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Prevention of Falls and Fall-Related Injuries in Community-Dwelling Seniors

An Evidence-Based Analysis

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About the Medical Advisory Secretariat

The Medical Advisory Secretariat is part of the Ontario Ministry of Health and Long-Term Care. The mandate of the Medical Advisory Secretariat is to provide evidence-based policy advice on the coordinated uptake of health services and new health technologies in Ontario to the Ministry of Health and Long-Term Care and to the healthcare system. The aim is to ensure that residents of Ontario have access to the best available new health technologies that will improve patient outcomes.

The Medical Advisory Secretariat also provides a secretariat function and evidence-based health technology policy analysis for review by the Ontario Health Technology Advisory Committee (OHTAC).

The Medical Advisory Secretariat conducts systematic reviews of scientific evidence and consultations with experts in the health care services community to produce the *Ontario Health Technology Assessment Series.*

About the Ontario Health Technology Assessment Series

To conduct its comprehensive analyses, the Medical Advisory Secretariat systematically reviews available scientific literature, collaborates with partners across relevant government branches, and consults with clinical and other external experts and manufacturers, and solicits any necessary advice to gather information. The Medical Advisory Secretariat makes every effort to ensure that all relevant research, nationally and internationally, is included in the systematic literature reviews conducted.

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If you are aware of any current additional evidence to inform an existing evidence-based analysis, please contact the Medical Advisory Secretariat: MASinfo.moh@ontario.ca. The public consultation process is also available to individuals wishing to comment on an analysis prior to publication. For more information, please visit http://www.health.gov.on.ca/english/providers/program/ohtac/public_engage_overview.html.

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Abbreviations

ADL	Activity of daily living
ALOS	Average length of stay
CI	Confidence interval
ED	Emergency department
FY	Fiscal year
HR	Hazard ratio
ICES	Institute of Clinical Evaluative Science
IRR	Incidence rate ratio
IU	International units
LOS	Length of stay
LTC	Long-term care
NNP	Number needed to prevent
OR	Odds ratio
OT	Occupational therapist
PT	Physical therapist
QoL	Quality of life
OR	Odds ratio
RCT	Randomized controlled trial
RR	Relative risk
UI	Urinary incontinence

Executive Summary

In early August 2007, the Medical Advisory Secretariat began work on the Aging in the Community project, an evidence-based review of the literature surrounding healthy aging in the community. The Health System Strategy Division at the Ministry of Health and Long-Term Care subsequently asked the secretariat to provide an evidentiary platform for the ministry's newly released Aging at Home Strategy.

After a broad literature review and consultation with experts, the secretariat identified 4 key areas that strongly predict an elderly person's transition from independent community living to a long-term care home. Evidence-based analyses have been prepared for each of these 4 areas: falls and fall-related injuries, urinary incontinence, dementia, and social isolation. For the first area, falls and fall-related injuries, an economic model is described in a separate report.

Please visit the Medical Advisory Secretariat Web site, http://www.health.gov.on.ca/english/providers/program/mas/mas_about.html, to review these titles within the Aging in the Community series.

1. *Aging in the Community: Summary of Evidence-Based Analyses*
2. *Prevention of Falls and Fall-Related Injuries in Community-Dwelling Seniors: An Evidence-Based Analysis*
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4. *Caregiver- and Patient-Directed Interventions for Dementia: An Evidence-Based Analysis*
5. *Social Isolation in Community-Dwelling Seniors: An Evidence-Based Analysis*
6. *The Falls/Fractures Economic Model in Ontario Residents Aged 65 Years and Over (FEMOR)*

Objective

To identify interventions that may be effective in reducing the probability of an elderly person's falling and/or sustaining a fall-related injury.

Background

Although estimates of fall rates vary widely based on the location, age, and living arrangements of the elderly population, it is estimated that each year approximately 30% of community-dwelling individuals aged 65 and older, and 50% of those aged 85 and older will fall. Of those individuals who fall, 12% to 42% will have a fall-related injury.

Several meta-analyses and cohort studies have identified falls and fall-related injuries as a strong predictor of admission to a long-term care (LTC) home. It has been shown that the risk of LTC home admission is over 5 times higher in seniors who experienced 2 or more falls without injury, and over 10

times higher in seniors who experienced a fall causing serious injury.

Falls result from the interaction of a variety of risk factors that can be both intrinsic and extrinsic. Intrinsic factors are those that pertain to the physical, demographic, and health status of the individual, while extrinsic factors relate to the physical and socio-economic environment. Intrinsic risk factors can be further grouped into psychosocial/demographic risks, medical risks, risks associated with activity level and dependence, and medication risks. Commonly described extrinsic risks are tripping hazards, balance and slip hazards, and vision hazards.

Note: It is recognized that the terms "senior" and "elderly" carry a range of meanings for different audiences; this report generally uses the former, but the terms are treated here as essentially interchangeable.

Evidence-Based Analysis of Effectiveness

Research Question

Since many risk factors for falls are modifiable, what interventions (devices, systems, programs) exist that reduce the risk of falls and/or fall-related injuries for community-dwelling seniors?

Inclusion and Exclusion Criteria

Inclusion Criteria

- English language;
- published between January 2000 and September 2007;
- population of community-dwelling seniors (majority aged 65+); and
- randomized controlled trials (RCTs), quasi-experimental trials, systematic reviews, or meta-analyses.

Exclusion Criteria

- special populations (e.g., stroke or osteoporosis; however, studies restricted only to women were included);
- studies only reporting surrogate outcomes; or
- studies whose outcome cannot be extracted for meta-analysis.

Outcomes of Interest

- number of fallers, and
- number of falls resulting in injury/fracture.

Search Strategy

A search was performed in OVID MEDLINE, MEDLINE In-Process and Other Non-Indexed Citations, EMBASE, the Cumulative Index to Nursing & Allied Health Literature (CINAHL), The Cochrane Library, and the International Agency for Health Technology Assessment (INAHTA) for studies published between January 2000 and September 2007. Furthermore, all studies included in a 2003 Cochrane review were considered for inclusion in this analysis. Abstracts were reviewed by a single author, and studies meeting the inclusion criteria outlined above were obtained. Studies were grouped

based on intervention type, and data on population characteristics, fall outcomes, and study design were extracted. Reference lists were also checked for relevant studies. The quality of the evidence was assessed as high, moderate, low, or very low according to the GRADE methodology.

Summary of Findings

The following 11 interventions were identified in the literature search: exercise programs, vision assessment and referral, cataract surgery, environmental modifications, vitamin D supplementation, vitamin D plus calcium supplementation, hormone replacement therapy (HRT), medication withdrawal, gait-stabilizing devices, hip protectors, and multifactorial interventions.

Exercise programs were stratified into targeted programs where the exercise routine was tailored to the individuals' needs, and untargeted programs that were identical among subjects. Furthermore, analyses were stratified by exercise program duration (<6 months and ≥6 months) and fall risk of study participants. Similarly, the analyses on the environmental modification studies were stratified by risk. Low-risk study participants had had no fall in the year prior to study entry, while high-risk participants had had at least one fall in the previous year.

A total of 17 studies investigating multifactorial interventions were identified in the literature search. Of these studies, 10 reported results for a high-risk population with previous falls, while 6 reported results for study participants representative of the general population. One study provided stratified results by fall risk, and therefore results from this study were included in each stratified analysis.

Executive Summary Table 1: Summary of Meta-Analyses of Studies Investigating the Effectiveness of Interventions on the Risk of Falls in Community-Dwelling Seniors*

Intervention	RR [95% CI]	GRADE
Exercise programs		
1. Targeted programs		
General population	0.81 [0.67–0.98]	Low
High-risk population	0.93 [0.82–1.06]	High
Short duration	0.91 [0.73–1.13]	High
Long duration	0.89 [0.79–1.01]	Moderate
2. Untargeted programs		
General population	0.78 [0.66–0.91]	Moderate
High-risk population	0.89 [0.72–1.10]	Very low
Short duration	0.85 [0.71–1.01]	Low
Long duration	0.76 [0.64–0.91]	Moderate
3. Combined targeted vs. untargeted programs		
General population	N/A	N/A
High-risk population	0.87 [0.57–1.34]	Moderate
Short duration	1.11 [0.73–1.70]	High
Long duration	0.73 [0.57–0.95]	High
Vision intervention		
Assessment/referral	1.12 [0.82–1.53]	Moderate
Cataract surgery	1.11 [0.92–1.35]	Moderate
Environmental modifications		
Low-risk population	1.03 [0.75–1.41]	High
High-risk population	0.66 [0.54–0.81]	High
General population	0.85 [0.75–0.97]	High
Drugs/Nutritional supplements		
Vitamin D (men and women)	0.94 [0.77–1.14]	High
Vitamin D (women only)	0.55 [0.29–1.08]	Moderate
Vitamin D and calcium (men and women)	0.89 [0.74–1.07]	Moderate
Vitamin D and calcium (women only)	0.83 [0.73–0.95]	Moderate
Hormone replacement therapy	0.98 [0.80–1.20]	Low
Medication withdrawal	0.34 [0.16–0.74]†	Low
Gait-stabilizing device	0.43 [0.29–0.64]	Moderate
Multifactorial intervention		
Geriatric screening (general population)	0.87 [0.69–1.10]	Very low
High-risk population	0.86 [0.75–0.98]	Low

*CI refers to confidence interval; RR, relative risk.
†Hazard ratio is reported, because RR was not available.

