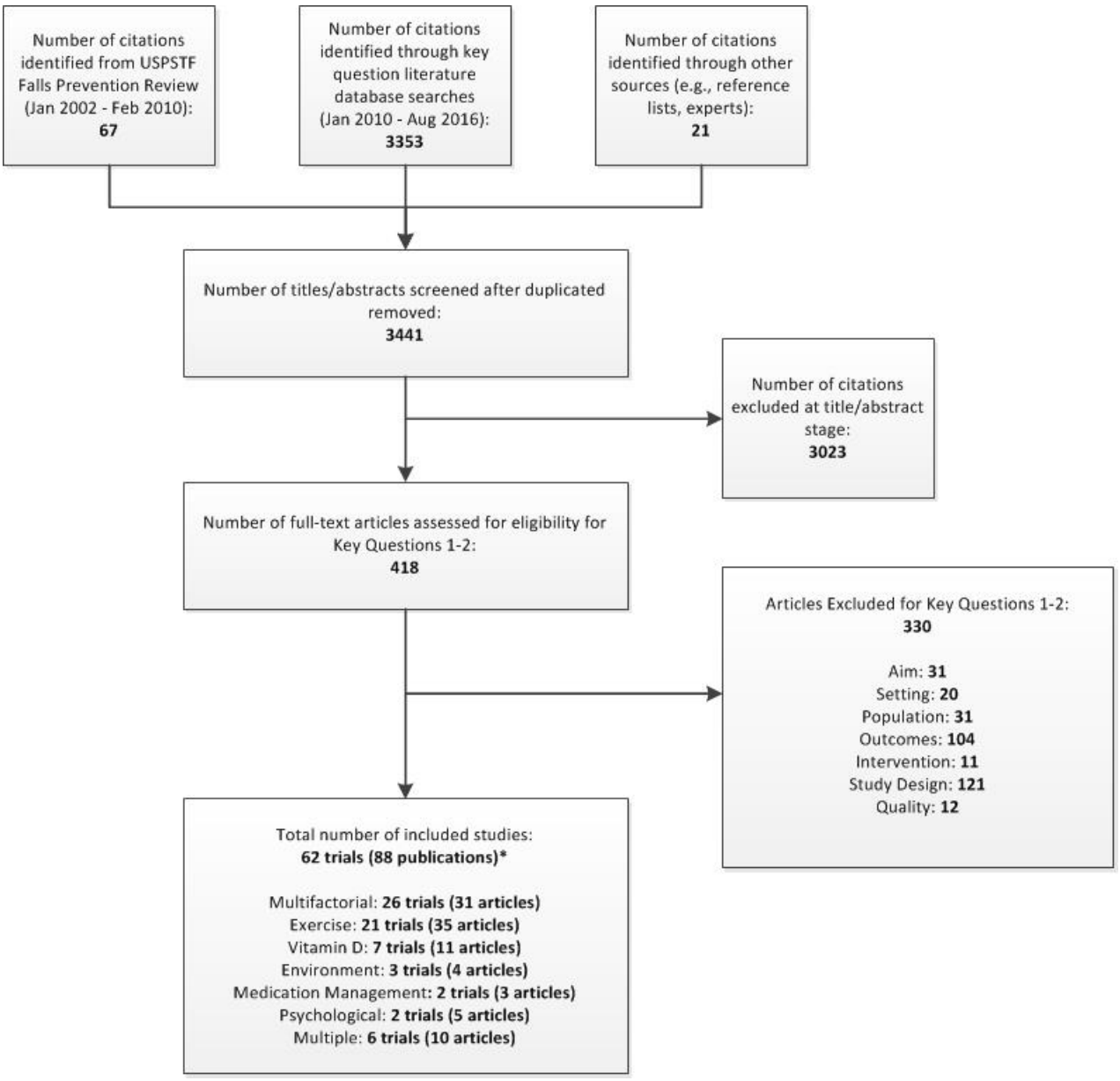
Abbreviations: ADL = activities of daily living; ED = emergency department; HDI = Human Development Index; IADL = instrumental activities of daily living

Appendix B Table 2. Quality assessment criteria

Study Design	Adapted Quality Criteria*
Randomized controlled trials, adapted from the U.S. Preventive Services Task Force methods[204]	Valid random assignment? Was allocation concealed? Was eligibility criteria specified? Were groups similar at baseline? Was there a difference in attrition between groups? Were outcome assessors blinded? Were measurements equal, valid and reliable? Was there intervention fidelity? Was there risk of contamination? Was there adequate adherence to the intervention? Were the statistical methods acceptable? Was the handling of missing data appropriate? Was there acceptable followup? Was there evidence of selective reporting of outcomes? Was there a clear definition of the intervention?