Executive Summary Table 2: Summary of Meta-Analyses of Studies Investigating the Effectiveness of Interventions on the Risk of Fall-Related Injuries in Community-Dwelling Seniors*

Intervention	RR [95% CI]	GRADE
Exercise programs		
Targeted programs	0.67 [0.51–0.89]	Moderate
Untargeted programs	0.57 [0.38–0.86]	Low
Combined targeted vs untargeted programs	0.31 [0.13–0.74]	High
Drugs/nutritional supplements		
Vitamin D plus calcium (women only)	0.77 [0.49–1.21]	Moderate
Gait-stabilizing device	0.10 [0.01–0.74]	Moderate
Hip protectors	3.49 [0.68–17.97] †	Low
Multifactorial intervention		
Geriatric screening (general population)	0.90 [0.53–1.51]	Low
High-risk population	0.86 [0.66–1.11]	Moderate

*CI refers to confidence interval; RR, relative risk.
†Odds ratio is reported, because RR was not available.

Conclusions

1. High-quality evidence indicates that long-term exercise programs in mobile seniors and environmental modifications in the homes of frail elderly persons will effectively reduce falls and possibly fall-related injuries in Ontario's elderly population.
2. A combination of vitamin D and calcium supplementation in elderly women will help reduce the risk of falls by more than 40%.
3. The use of outdoor gait-stabilizing devices for mobile seniors during the winter in Ontario may reduce falls and fall-related injuries; however, evidence is limited and more research is required in this area.
4. While psychotropic medication withdrawal may be an effective method for reducing falls, evidence is limited and long-term compliance has been demonstrated to be difficult to achieve.
5. Multifactorial interventions in high-risk populations may be effective; however, the effect is only marginally significant, and the quality of evidence is low.

In early August 2007, the Medical Advisory Secretariat began work on the Aging in the Community project, an evidence-based review of the literature surrounding healthy aging in the community. The Health System Strategy Division at the Ministry of Health and Long-Term Care subsequently asked the secretariat to provide an evidentiary platform for the ministry's newly released Aging at Home Strategy.

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Objective

To identify interventions that may be effective in reducing the probability of an elderly person's falling and/or sustaining a fall-related injury.

Clinical Need: Target Population and Condition

Definition of a Fall

Several definitions for falls exist in the literature; however, a recently published consensus statement suggested that a fall be defined as "an unexpected event in which the participant comes to rest on the ground, floor, or lower level." (1)

Target Population and Prevalence of Falls

Although estimates of fall rates vary widely based on the location, age, and living arrangements of the elderly population, it is estimated that approximately 30% of community-dwelling individuals aged 65 and older, and 50% of those aged 85 and older will fall each year. (2-4) Of those individuals who fall, 12% to 42% will have a fall-related injury. (5;6) Elderly women living independently in the community are more likely to experience a fall than men, (6;7) and a study by Campbell et al. (8) found that the risk of falling for women was more than 1.5 times higher than for men, even after controlling for physical and sociological variables associated with increased fall risk.

In 2005, 12.8% of Ontario's population was aged 65 or older, a figure that is expected to increase by almost 65% by 2031. (9) With more than 1 in 5 Ontarians being 65 or older in 2031, the number of community-dwelling seniors at risk for encountering a fall will dramatically increase, thus increasing the demand for community-based services and the burden on Ontario's health system.

Note: It is recognized that the terms "senior" and "elderly" carry a range of meanings for different audiences; this report generally uses the former, but the terms are treated here as essentially interchangeable.

Fall Outcomes and Burden

Minor injuries such as bruises, abrasions, lacerations and sprains occur after 44% of falls (10), while major injuries such as hip and wrist fractures occur after approximately 4% to 5% of falls. (11;12) As an individual ages, their ability to use their hands to break a fall and protect their hip is reduced, and therefore wrist fractures are more common than hip fractures between the ages of 65 and 75, while hip fractures become more prevalent after the age of 75. (13)

Injuries due to falls place a significant burden on the Ontario health system and are the leading cause of injury-related hospital visits (1,201/100,000 population) and emergency department visits (4,821/100,000 population) in Ontarians aged 65 and older. (14) Furthermore, once an individual is admitted into an acute hospital following a fall, their average length of stay (ALOS) is approximately 40% longer than that for all-cause hospitalizations. (15) This highlights not only the severity of injuries due to falls, but also the need for community-based services that will allow a more expedient discharge of elderly individuals back to their homes following a fall-related hospitalization.

Difficulties exist in measuring mortality directly associated with falls; however, it is estimated that up to 40% of injury-related deaths, and 1% of total deaths in those aged 65 and over, are due to falls. (16)

Falls as a Predictor of Long-Term Care Home Admission

A prospective cohort study was conducted in 1997 by Tinetti and Williams (17) to assess the risk of admission to a LTC home following falls and fall-related injuries. A cohort of 1,103 community-dwelling seniors aged 71 and older were followed for a median of 12 months. The outcome of interest in this study was the number of days from initial assessment to a first long-term admission to a skilled-nursing facility. The results of this study showed that after adjusting for demographic, psychosocial, cognitive, health-related and functional characteristics, there was a significant increase in the hazard of LTC home admission following falls (Table 1).

A meta-analysis published by Gaugler et al. in 2007 (18) investigated predictors of LTC home admission in community-dwelling elderly populations. This analysis was based on two large cohort studies in the United States, and found that the hazard of LTC home admission was approximately 16% higher in seniors with a history of falls than in those without (hazard ratio [HR], 1.16, [95% confidence interval (CI), 1.02–1.30]). The smaller effect size in this study as compared with the Tinetti and Williams study is likely due to the fact that fall status was based on annual recall in the studies included in the Gaugler et al. review, while the Tinetti and Williams study measured falls based on monthly calendars. While evidence regarding the most valid method of falls-outcome collection is limited, the use of monthly falls calendars is generally accepted to be a more rigorous and sensitive method of measuring fall status in elderly individuals. (19)

Table 1: Hazard Ratios for Admission to a Long-term Care Home Following Falls and Fall-related Injuries*

Fall Severity	HR [95% CI]	Population Attributable Risk (%)
1 fall without serious injury	3.1 [1.9–4.9]	13%
2 or more falls without serious injury	5.5 [2.1–14.2]	3%
At least one fall causing serious injury	10.2 [5.8–17.9]	10%

*CI refers to confidence interval; HR, hazard ratio.
Tinetti and Williams (20)

Fall Risks for Community-Dwelling Seniors

Falls result from the interaction of a variety of risk factors that can be both intrinsic and extrinsic. Intrinsic factors are those that pertain to the physical, demographic, and health status of the individual, while extrinsic factors relate to the physical and socio-economic environment. (21;22) Intrinsic risk factors can be further grouped into psychosocial/demographic risks, medical risks, risks associated with activity level and dependence, and medication risks.

Intrinsic Risk Factors

Psychosocial and Demographic Risks

As mentioned earlier in this report, increasing age and gender are both strong risk factors for falls. (6;23;24) Two psychosocial risk factors that have also been studied extensively are previous history of falls and fear of falling. A previous history of falls has been demonstrated as one of the strongest predictors of future falls and injurious falls. (25) This may be due to a loss of mobility and balance, or because of increased fear of falling, which can in turn lead to activity restrictions, loss of strength, and social isolation. (26;27)

Medical Risk Factors

In general, the risk of falling and sustaining a fall-related injury increases with the number of chronic health problems, with individuals having 5 to 7 chronic illnesses having more than 2.5 times the risk of

falling and 4.5 times the risk of having an injurious fall as someone without chronic conditions. (28) More specifically, chronic medical problems that have been shown to be associated with an increased risk of falls are a history of stroke, arthritis of the knee, foot problems, low systolic blood pressure, poor vision, cognitive impairment, Parkinson's disease, poor strength, muscle weakness, decreased reaction time, limited mobility and impaired balance and gait. (6;29-31)

Activity and Dependence

As individuals age, limited mobility, fear of falling, chronic illnesses and various other factors lead to decreased physical activity, which can result in decreased muscle strength and balance. Several studies have indicated that inactivity and decreased physical fitness in seniors are a major risk factor for falls and injurious falls. (32) However, some studies identify high physical activity as a risk factor for falls in older populations, indicating that the risks associated with increased physical activity for some elderly people must also be considered. (6) More research is needed in this area to determine the potential harm and benefit of various types and intensities of physical activity.

Medications

Research surrounding the risks of falls and fall-related injuries following medication use is extensive. Multiple prescriptions can lead to dizziness, and to problems with alertness, coordination, and balance. (33) As a result, studies have found that taking multiple medications leads to a significant increase in the risk of falls and injurious falls. (34-37) Furthermore, several drugs that are frequently prescribed to elderly individuals are independently associated with a high risk of falls. These include sedatives and hypnotics, psychotropic medications, benzodiazepines, and diuretics. (6;38;39) Some studies indicate that antihypertensive medications may also increase the risk of falls and fall-related injuries; however, results in this area are inconsistent. (40)

Extrinsic Risk Factors

There is very little evidence surrounding the level of risk associated with extrinsic risk factors. Commonly described extrinsic risks are tripping hazards, balance and slipping hazards, and vision hazards. (6;41-43)

Tripping hazards

- loose rugs,
- electrical cords,
- pets,
- uneven sidewalks, and
- inappropriate or ill-fitting footwear.

Balance and slipping hazards

- narrow or slippery stairs,
- no handrails on stairs,
- bathroom hazards (e.g., low toilets, unsafe or slippery bathtubs/showers),
- low furniture, and
- ice and snow.

Vision hazards

- cataracts,

- eyeglasses, and
- poor lighting.

Evidence-Based Analysis of Effectiveness

Objective

To identify interventions that may be effective in reducing the probability of an elderly person's falling and/or sustaining a fall-related injury.

Research Questions

- Since many risk factors for falls are modifiable, what interventions (devices, systems, programs) exist that reduce the risk of falls and/or fall-related injuries for community-dwelling elderly persons?
- Are there differences in the effectiveness of interventions in high-risk groups (e.g., frail, history of falling)?

Methods

Inclusion and Exclusion Criteria

Inclusion Criteria

- English language;
- published between January 2000 and September 2007;
- population of community-dwelling seniors (majority aged 65+); and
- randomized controlled trials (RCTs), quasi-experimental trials, systematic reviews, or meta-analyses.

Exclusion Criteria

- special populations (e.g., stroke or osteoporosis; however, studies restricted only to women were included);
- studies only reporting surrogate outcomes; or
- studies whose outcome cannot be extracted for meta-analysis.

Outcomes of Interest

- number of fallers, and
- number of falls resulting in injury/fracture.

Method of Review

A search was performed in OVID MEDLINE, MEDLINE In-Process and Other Non-Indexed Citations, EMBASE, the Cumulative Index to Nursing & Allied Health Literature (CINAHL), The Cochrane Library, and the International Agency for Health Technology Assessment (INAHTA) for studies published between January 2000 and September 2007. The search strategy is detailed in Appendix 1.

Furthermore, all studies included in a 2003 Cochrane review published by Gillespie et al. (44) were considered for inclusion in this review.

Abstracts were reviewed, and studies meeting the inclusion criteria outlined above were obtained. Studies were grouped based on intervention type, and data on population characteristics, falls outcomes, and study design were extracted. Reference lists were also checked for relevant studies. Results for each outcome from individual studies were meta-analyzed using fixed-effects models.

Assessment of Quality of Evidence

The quality assigned to individual studies was determined using the Medical Advisory Secretariat's adaptation of the levels-of-evidence hierarchy proposed by Goodman. (45)

The overall quality of the evidence was examined according to the GRADE Working Group criteria (see Appendix 2). (46)

- Quality refers to criteria such as the adequacy of allocation concealment, blinding, and follow-up.
- Consistency refers to the similarity of estimates of effect across studies. If there is important unexplained inconsistency in the results, our confidence in the estimate of effect for that outcome decreases. Differences in the direction of effect, the size of the differences in effect, and the significance of the differences guide the decision about whether important inconsistency exists.
- Directness refers to the extent to which the interventions and outcome measures are similar to those of interest.

As stated by the GRADE Working Group, the following definitions were used in grading the quality of the evidence.

High	Further research is very unlikely to change confidence in the estimate of effect.
Moderate	Further research is likely to have an important impact on confidence in the estimate of effect and may change the estimate.
Low	Further research is very likely to have an important impact on confidence in the estimate of effect and is likely to change the estimate.
Very low	Any estimate of effect is very uncertain.

Results of Evidence-Based Analysis

The database search identified 507 citations published between January 2000 and September 2007. Of the 155 studies set in the community as opposed to a hospital or LTC home, 43 met the inclusion criteria described above. A further 17 studies were identified in the Cochrane review on falls in the elderly, 15 of which were published before the year 2000. (44) All studies identified were RCTs, and only one was defined as small (total sample size N=28) (Table 2).

Table 2: Quality of Evidence of Included Studies*

Study Design	Level of Evidence	Number of Eligible Studies
Large RCT, systematic review of RCTs	1	59
Large RCT unpublished but reported to an international scientific meeting	1(g)	0
Small RCT	2	1
Small RCT unpublished but reported to an international scientific meeting	2(g)	0
Non-RCT with contemporaneous controls	3a	0
Non-RCT with historical controls	3b	0
Non-RCT presented at international conference	3(g)	0
Surveillance (database or register)	4a	0
Case series (multisite)	4b	0
Case series (single site)	4c	0
Retrospective review, modeling	4d	0
Case series presented at international conference	4(g)	0

†For each included study, levels of evidence were assigned according to a ranking system based on a hierarchy proposed by Goodman. (45) An additional designation "g" was added for preliminary reports of studies that have been presented at international scientific meetings. Non-RCT, clinical trial that is not randomized, e.g., a cohort study; RCT, randomized controlled trial.
Adapted from the Oxford Centre for Evidence (45)

Summary of Existing Evidence

Interventions Identified in Literature

- physical exercise
- vision assessment and referral
- cataract surgery
- environmental modifications
- vitamin D supplements
- vitamin D and calcium supplements
- hormone replacement therapy (HRT)
- medication withdrawal
- gait-stabilizing devices
- hip protectors
- multifactorial interventions

Detailed study characteristics are provided in Appendix 3.

Exercise

There were 25 studies identified that described the effects of a physical exercise intervention on the proportion of people falling or experiencing a fall-related injury. The types of exercise programs provided to the intervention group varied considerably between trials. Most exercise programs contained a combination of exercises designed to improve balance, endurance, strength, coordination, and flexibility. Although most were conducted in a group setting, several programs incorporated a home-based exercise program to be completed between group sessions.

In general, the exercise interventions described in the literature can be grouped into 2 main categories:

targeted and untargeted. Targeted interventions are tailored exercise programs that are based on the individual's risk factors and needs, while untargeted interventions provide the same exercise program to all individuals enrolled. Eighteen studies investigated the effects of an untargeted intervention, 5 studies investigated the effects of a targeted intervention, and in 2 studies, the authors compared a combination of untargeted and targeted exercises against an untargeted exercise program. The meta-analysis of these studies indicated that there is a moderate reduction in the risk of falling following untargeted interventions (relative risk [RR], 0.82 [95% CI, 0.72–0.93]). Forest plots for all meta-analyses are presented in Appendix 4.

After evaluating the population and program characteristics found in the literature, two important stratifications were identified. The first stratification was by fall risk, where individuals were identified as high-risk if they were extremely frail or had a history of previous falls. Ten studies restricted the population of interest to frail elderly persons at high risk for falls, while the remaining 15 studies did not limit their population based on fall risk. The meta-analysis indicated that there was no statistically significant reduction in the number of high-risk individuals falling following an exercise program (Table 3). However, in studies that did not restrict the study population to those at high risk, both targeted and untargeted exercise programs significantly reduced an individual's risk of falling and having a fall-related injury (Tables 4 and 5).

Table 3: Summary of Evidence Surrounding the Risk of Falls After an Exercise Program: High-Risk Population*

	Untargeted Exercise vs. No Exercise	Targeted Exercise vs. No Exercise	Combination Exercise vs. Untargeted Exercise
Number of studies	6	2	2
Total N (case/control)	372/270	329/330	77/61
RR (95% CI)	0.89 (0.72–1.10)	0.93 (0.82–1.06)	0.87 (0.57–1.34)

*CI refers to confidence interval; RR, relative risk; combination refers to untargeted and targeted exercise programs.

Table 4: Summary of Evidence Surrounding the Risk of Falls After an Exercise Program: General Population*

	Untargeted Exercise vs. No Exercise	Targeted Exercise vs. No Exercise	Combination Exercise vs. Untargeted Exercise
Number of studies	12	3	0
Total N (case/control)	1250/1234	282/284	0/0
RR (95% CI)	0.78 (0.66–0.91)	0.81 (0.67–0.98)	N/A

* CI refers to confidence interval; RR, relative risk; combination refers to untargeted and targeted exercise programs.

Table 5: Summary of Evidence Surrounding the Risk of Fall-Related Injuries After an Exercise Program: General Population*

	Untargeted Exercise vs. No Exercise	Targeted Exercise vs. No Exercise	Combination Exercise vs. Untargeted Exercise
Number of studies	2	3	0
Total N (case/control)	239/187	269/277	0/0
RR (95% CI)	0.44 (0.27–0.72)	0.67 (0.51–0.89)	N/A

* CI refers to confidence interval; RR, relative risk; combination refers to untargeted and targeted exercise programs.

The second stratification considered was based on intervention duration. There was inconsistency in results of studies based on the duration of the exercise program, and therefore studies were stratified into those exercise programs lasting for less than 6 months, and those lasting 6 months or more. The results of this meta-analysis indicated that there was no statistically significant reduction in the risk of falling following a short exercise intervention of any kind (Table 6). Conversely, untargeted exercise interventions lasting 6 months or longer showed a statistically significant reduction in the risk of falling (Table 7). Only two studies investigating a short-term exercise intervention reported fall-related injuries as an outcome (47;48), and only one of these studies (49) reported any fall-related injuries during its follow-up period. The authors of this study reported a reduction in the risk of fall-related injuries following an untargeted exercise program; however, this reduction was not significant. A meta-analysis of the effectiveness of long-term exercise interventions on risk of fall-related injury indicated that targeted exercise programs moderately reduce the risk of fall-related injuries (Table 8).