* Good quality studies generally meet all quality criteria. Fair quality studies do not meet all the criteria but do not have critical limitations that could invalidate study findings. Poor quality studies have a single fatal flaw or multiple important limitations that could invalidate study findings. Critical appraisal of studies using a priori quality criteria are conducted independently by at least two reviewers. Disagreements in final quality assessment are resolved by consensus, and, if needed, consultation with a third independent reviewer.

Appendix B Figure 1. Literature flow diagram



* Trials may appear in more than one intervention type

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>
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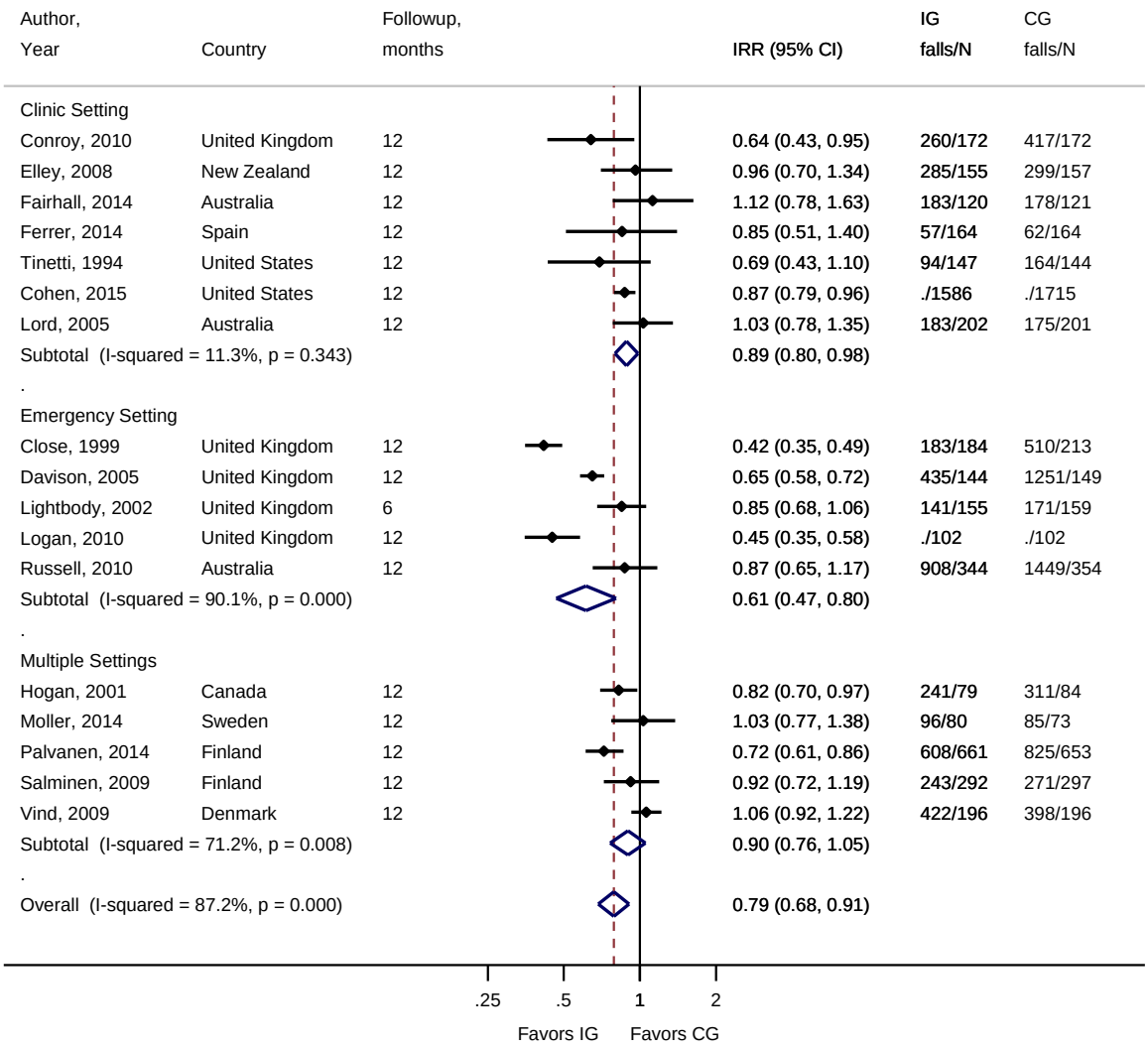
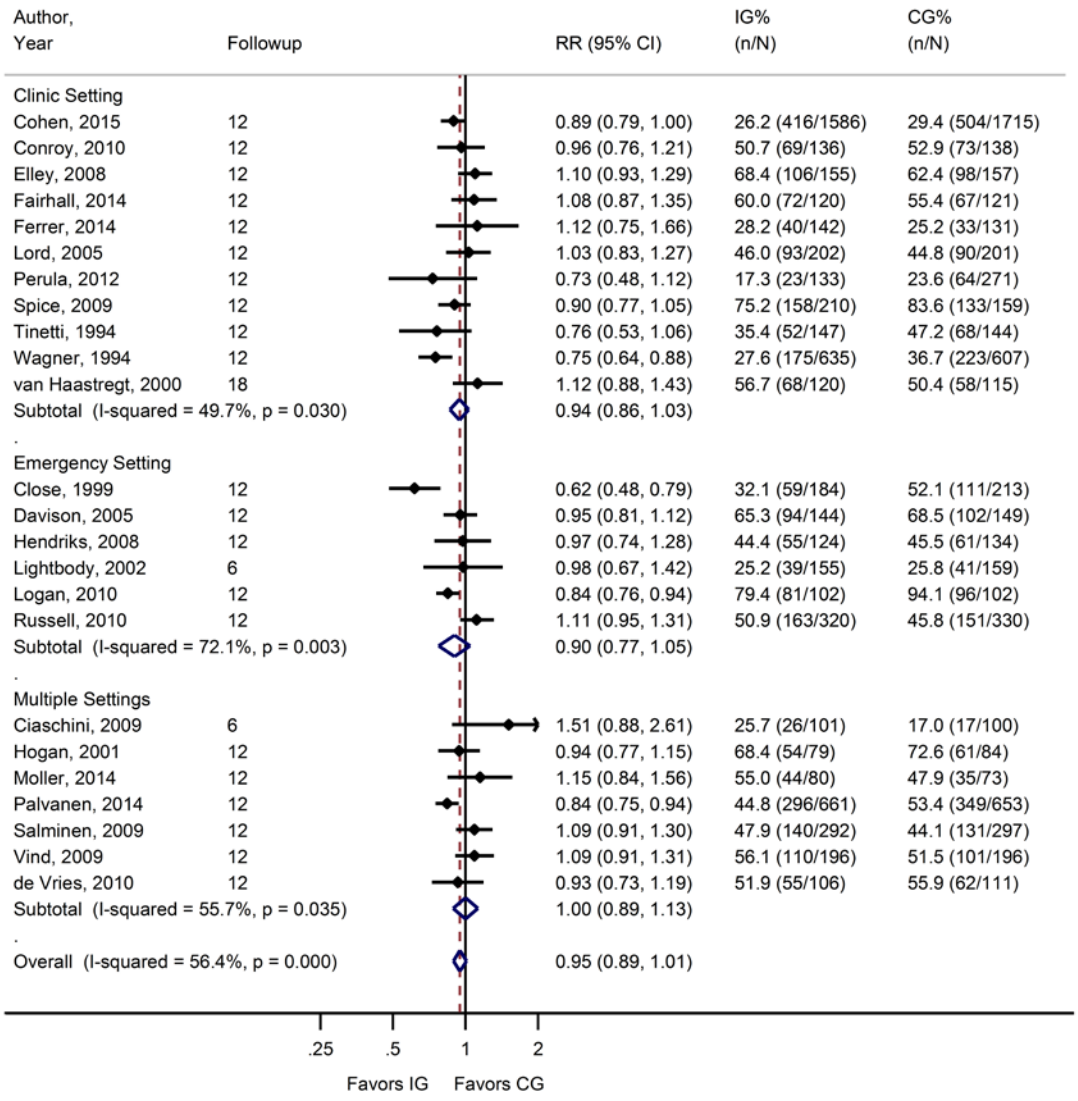
Appendix E Figure 1. Pooled analysis of multifactorial intervention randomized controlled trials for falls at longest followup (6–12 months), stratified by recruitment setting



Abbreviations: CG = control group; CI = confidence interval; IG = intervention group; IRR = incidence rate ratio