Table 6: Summary of Evidence Surrounding the Risk of Falls After an Exercise Program: Short Intervention (<6 months)*

	Untargeted	Targeted	Combination* Versus Untargeted
Number of studies	10	2	1
Total N (case/control)	1160/1070	157/158	34/34
RR (95% CI)	0.85 (0.71–1.01)	0.91 (0.73–1.13)	1.11 (0.73–1.70)

*CI refers to confidence interval; RR, relative risk; combination refers to untargeted and targeted exercise programs.

Table 7: Summary of Evidence Surrounding the Risk of Falls After an Exercise Program: Long Intervention (≥6 months)*

	Untargeted	Targeted	Combination* Versus Untargeted
Number of studies	8	3	1
Total N (case/control)	462/434	454/456	43/27
RR (95% CI)	0.76 (0.64–0.91)	0.89 (0.79–1.01)	0.73 (0.57–0.95)

*CI refers to confidence interval; RR, relative risk; combination refers to untargeted and targeted exercise programs

Table 8: Summary of Evidence Surrounding the Risk of Fall-Related Injuries After an Exercise Program: Long Intervention (≥6 months)*

	Untargeted	Targeted	Combination* Versus Untargeted
Number of studies	2	2	1
Total N (case/control)	171/167	224/229	43/27
RR (95% CI)	0.61 (0.33–1.12)	0.68 (0.51–0.90)	0.31 (0.13–0.74)

*CI refers to confidence interval; RR, relative risk; combination refers to untargeted and targeted exercise programs

Vision Assessment and Referral

The literature search identified two studies that investigated the effects of vision assessment and referral on fall risk in a population of healthy elderly people aged 70 and over. (50;51) The intervention in the study by Day et al. (52) consisted of a visual acuity test by a trained assessor followed by referrals to an eye care provider, general practitioner, or optometrist where needed. In the study by Cumming et al. (53), the vision assessment was performed by an optometrist, and further referrals to an ophthalmologist or eye clinic were determined by the optometrist. A meta-analysis of these two studies showed that there was no significant reduction in the risk of falls following vision assessment and referral (Table 9).

Table 9: Summary of Evidence Surrounding the Risk of Falls After Vision Interventions*

	Vision Assessment and Referral	Cataract Surgery
Number of studies	2	2
Total N (case/control)	448/444	274/271
RR (95% CI)	1.12 (0.82–1.53)	1.11 (0.92–1.35)

*CI refers to confidence interval; RR, relative risk.

Cataract Surgery

Two studies have investigated the effects of cataract surgery in women aged 70 and over on risk of falling after 12 months of follow-up. (54;55) The intervention in the study by Harwood et al. (56) was small-incision cataract surgery and implantation of a folding silicone intraocular lens in women with cataracts and no previous ocular surgery. The study by Foss et al. (57) was a follow-up to this study and investigated the effects of cataract surgery on the second eye following successful cataract surgery in the study by Harwood et al. The results of a meta-analysis on these studies indicates that there is no reduction in risk of falls following cataract surgery in elderly women eligible for this procedure (Table 9).

Environmental Modifications

Environmental modifications are generally implemented in an elderly person's home to reduce the risk associated with many of the extrinsic risk factors such as loose rugs, poor lighting, and slippery floors. This literature search identified 4 studies that assessed the effectiveness of a home modification program in community-dwelling seniors. (58-61) The interventions consisted of one assessment visit in the elderly individual's home, followed by any necessary modifications such as the removal of floor coverings and loose electrical cords, changes to footwear, and the addition of hand rails, contrast edging to stairs, and non-slip bathmats. While the modifications available in each study were similar, the personnel responsible for the assessment and the cost of materials differed between programs. In two studies, an

occupational therapist was responsible for the home assessment, (58;62) while in the remaining two studies, the assessment was carried out by a trained assessor (63) and a team consisting of a physical medicine and rehabilitation doctor and ergotherapist. (64) Only 2 studies described the costs associated with the home modifications. In the trial by Cumming et al., (65) modifications were funded through the usual sources available in the Central Sydney Area Health Service, and in the study by Day et al., (66) labour and materials up to a value of $100 (Australian) ($54 US) were provided at no cost to the client.

Several of these studies investigated whether prior fall risk was associated with fall outcomes following an environmental modification program, and therefore the results are stratified by fall risk. High-risk populations are those with one or more falls in the previous year, and low-risk populations are those with no fall in the previous year. Three studies reported results on the risk of falling for high-risk populations, and 1 study reported outcomes for low-risk populations. The results of meta-analyses on these subgroups showed that environmental modifications effectively reduce the risk of falling in high-risk populations (RR, 0.66 [95% CI, 0.54–0.81]) but show no effect for seniors at low risk of falling (RR, 1.03 [95% CI, 0.65–1.41]) (Table 10). Three studies also reported results in a population that contained both high- and low-risk individuals. A meta-analysis of these studies showed that there was a slight reduction in risk of falling following a home modification program if the program was implemented in a population with mixed risk of falling (RR, 0.85 [95% CI, 0.75–0.97]) (Table 10). No studies reported fall-related injuries as an outcome.

Table 10: Summary of Evidence Surrounding the Risk of Falls After Environmental Modifications*

	High Risk (≥1 fall in previous year)	Low Risk (no fall in previous year)	High and Low Risk
Number of studies	3	1	3
Total N (case/control)	186/188	161/163	581/582
RR (95% CI)	0.66 (0.54–0.81)	1.03 (0.75–1.41)	0.85 (0.75–0.97)

*CI refers to confidence interval; RR, relative risk.

Vitamin D Supplements

Studies have shown that vitamin D deficiency may play a role in the development of osteoporosis and risk of fractures. (67;68) In 1999, two cross-sectional studies showed that vitamin D levels are associated with reduced muscle function and strength, (69;70) and as a result, several published studies have looked at the relationship between vitamin D supplementation and the risk of falls and fall-related injuries.

Four RCTs meeting the inclusion criteria were identified, one of which restricted the study population to women only. In two studies, a single dose of vitamin D was administered at study entry, after which participant fall outcomes were monitored for 6 months. (71;72) In the third study, participants received 1-µg capsules of alfacalcidol for 36 weeks, (73) and in the last study, participants were randomized to receive for 3 months either a 600-mg calcium carbonate supplement alone, or a combination supplement containing 600 mg calcium carbonate and 400 IU cholecalciferol (74). The results of the meta-analysis indicated that supplementation with vitamin D does not significantly reduce the risk of falling in the community-dwelling elderly population (Table 11). Similarly, in the study restricted to a population of elderly women, there was no evidence that vitamin D supplementation reduced the risk of falls (RR, 0.55 [95% CI, 0.29–1.08]) or fall-related injuries (RR, 0.48 [95% CI, 0.12–1.84]).

Table 11: Summary of Evidence Surrounding the Risk of Falls After Supplementation with Vitamin D*

	Men and Women	Women
Number of studies	3	1
Total N (case/control)	383/369	70/67
RR (95% CI)	0.94 (0.77–1.14)	0.55 (0.29–1.08)

*CI refers to confidence interval; RR, relative risk.

Vitamin D and Calcium Supplements

Supplementation with calcium has been shown to be effective in reducing bone loss by approximately 1% per year in post-menopausal women. (75) As a result, it has been hypothesized that the combination of vitamin D and calcium supplementation will reduce bone loss, body sway and loss of muscle strength, thus reducing the risk of falls and fractures in elderly individuals. Two studies were identified which investigated the joint effect of vitamin D and calcium supplementation in an elderly community-dwelling population. Both studies followed patients prospectively for 1 to 3 years; however, there were substantial differences in the intervention between the trials. A 3-year RCT conducted by Bischoff-Ferrari et al. (76) investigated the effects of a combination of 700 IU vitamin D_3 and 600 mg calcium citrate malate each day on risk of falling in elderly men and women, while Barr et al. (77) investigated a screening intervention where supplementation with vitamin D and calcium were only suggested for women at increased risk of hip fracture.

The results of the analyses indicated that supplementation with vitamin D and calcium can effectively reduce the risk of falls in women. Although the meta-analysis of two small studies investigating the effect of vitamin D alone on fall risk were not significant, the relative risk was small (RR, 0.55 [95% CI, 0.29–1.08]), and the meta-analysis may not have been adequately powered to detect a significant reduction. Therefore, it is not possible to draw from these analyses any conclusions regarding the *individual* effectiveness of vitamin D or calcium on fall risk in women. The evidence does not suggest a statistically significant reduction in falls in the study that included both men and women in their study population or in fall-related injuries in women (Tables 12 and 13).

Table 12: Summary of Evidence Surrounding the Risk of Falls After Supplementation with Vitamin D and Calcium

	Men and Women	Women
Number of studies	1	2
Total N (case/control)	219/226	720/1401
RR (95% CI)	0.89 (0.74–1.07)	0.83 (0.73–0.95)

*CI refers to confidence interval; RR, relative risk.

Table 13: Summary of Evidence Surrounding the Risk of Fall-Related Fractures After Supplementation with Vitamin D and Calcium*

	Men and Women	Women
Number of studies	0	2
Total N (case/control)	0/0	1313/2667
RR (95% CI)	N/A	0.77 (0.49–1.21)

*CI refers to confidence interval; RR, relative risk.

Hormone Replacement Therapy

The literature search identified one study that examined the effect of HRT on fall risk in elderly women. (78) In this study, women in the intervention group with a hysterectomy were given conjugated equine estrogen (0.625 mg/day), and women without a hysterectomy were given conjugated equine estrogen (0.625 mg/day) and medroxyprogesterone (2.5 mg/day). All women in the trial were given a calcium and vitamin D supplement. This study found no evidence of a reduction in the risk of falling following HRT (RR, 0.98 [95% CI, 0.80–1.20]).

Medication Withdrawal

As described earlier, the use of medications, particularly psychotropic medications, is frequently identified as a major risk factor for falls in the elderly. The literature search identified one study that investigated the effect of psychotropic medication withdrawal on the risk of falls in a community-dwelling elderly population. (79) Participants in the intervention arm of this study had the amount of active ingredient in their medication gradually reduced over 14 weeks. After 14 weeks, these individuals were taking capsules that contained inert substances only. Individuals in the control arm did not have any change in the active ingredients in their medication. After controlling for fall history and total number of medications taken, the relative hazard of falls was significantly lower in the medication withdrawal group than in the control group (HR, 0.34 [95% CI, 0.16–0.74]). However, a major limitation of this study was that compliance 1 month following study completion was very low, with 47% of the participants in the medication withdrawal group restarting psychotropic medications. Therefore, the acceptability of this intervention as a method of reducing falls in community-dwelling seniors is questionable.

Gait-stabilizing Devices

One study published in 2005 investigated the effects of a gait-stabilizing device on outdoor slips and falls in 109 community-dwelling seniors with a history of falls. (80) Study participants in the intervention arm were provided with a gait-stabilizing device (Yaktrax Walker) for use outdoors during the winter months. The Yaktrax Walker is an injection-molded thermal plastic elastomer netting with high-strength horizontal coils to provide forward and backward stability. (81) This study found that there was a significant reduction in the risks of outdoor falls and of injurious falls when using the gait-stabilizing device as compared with the controls (RR, 0.43 [95% CI, 0.29–0.64]; RR, 0.10 [95% CI, 0.01–0.74], respectively). This results in a number needed to prevent (NNP) of 3 to prevent one fall, and 6 to prevent one injurious fall. Furthermore, the compliance with this intervention was high, with 78% of study participants reporting the Yaktrax Walker as their primary winter footwear during the course of the study.

Hip Protectors

Most studies of the effectiveness of hip protectors on fall-related injury risk in the elderly are conducted

in an institutionalized elderly population, and due to different population characteristics and risk factors, the results of these studies are not generalizable to the community-dwelling elderly population. The literature search identified one study that investigated the effects of a hip protector on hip fracture risk in community-dwelling seniors with a previous hip fracture. (82) During a median follow-up of 14 months, 8 hip fractures were reported among the 279 study participants. There was no significant difference in the odds of a second hip fracture between those study participants wearing a hip protector and those in the control group (OR, 3.5 [95% CI, 0.7–18.0]). However, compliance in the intervention group was low (34%), and only one of the 6 individuals in the intervention arm who suffered a hip fracture was wearing the hip protector at the time of the fall. This woman reported falling backwards and not to the side.

Multifactorial Interventions

Several studies have investigated the effect of a combination of interventions whose purpose is to reduce the risk of falls for community-dwelling seniors. In this review, 17 studies provided an initial assessment followed by a multifactorial intervention to reduce falls and fall-related injuries. The components of the multifactorial interventions differed between trials; however, most included a combination of home hazard assessment and environmental modification, an exercise program, and medication review. Other interventions offered in some studies included vision assessment, podiatry, assessment of cognition, provision of assistive devices, and community safety education. In general, services were provided by an occupational therapist, physical therapist, or nurse.

The intervention duration and target population differed among studies. The majority of studies (83-88) had a follow-up of 1 year; however, there was a wide variation, with two studies following participants for only 3 months (89;90), and two studies with a 3-year follow-up period. (91;92) Furthermore, 6 studies restricted their population to the general elderly population ("geriatric screening"), while 10 studies considered a more targeted approach, restricting their inclusion criteria to seniors at high risk of falls. One study performed a stratified analysis, with results provided for both the general elderly population, and that at high risk of falls. (83)

Two studies (93;94) were excluded from the meta-analysis. The mean number of falls in the previous 6 months, and the percentage of recurrent fallers at baseline in the study by Whitehead et al. (93) were significantly higher in the intervention compared with the control group. Since these are important covariates to consider when assessing fall risk, it was not appropriate to include the unadjusted results of this study in the meta-analysis. The adjusted results of this study found no significant change in fall risk following the multifactorial intervention (OR, 1.7; 95% CI, 0.7–4.4). In the study by Mahoney et al. (95) raw data were not presented, and therefore data extraction for meta-analysis was not possible. Similarly, this study did not demonstrate a significant reduction in falls following a multifactorial intervention (RR, 0.81; 95% CI, 0.57–1.17).

The results of the meta-analysis indicated that multifactorial interventions do not significantly reduce the risk of falls among the general elderly population (RR, 0.87 [95% CI, 0.69–1.10]), but there is a marginally significant reduction in the risk of falls in high-risk populations following a multifactorial intervention (RR, 0.86 [95% CI, 0.75-0.98]; Table 14). Only 7 studies reported fall-related injuries as an outcome. The results of the meta-analyses of these trials did not indicate a significant reduction in the risk of fall-related injuries following a multifactorial intervention (Table 15).

Despite the lack of a large effect of multifactorial interventions on falls and fall-related injuries, it is important to note that the studies were all quite diverse in the composition of the multifactorial intervention. Furthermore, since studies did not generally describe the uptake of specific interventions within their study population, it is possible that the effects of effective interventions were diluted. Therefore, it is difficult to draw a strong conclusion as to whether appropriate, well-conducted

multifactorial interventions would be effective in the population of Ontario's seniors.

Four study protocols for multifactorial interventions were identified in the literature search. These studies are all investigating the effectiveness of multifactorial interventions in high-risk populations in preventing falls after 12 months of follow-up. (96-99)

Table 14: Summary of Evidence Surrounding the Risk of Falls After a Multifactorial Intervention*

	Geriatric Screening	High Risk	Total
Number of studies	6	10	16
Total N (case/control)	1430/1427	1301/1309	2731/2736
RR (95% CI)	0.87 (0.69–1.10)	0.86 (0.75–0.98)	0.87 (0.78–0.97)

*CI refers to confidence interval; RR, relative risk.

Table 15: Summary of Evidence Surrounding the Risk of Fall-Related Injuries After a Multifactorial Intervention*

	Geriatric Screening	High Risk	Total
Number of studies	2	5	7
Total N (case/control)	845/811	771/783	1616/1594
RR (95% CI)	0.90 (0.53–1.51)	0.86 (0.66–1.11)	0.87 (0.69–1.10)

*CI refers to confidence interval; RR, relative risk.

Summary of Findings of Literature Review

The results of the meta-analyses for the interventions identified in the literature search are summarized below in Tables 16 and 17.

Table 16: Summary of Meta-Analyses of Studies Investigating the Effectiveness of Interventions on the Risk of Falls in Community-Dwelling Seniors*

Intervention	RR [95% CI]
Exercise programs	
1. Targeted programs	
General population	0.81 [0.67–0.98]
High-risk population	0.93 [0.82–1.06]
Short duration	0.91 [0.73–1.13]
Long duration	0.89 [0.79–1.01]
2. Untargeted programs	
General population	0.78 [0.66–0.91]
High risk population	0.89 [0.72–1.10]
Short duration	0.85 [0.71–1.01]
long duration	0.76 [0.64–0.91]
3. Combined targeted vs. untargeted programs	
General population	N/A
High-risk population	0.87 [0.57–1.34]
Short duration	1.11 [0.73–1.70]
Long duration	0.73 [0.57–0.95]
Vision intervention	
Assessment/referral	1.12 [0.82–1.53]
Cataract surgery	1.11 [0.92–1.35]
Environmental modifications	
Low-risk population	1.03 [0.75–1.41]
High-risk population	0.66 [0.54–0.81]
General population	0.85 [0.75–0.97]
Drugs/nutritional supplements	
Vitamin D (men and women)	0.94 [0.77–1.14]
Vitamin D (women only)	0.55 [0.29–1.08]
Vitamin D and calcium (men and women)	0.89 [0.74–1.07]
Vitamin D and calcium (women only)	0.83 [0.73–0.95]
Hormone replacement therapy	0.98 [0.80–1.20]
Medication withdrawal	0.34 [0.16–0.74]†
Gait-stabilizing device	0.43 [0.29–0.64]
Multifactorial intervention	
Geriatric screening (general population)	0.87 [0.69–1.10]
High-risk population	0.86 [0.75–0.98]

*CI refers to confidence interval; N/A, not applicable; RR relative risk.
†Hazard ratio is presented, because relative risk was not reported

Table 17: Summary of meta-analyses of studies investigating the effectiveness of interventions on the risk of fall-related injuries in community-dwelling seniors*

Intervention	RR [95% CI]
Exercise programs	
Targeted programs	0.67 [0.51–0.89]
Untargeted programs	0.57 [0.38–0.86]
Combined targeted vs untargeted programs	0.31 [0.13–0.74]
Drugs/nutritional supplements	
Vitamin D plus calcium (Women only)	0.77 [0.49–1.21]
Gait-stabilizing device	0.10 [0.01–0.74]
Hip protectors	3.49 [0.68–17.97]†
Multifactorial intervention	
Geriatric screening (general population)	0.90 [0.53–1.51]
High-risk population	0.86 [0.66–1.11]