Appendix E Figure 2. Pooled analysis of multifactorial intervention randomized controlled trials for people experiencing a fall at longest followup (6–12 months), stratified by recruitment setting



Abbreviations: CG = control group; CI = confidence interval; IG = intervention group; RR = relative risk

Appendix F. Ongoing studies

Trial Identifier	Study Name	Location	Estimated N	Aim	Reported relevant Outcomes	2017 Status
NCT01698580	Multifactorial Falls Prevention Program – Brazil	Brazil	612	Clinical trial designed to evaluate the effectiveness of a multifactorial fall-prevention program in reducing the rate of falls. A multifactorial fall-prevention program consisting of an individualized medical management of the modifiable risk factors, a progressive on-site body balance exercise plus a home-based exercise program, an educational/behavioral intervention and a fall-prevention booklet will reduce the number of falls and fall rates when compared with usual care	Falls	Active Est. Completion Date: Jul 2018
NCT02665169	Kuopio Fall Prevention Study. (KFPS)	Finland	1078	Evaluates the 6-month exercise intervention (Taiji and gym course) combined with free use of communal recreation facilities in fall prevention. Morbidity, use of social services and health outcomes of aging women in province of Kuopio, Finland are also monitored. The study combines 6 months of supervised exercise, followed by six months free, but unsupervised, use of recreational facilities and observational period of second year into total of 2 year follow up duration.	Falls; Physical function; QOL	Recruiting Est. Completion Date: Oct 2019
NCT02634736	Cluster RCT of Falls Prevention Exergames for Older Adults (Profexs)	UK	108	Investigate the effectiveness of strength/balance Exergames (exercise and computer games that use body movements as controls) developed to improve balance, function, prevent falls and increase exercise adherence for older people in the home setting.	Fear of falling	Recruiting Est. Completion Date: Sep 2017
NCT02732366	Living in Fitness Together (LIFT): Testing an Innovative Fall Prevention Program	USA	48	To test the feasibility and preliminary efficacy of a group-based fall-prevention program for older adults.	Falls; Fall-related injuries	Recruiting Est. Completion Date: Jan 2018
NCT02475850	Strategies to Reduce Injuries and Develop Confidence in Elders (STRIDE)	USA	6000	The aim of this pragmatic cluster-randomized trial is to determine the effectiveness of an evidence-based, patient-centered multifactorial fall injury prevention strategy in community-dwelling older adults at risk of falls recruited from 86 primary care practices around the U.S.	Falls; Fall-related injuries; Physical function	Active Est. Completion Date: Nov 2019

Appendix F. Ongoing studies

Trial Identifier	Study Name	Location	Estimated N	Aim	Reported relevant Outcomes	2017 Status
NCT02631330	Effect on Falls Reduction of a Multimodal Intervention in Frail and Pre-frail Elderly Community-dwelling People (FAREMAVA)	Spain & Portugal	466	To determine the efficacy of a comprehensive program to prevent falls in the community.	Falls; Fall-related medical care	Recruiting Est. Completion Date: Jul 2017 No results published as of Aug 2017
NCT02617303	Prevention of Falls and Its Consequences in Elderly People (PRECIOSA)	Spain	402	This is a randomized clinical trial carried out in primary care. The study's scope of activity will include four urban primary care centers. All selected patients with inclusion criteria will receive a geriatric assessment and other required medical treatment. Next, they will be allocated either to an intervention group or control group. The intervention group will be trained for 3 months according to the OTAGO exercise program (training phase). Followed by a loyalty phase during which they will be monitored quarterly for a year by their assessment team. The control group will be receiving normal medical treatment. Falls and fractures will be monitored quarterly in both groups during 15 months.	Falls; Fall-related fractures	Active Est. Completion Date: Jun 2017 No results published as of Aug 2017
NCT02847871	Elderly Patient at Risk of Loss of Mobility, Exercise - Primary Care, Prevention, Care Pathways (PRISME-3P)	France	300	PRISME-3P program aims to develop and evaluate a dedicated care pathway, in primary care, based on a personalized multimodal intervention: screening, support combining physician, teaching exercises by a specialized Monitor in Adapted Physical Activities (MAPA) and nutritional counseling.	Falls; QOL	Recruiting Est. Completion Date: Jan 2020
NCT02166333	Study To Understand Fall Reduction and Vitamin D in You (STURDY)	USA	1200	The proposed study is a clinical trial that will determine the effects of Four doses of vitamin D (200 International Units [IU]/day, 1000 IU/day, 2000 IU/day and 4000 IU/day) as a means to prevent falls in high-risk adults, ages 70 and older.	Falls	Recruiting Est. Completion Date: Dec 2019