*CI refers to confidence interval; RR relative risk
†Odds ratio is presented, because relative risk could not be calculated

Quality of the Evidence

Table 18: Summary of GRADE Quality Assessment for Exercise Interventions: Stratified by Intervention Length*

		Quality Assessment					Summary of Findings			
							No. of Patients		Effect	
Intervention	No. of Studies	Design	Quality	Consistency	Directness	Other	Interv	Control	(RR [95% CI])	Quality
Exercise (untargeted, long duration)	8	RCT	Serious limitations†	Consistent	Direct	None	462	434	0.76 [0.64–0.91]	Moderate
		High	Moderate	Moderate	Moderate	Moderate				
Long duration: targeted	3	RCT	No serious limitations	Consistent	Some uncertainty about directness‡	None	454	456	0.89 [0.79–1.01]	Moderate
		High	High	High	Moderate	Moderate				
Long duration: Combined	1	RCT	No serious limitations	Only 1 study	Direct	None	43	27	0.73 [0.57–0.95]	High
		High	High	High	High	High				
Short duration: Untargeted	10	RCT	Serious limitations§	Slightly inconsistent	Direct	None	1160	1070	0.85 [0.71–1.01]	Low
		High	Moderate	Low	Low	Low				
Short duration: Targeted	2	RCT	No serious limitations	Consistent	Direct	None	157	158	0.91 [0.73–1.13]	High
		High	High	High	High	High				
Short duration: Combined	1	RCT	No serious limitations	Only 1 study	Direct	None	34	34	1.11 [0.73–1.70]	High
		High	High	High	High	High				

*RR refers to relative risk; CI, confidence interval; Interv, intervention; RCT, randomized controlled trial;
†Several studies (100-103) did not describe randomization process and by this omission might conceal biases in study allocation. Heterogeneity in exercise programs.
‡Two studies on older individuals aged 80+ and 85+ (104;105). Study by Campbell et al. on women only. (106)
§Five studies didn't have adequate blinding. (107-111) Two studies were not completely randomized (111;112)

Table 19: Summary of GRADE Quality Assessment for Exercise Interventions: Stratified by Target Population*

Intervention	No. of Studies	Quality Assessment					Summary of Findings			
							No. of Patients		Effect	
		Design	Quality	Consistency	Directness	Other	Interv	Control	(RR [95% CI])	Quality
General population: Untargeted	12	RCT	Serious limitations†	Consistent	Direct	None	1250	1234	0.78 [0.66–0.91]	Moderate
		High	Moderate	Moderate	Moderate	Moderate				
General population: Targeted	3	RCT	Serious limitations‡	Consistent	Some uncertainty about directness§	None	282	284	0.81 [0.66–0.98]	Low
		High	Moderate	Moderate	Low	Low				
High-risk population: Untargeted	6	RCT	Serious limitations‖	Some inconsistency	Some uncertainty about directness¶	None	372	270	0.89 [0.72–1.10]	Very low
		High	Moderate	Low	Very low	Very low				
High-risk population: Targeted	2	RCT	No serious limitations	Consistent	Direct	None	329	330	0.93 [0.82–1.06]	High
		High	High	High	High	High				
High-risk population: Combined	2	RCT	No serious limitations	Some inconsistency	Direct	None	77	61	0.87 [0.57–1.34]	Moderate
		High	High	Moderate	Moderate	Moderate				

*RR refers to relative risk; CI, confidence interval; Interv, intervention; RCT, randomized controlled trial;
†Three studies (102) (100;113) did not describe randomization process, an omission which could conceal biases in study allocation; Exercise programs differed.
‡One study (114) only 19% randomized; Exercise programs differed.
§One study only on older (80+) women (115)
‖One study (116) did not describe randomization process; One study (111) not completely randomized; Three studies (111;117;118) not adequately blinded
¶One study in women only, (119) and one study in men only. (120)

Table 20: Summary of GRADE Quality Assessment for Nutritional Supplementation*

Intervention	No. of Studies	Quality Assessment					Summary of Findings			
							No. of Patients		Effect	
		Design	Quality	Consistency	Directness	Other	Interv	Control	(RR [95% CI])	Quality
Vitamin D: Men and women	3	RCT	No serious limitations	Consistent	Direct	None	383	369	0.94 [0.77–1.14]	High
		High	High	High	High	High				
Vitamin D: Women	1	RCT	Serious limitations†	Only 1 study	Direct	None	70	67	0.55 [0.29–1.08]	Moderate
		High	Moderate	Moderate	Moderate	Moderate				
Vitamin D plus calcium: Men and Women	1	RCT	Serious limitations†	Only 1 study	Direct	None	219	226	0.89 [0.74–1.07]	Moderate
		High	Moderate	Moderate	Moderate	Moderate				
Vitamin D plus calcium: Women	2	RCT	No serious limitations	Consistent	Direct	High probability of reporting bias‡	720	1401	0.83 [0.73–0.95]	Moderate
		High	High	High	High	Moderate				
Vitamin D plus calcium: Women Outcome: injurious Falls	2	RCT	No serious limitations	Consistent	Direct	High probability of reporting bias‡	1313	2667	0.77 [0.49–1.21]	Moderate
		High	High	High	High	Moderate				
Hormone replacement therapy	1	RCT	Serious limitations§	Only 1 study	Direct	None	187	186	0.09 [0.80–1.20]	Moderate
		High	Moderate	Moderate	Moderate	Moderate				
Medication withdrawal	1	RCT	No serious limitations	Only 1 study	Major uncertainty about directness§	Sparse data‖ Strong evidence of association	24	24	0.34 [0.16–0.74]¶	Low
		High	High	High	Low	Low				

*RR refers to relative risk; CI, confidence interval; Interv, intervention; RCT, randomized controlled trial
†No description of randomization or blinding (although stated "double-blinded RCT") (74)
‡In one study, use of vitamin D and calcium by self-report only over a period of 1 to 3 years, and falls outcome reported as interval recall (falls in past year). (121)
§Study relied on long recall times (6 months) for falls outcome. (122)
‖Large amount of withdrawal (123-125)
¶Hazard Ratio

Table 21: Summary of GRADE Quality Assessment for Environmental Modifications*

		Quality Assessment					Summary of Findings			
							No. of Patients		Effect	
Intervention	No. of Studies	Design	Quality	Consistency	Directness	Other	Interv	Control	(RR [95% CI])	Quality
Environmental modification (low-risk seniors)	1	RCT	No serious limitations	Only 1 study	Direct	None	161	163	1.03 [0.75–1.41]	High
		High	High	High	High	High				
Environmental modification (high-risk seniors)	3	RCT	No serious limitations	Consistent	Direct	None	186	188	0.66 [0.54–0.81]	High
		High	High	High	High	High				
Environmental modification (all seniors)	3	RCT	No serious limitations	Consistent	Direct	None	581	582	0.85 [0.75–0.97]	High
		High	High	High	High	High				

*RR refers to relative risk; CI, confidence interval; Interv, intervention; RCT, randomized controlled trial

Table 22: Summary of GRADE Quality Assessment for Vision Interventions*

		Quality Assessment					Summary of Findings			
							No. of Patients		Effect	
Intervention	No. of Studies	Design	Quality	Consistency	Directness	Other	Interv	Control	(RR [95% CI])	Quality
Vision assessment and referral	2	RCT	No serious limitations	Some inconsistency†	Direct	None	448	444	1.12 [0.82–1.53]	Moderate
		High	High	Moderate	Moderate	Moderate				
Cataract surgery	2	RCT	No serious limitations	Consistent	Some uncertainty about directness‡	None	274	271	1.11 [0.92–1.35]	Moderate
		High	High	High	Moderate	Moderate				

*RR refers to relative risk; CI, confidence interval; Interv, intervention; RCT, randomized controlled trial
†One study shows positive effect, (126) and one shows negative. (127)
‡Only women included in studies. (128;129)

Table 23: Summary of GRADE Quality Assessment for Devices*

Intervention	No. of Studies	Quality Assessment					Summary of Findings			
							No. of Patients		Effect	
		Design	Quality	Consistency	Directness	Other	Interv	Control	(RR [95% CI])	Quality
Hip Protector	1	RCT	Serious limitations†	Only 1 study	Some uncertainty about directness‡	None	139	140	3.49 (0.68–17.97)	Low
		High	Moderate	Moderate	Low	Low				
Gait-stabilizing device	1	RCT	Serious limitations§	Only 1 study	Some uncertainty about directness‖	Strong evidence of association	55	54	0.43 [0.29–0.64]	Moderate
		High	Moderate	Moderate	Low	Moderate				

*RR refers to relative risk; CI, confidence interval; Interv, intervention; RCT, randomized controlled trial
†High dropout in hip protector group; randomization technique not described. (82)
‡Study population of people with previous hip fracture, therefore may not be generalizable to all seniors. (82)
§No information as to whether groups comparable at study entry. (80)
‖No information on number of people excluded because they couldn't put on device. This may affect the generalizability and use in the general ambulatory, elderly population. (82)

Table 24: Summary of GRADE Quality Assessment for Multifactorial Interventions

Population and Outcome	No. of Studies	Quality Assessment					Summary of Findings			
							No. of Patients		Effect	
		Design	Quality	Consistency	Directness	Other	Interv	Control	(RR [95% CI])	Quality
Geriatric screening Falls	6	RCT	Very serious limitations†	Some Inconsistency	Direct	None	1430	1427	0.87 [0.69–1.10]	Very low
		High	Low	Very low	Very low	Very low				
Geriatric screening Injurious falls	2	RCT	Very serious limitations‡	Some Inconsistency	Direct	None	845	811	0.90 [0.53–1.51]	Low
		High	Moderate	Low	Low	Low				
High risk Falls	10	RCT	Serious limitations§	Some inconsistency	Direct	None	1301	1309	0.91 [0.75–0.98]	Low
		High	Moderate	Low	Low	Low				
High risk Injurious falls	4	RCT	Serious limitations ‖	Consistent	Direct	None	624	639	0.85 (0.63–1.17)	Moderate
		High	Moderate	Moderate	Moderate	Moderate				

*RR refers to relative risk; CI, confidence interval; Interv, intervention; RCT, randomized controlled trial.

†No blinding of outcome assessors in 4 studies; (130-133) high dropout in 2 studies; (134;135) fall outcome based on recall at end of study for 4 studies; (133;136-138) randomization technique not described in study by Jitapunkul et al. (139)

‡Recall required for falls outcome and no blinding or intention-to-treat analysis in one study (133)

§No blinding of outcome assessors in 5 studies; (140-144) high dropout in 2 studies (145;146)

‖High loss to follow-up in two studies; (147;148) outcome assessors not blind in two studies (149;150)

Feedback from Expert Panel

The systematic review on falls and fall-related injuries was presented at two expert panel meetings (January 23, 2008, and May 16, 2008). The panel contextualized the evidence and identified several important issues to consider. The following is a summary of comments that were made:

Medication Withdrawal

- Medication withdrawal involves a fine balance between benefit and risk, and cannot be as accurately implemented as other initiatives.
- There are not enough best practice guidelines for medication withdrawal in seniors.
- As a general rule, psychotropic medications are not prescribed unless there are specific needs (such as wandering, inability to sleep, hitting, and other abusive behaviour). In these cases, it is difficult (and perhaps inappropriate) to withdraw this medication since doing so can greatly increase caregiver burden.
- A discussion followed that indicated that inadequate training of caregivers to deal with behaviours in seniors may increase the reliance on psychotropic medications. Perhaps if proper training were provided, medication withdrawal could be more successful.
- In a home setting, individual compliance with taking psychotropic medications can be low and requires caregiver support for reminders.

Causes of Falls and Injury in Seniors

- Many injurious falls occur around indoor stairs, and therefore the proper design of stairs and appropriate handrails (shape, diameter, and height) should be investigated.
- Injuries following falls from ladders frequently occur in seniors (largely due to cleaning of eavestroughs and windows). Ladders with hoops or services to clean eavestroughs and windows for seniors should be considered.
- Falls on sidewalks and road crossings are frequent, particularly in the winter. With the deteriorating condition of street clearing, this is becoming a larger issue.
- Fear of falling is another important cause of falls since it perpetuates a cycle of immobility, followed by deconditioning and falls.

Falls in the Winter

- In the winter, several factors reduce the likelihood that an elderly person will go outdoors:
  - Seniors are most likely to go out during daylight hours, which are fewer.
  - Fear of slipping on the ice and snow reduces the likelihood of an elderly person choosing to go outdoors unless it is absolutely necessary.
  - Poorly designed coats and boots make it difficult for seniors with difficulty moving or with lowered flexibility to dress for the outdoors.
- These factors can lead to lowered fitness levels, which in turn leads to an increased likelihood of falls both indoors and outdoors.
- Furthermore, in the colder months, people tend to walk faster when outdoors, which can increase the likelihood that an individual will fall.

Mobility Aids

- At both meetings, the issues of mobility aids was raised by experts on the panel. Regrettably it is very rare to find published trials investigating the effectiveness of mobility aids, and therefore it was not appropriate to include this as a section of this literature review. However, the panel felt that it was important to discuss these aids and their use in reducing falls and fall-related injuries in the elderly population, and that more work should be done to improve existing mobility devices.
- Mobility aids that were discussed as being effective included
  - wheeled walkers – while wheeled walkers can decrease the frequency of falls, the panel mentioned that walkers must be properly designed to ensure the best stability and that poorly designed walkers can actually increase the likelihood of falls.
  - handrails that are at an appropriate height, are cylindrical and are easy to see and grab
  - raised toilet seats to decrease falls that occur when sitting at and standing up from the toilet
  - grab bars, particularly in washrooms
- While mobility aids are an important tool to reduce falls in community-dwelling seniors, when renovations are not done to an appropriate standard, they can actually increase home hazards and risk of falling. Therefore, it was felt that elderly populations should be provided with access to affordable high-standard renovations.
- Emergency buttons that act as a lifeline after a fall were discussed. Because quick access to help can prevent long-term complications and disabilities, it was argued that these emergency buttons are highly effective in elderly populations, although it was suggested that uptake of the technology may be limited, based on reports that many people forget after a fall that they have access to these buttons.

Follow-Up to Comments Made by Expert Panel

Following the expert panel meeting, a literature search was performed to attempt to identify any literature surrounding the effectiveness of mobility devices. It was confirmed that there is very little evidence surrounding mobility devices in the published literature. One recent Canadian study was identified which described current fall-prevention interventions in seniors. (151) This paper described a handrail cueing system, balance-enhancing footwear inserts, and a modified walking aid. The results of these studies indicated that the balance-enhancing footwear inserts improved the ability to stabilize one's body and may reduce the number of falls, while more research is needed in an elderly population to determine whether an extended arched walker can increase stability in seniors. A study is currently underway to test the effectiveness of handrail cueing systems (both visual and combined visual and verbal cueing) on handrail use and reaching reactions.

In response to the discussion regarding the reasons for falls in the elderly population, the Medical Advisory Secretariat analyzed fall-related data for FY2006/07 on inpatient hospitalization of and emergency department use by elderly Ontarians. Hospitalizations with an external cause recorded as a fall were extracted for Ontarians aged 65 and over between April 1, 2006, and March 31, 2007. The resulting distribution of cause of falls appears in Table 25. This table indicates that mobility devices and furniture are frequently reported as the causes of falls in seniors going to the emergency department, and those admitted to hospital. Additionally, outdoor falls involving ice and snow, falls involving ladders, and falls involving stairs and steps explain 13.0% of hospitalizations for falls and 15.7% of emergency department visits for falls among Ontario's seniors.

Table 25: Distribution of the Cause of Falls in Hospitalizations for Elderly (Aged 65+) Ontarians (FY2006/2007)*

	ED Visits			Hospitalizations		
Type of Fall	**% of all falls**	**% of specified falls†**	**N‡**	**% of all falls**	**% of specified falls†**	**N‡**
Fall involving mobility devices						
Fall involving adult walker	1.55	2.13	1,410	2.10	2.88	518
Fall involving wheelchair	1.23	1.69	1,119	1.21	1.65	298
Fall involving other specified walking devices	0.09	0.12	79	0.13	0.17	31
Fall involving unspecified walking devices	0.01	0.02	12	–	–	≤5
Outdoor Fall						
Fall on same level involving ice and snow	3.69	5.08	3,359	2.72	3.73	671
Fall from tree	0.06	0.08	51	0.06	0.08	15
Fall from scaffolding	0.04	0.05	32	0.03	0.04	8
Fall involving playground equipment	0.01	0.01	9	–	–	≤5
Fall involving furniture						
Fall involving bed	3.87	5.32	3,520	5.00	6.85	1,233
Fall involving chair	2.08	2.86	1,892	2.09	2.86	515
Fall involving other furniture	0.59	0.81	537	0.52	0.71	128
Fall involving baby walker	–	–	≤5	–	–	≤5
Other Falls						
Fall on the same level from slip, trip, or stumble	32.44	44.66	29,540	32.72	44.81	8,070
Unspecified fall	27.36	N/A	24,907	26.99	N/A	6,658
Other fall on same level	13.31	18.32	12,118	14.85	20.35	3,664
Fall on and from stairs and steps	10.19	14.02	9,276	8.78	12.02	2,165
Fall on and from ladder	1.81	2.49	1,647	1.51	2.07	372
Other fall from one level to another	1.47	2.02	1,335	0.99	1.35	244
Fall out of/through building structure	0.22	0.31	203	0.29	0.39	71

*ED indicated emergency department; N, number.

†Excludes "Unspecified fall" from denominator

‡To maintain privacy, all cell sizes of 5 or less are suppressed

Source: The Ministry of Health and Long-Term Care, Provincial Health Planning Database

Conclusions

1. High-quality evidence indicates that long-term exercise programs in mobile seniors and environmental modifications in the homes of frail elderly persons will effectively reduce falls and possibly fall-related injuries in Ontario's elderly population.
2. A combination of vitamin D and calcium supplementation in elderly women will help reduce the risk of falls by more than 40%.
3. The use of outdoor gait-stabilizing devices for mobile seniors during the winter in Ontario may reduce falls and fall-related injuries; however, evidence is limited and more research is required in this area.
4. While psychotropic medication withdrawal may be an effective method for reducing falls, evidence is limited and long-term compliance has been demonstrated to be difficult to achieve.
5. A multifactorial intervention, including a combination of fall prevention interventions such as exercise, medication withdrawal, environmental modifications, vision and hearing interventions may reduce the risk of falls in high-risk populations. However, the quality of the evidence in this area is low, and included interventions are varied. Therefore more research is needed into the most appropriate and effective multifactorial intervention design.