Appendix F. Ongoing studies

Trial Identifier	Study Name	Location	Estimated N	Aim	Reported relevant Outcomes	2017 Status
NCT02828826	Impact of Telephone Coaching on Physical Performance in a Physical Exercise Maintenance Program for Fallers Elderly Patients Living at Home (STEP-PA)	France	180	The recent OSSEBO study (intervention for the prevention of injurious falls in elderly women: background and design) recalled the interest to propose a program of physical exercise to reduce trauma and falls in the elderly. It also shows the possibility to implement an effective program on a long-term and large scale in France. The study allowed patients to participate in collective sessions of physical exercises, within the framework of an association. Patients were invited to continue their home exercises they had learned.	Falls	Not Yet Recruiting Est. Completion Date: Oct 2019
NCT02570178 (Protocol)	Effectiveness of an Intervention to Improve Balance and Decrease Falls in the Elderly (EWii) (EWii)	Spain	760	The objectives of this study are to evaluate the usefulness of an intervention utilizing the NintendoTM Wii console in order to improve balance, thereby decreasing both the fear of falling as well as the number of falls, and to evaluate the correlation between balance as determined by the console and the value obtained in the Tinetti tests and the one-foot stationary test.	Falls	Completed Protocol published Jan 2016; No results published as of Aug 2017
NCT02392013	Home Hazard Removal Program to Reduce Falls (HARP)	USA	300	This study evaluates the effectiveness and implementation of a home-hazard removal program to reduce falls in older adults through a community program delivered through the aging services network. The investigators will conduct a hybrid effectiveness/implementation trial of 300 older adults at risk for a fall who will be randomized to a home-hazard removal program or usual care and then followed for 12 months.	Falls	Active Est. Completion Date: Nov 2017
NCT02714257	Seniors Avoiding Falls Through Exercise Study (SAFE)	USA	2280	A 36-month multi-center randomized effectiveness trial to compare the impact of an Enhanced Usual Care (Control) intervention, with Exercise Coaching (Exercise), on Fragility Fractures and Serious Fall-Related Injuries (FF/SFRI) in patients with a previous fragility fracture (FF)	Falls; Fall-related injuries	Not Yet Recruiting Est. Completion Date: Aug 2020
NCT02374307	Falls-prevention in Older People Receiving Home-help Services	Norway	150	Investigate the effect of a fall-prevention program on quality of life, fear of falling, falls and physical function in older people receiving home-help services. The participants in the intervention group will perform conduct the Otago exercise programme. The participants in the control group will continue with their usual activities.	Falls; QOL	Recruiting Est. Completion Date: Jan 2018

Appendix F. Ongoing studies

Trial Identifier	Study Name	Location	Estimated N	Aim	Reported relevant Outcomes	2017 Status
ISRCTN22202133	Occupational Therapist Home Assessment and Modification for Prevention of Falls	UK	1329	A small study found that people in the community who had not been admitted to hospital because of a fall also had fewer falls when visited by an occupational therapist. To be more confident of these results, we wish to conduct a larger study to find out if people in the community would have fewer falls if they have a home hazard assessment by an occupational therapist.	Falls; QOL	Active Est. Completion Date: Nov 2018
ISRCTN 71002650 (Protocol)	Prevention of Falls Injury Trial (PreFIT)	UK	9000	A three-arm, pragmatic, cluster randomised controlled trial, conducted within primary care in England, UK. Sixty-three general practices will be randomised to deliver one of three falls prevention interventions: (1) advice only; (2) advice with exercise; or (3) advice with multifactorial falls prevention (MFFP).	Falls, Fall-related injuries; QOL	Complete Protocol published Jan 2016; No results available as of Aug 2017
NCT01745263	Do-HEALTH	Europe (7 cities)	2152	A randomized 2x2x2 factorial design trial of a simple home exercise program and/or vitamin D, and/or omega-3 fatty acids, over a 3-year period. The specific aim is to establish whether vitamin D, omega-3 fatty acids, and a simple home exercise program will prevent disease at older age.	Falls	Active Est. Completion Date: Nov 2017

Abbreviations: Aug = August; Dec = December; Est = estimated; Feb = February; IU = international units; Jan = January; Jun = June; Jul = July; N = number; Nov = November; Oct = October; QOL = quality of life; UK = United Kingdom; USA = United States of America