Appendices

Appendix 1: Search Strategies

Search date: October 2, 2007
Databases searched: OVID MEDLINE, MEDLINE In-Process and Other Non-Indexed Citations, EMBASE, CINAHL, Cochrane Library, INAHTA/NHS EED

Database: Ovid MEDLINE(R) <1996 to September Week 3 2007>
Search Strategy:
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1 exp Accidental Falls/pc [Prevention & Control] (2140)
2 exp Accidental Falls/ (6124)
3 exp Accident Prevention/ or exp Primary Prevention/ or exp risk reduction behavior/ or exp Preventive Health Services/ or exp Preventive Medicine/ (172856)
4 2 and 3 (718)
5 (fall$ adj4 prevent$).mp. [mp=title, original title, abstract, name of substance word, subject heading word] (1416)
6 1 or 4 or 5 (2961)
7 limit 6 to (humans and english language and yr="2000 - 2007") (1906)
8 limit 7 to "all aged (65 and over)" (1259)
9 (elder$ or senior$).mp. [mp=title, original title, abstract, name of substance word, subject heading word] (71440)
10 7 and (8 or 9) (1292)
11 limit 10 to (controlled clinical trial or meta analysis or randomized controlled trial) (200)
12 (meta analy$ or metaanaly$ or pooled analysis or (systematic$ adj2 review$)).mp. or (published studies or published literature or medline or embase or data synthesis or data extraction or cochrane).ab. (54569)
13 exp Random Allocation/ or random$.mp. [mp=title, original title, abstract, name of substance word, subject heading word] (326025)
14 exp Double-Blind Method/ (48004)
15 exp Control Groups/ (493)
16 exp Placebos/ (8371)
17 RCT.mp. (1998)
18 or/11-17 (366985)
19 10 and 18 (296)

Database: EMBASE <1980 to 2007 Week 39>
Search Strategy:
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1 exp Falling/pc [Prevention] (2)
2 exp Falling/ (9062)
3 exp prevention/ or exp Preventive Health Service/ or exp Preventive Medicine/ or exp Risk Reduction/ (456395)
4 2 and 3 (1568)
5 (fall$ adj4 prevent$).mp. [mp=title, abstract, subject headings, heading word, drug trade name,

original title, device manufacturer, drug manufacturer name] (2198)
6 1 or 4 or 5 (2963)
7 limit 6 to (human and english language and yr="2000 - 2008") (1351)
8 limit 7 to aged <65+ years> (661)
9 (senior$ or elder$).mp. [mp=title, abstract, subject headings, heading word, drug trade name, original title, device manufacturer, drug manufacturer name] (115074)
10 8 or 9 (115397)
11 7 and 10 (797)
12 Randomized Controlled Trial/ (149282)
13 exp Randomization/ (24000)
14 exp RANDOM SAMPLE/ (792)
15 (meta analy$ or metaanaly$ or pooled analysis or (systematic$ adj2 review$)).ti,mp. or (published studies or published literature or medline or embase or data synthesis or data extraction or cochrane).ab. (76601)
16 Double Blind Procedure/ (66657)
17 exp Triple Blind Procedure/ (8)
18 exp Control Group/ (1007)
19 exp PLACEBO/ (104532)
20 (random$ or RCT).mp. [mp=title, abstract, subject headings, heading word, drug trade name, original title, device manufacturer, drug manufacturer name] (386635)
21 or/12-20 (511379)
22 11 and 21 (238)

Database: CINAHL - Cumulative Index to Nursing & Allied Health Literature <1982 to September Week 4 2007>
Search Strategy:
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1 exp Accidental Falls/pc [Prevention and Control] (2193)
2 exp Accidental Falls/ (4650)
3 exp "FALL PREVENTION (IOWA NIC)"/ (1)
4 exp Preventive Health Care/ (73373)
5 exp SAFETY/ (37546)
6 or/3-5 (109313)
7 2 and 6 (972)
8 1 or 7 (2510)
9 (fall$ adj4 prevent$).mp. [mp=title, subject heading word, abstract, instrumentation] (1057)
10 8 or 9 (2776)
11 limit 10 to (english and yr="2000 - 2007") (1916)
12 random$.mp. or exp RANDOM ASSIGNMENT/ or exp RANDOM SAMPLE/ (60536)
13 RCT.mp. (736)
14 exp Meta Analysis/ (5696)
15 exp "Systematic Review"/ (3320)
16 (meta analy$ or metaanaly$ or pooled analysis or (systematic$ adj2 review$) or published studies or medline or embase or data synthesis or data extraction or cochrane).mp. (19960)
17 exp double-blind studies/ or exp single-blind studies/ or exp triple-blind studies/ (11524)
18 exp PLACEBOS/ (3799)
19 or/12-18 (78869)
20 11 and 19 (222)

Appendix 2: GRADE Score for the Body of Evidence

Number of Studies	Study Design	Quality of Studies	Consistency	Directness	Other Modifying Factors
N	RCT=High Observational =Low Any other evidence =Very Low	Serious limitation to study quality (−1) Very serious limitation to study quality (−2)	Important inconsistency (−1)	Some uncertainty about directness (−1) Major uncertainty about directness (−2)	Association strong (+1) Association very strong (+2) Dose response gradient (+1) All plausible confounders would have reduced the effect (+1) Imprecise or sparse data (−1) High probability of reporting bias (−1)

Source: Atkins D et al. Grading quality of evidence and strength of recommendations. BMJ 2004;328(7454):1490. (46)

Appendix 3: Study Characteristics

Exercise Interventions – Summary of Evidence*

Study	Population	Intervention and Referent Group	Intensity (No. Times/Week)	Targeted or Untargeted	Follow-Up	Outcomes Measured	Results
Gillespie: Cochrane Review (2003) (44)	• Elderly • RCTs • Community-dwelling	Exercise alone vs. control	Varied	1. Untargeted 2. Targeted (strength, balance, training) 3. Targeted (strength)	Varied	Number of falls	Meta-analysis results: 1. RR, 0.89 (0.79–1.01) 2. RR, 0.80 (0.66–0.98) 3. RR, 0.92 (0.73–1.16)
				1. Individually targeted	Varied	Number sustaining injury fall	Meta-analysis results: 1. RR, 0.67 (0.51–0.89)
				1. Untargeted 2. Targeted	Varied	Number sustaining 2 or more falls	Meta-analysis results: 1. RR, 0.78 (0.52–1.18) 2. RR, 0.76 (0.54–1.05)
Barnett (2003) (152)	• Aged 65+ • High risk	Exercise (balance, coordination, strength, tai chi) vs. control	37 classes over 1 year 1 h	Untargeted, Group and Home	12 months	Falls, fear of falling, fall injuries	No difference in fear of falling at 6 months Falls: • IRR, 0.60 (0.36–0.99) • ≥1 fall RR, 0.71 (0.49–1.04) • ≥2 fall RR, 0.44 (0.21–0.96) Fall injuries – no difference: • IRR, 0.66 (0.38–1.15) • ≥1 fall RR, 0.77 (0.48–1.21) • ≥2 fall RR, 0.58 (0.22–1.52)
Day (2002)† (153)	• Aged 70+	Strength and balance (n=135) vs. control (n=137)	1x/week for 15 weeks 1 h Daily home exercises	Untargeted, group and home	18 months	Number of falls	• RR, 0.82 (0.70–0.97) • % reduction in annual fall rate: 6.9 (1.1–12.8)
Freiberger (2007) (154)	• Aged 70+	Psychomotor intervention vs. fitness intervention (strength, endurance, flexibility) vs. control	2x/week for 16 weeks 1 h Practice at home daily	Untargeted, Group and home (unsupervised)	12 months	Number falls, fallers, multiple fallers	Fitness Intervention: • No. of fallers: RR, 0.77 (0.60–0.97) • Multiple fallers and number falls: RR, not significant Psychomotor intervention: • No outcomes significant Time to first fall: • Psychomotor: 281 ± 16 days

Study	Population	Intervention and Referent Group	Intensity (No. Times/Week)	Targeted or Untargeted	Follow-Up	Outcomes Measured	Results
							• Fitness: 337 ± 9 days • Control: 216 ± 15 days
Hauer (2001) (155)	• Women • Aged 75–90 • High risk • Past fall • Recruited from rehab ward	Resistance and balance training vs. placebo activity (flexibility, calisthenics, ball games, memory tasks)	3 days/week for 12 weeks 1.5 h resistance 45 min balance	Untargeted, Group	6 months	falls	• No difference: • RR, 0.75 (0.46–1.25)
Helbostad (2004) (156)	• Aged 75+ • High risk (fall or use of walking aid)	Home-based (HT) exercise vs. group exercise (CT)	HT: Daily home exercises + 3 group meetings CT: 2x/wk for 12 weeks (1hr) + same home exercises as HT group daily	Targeted vs. untargeted, Group vs. home	1 year	Number of falls	• No significant difference in number of falls (*P* = .78)
Latham (2003) (157)	• Frail • Mean age 79	Quadriceps exercise program (home) vs. regular home and telephone support	3/week for 10 weeks	Targeted, Home	10-week intervention plus 6-month follow-up	Falls, time to first fall	Falls outcome: • RR, 0.96 (0.67–1.36) Time to first fall: • HR, 0.97 (0.68–1.37)
Li (2005) (158)	• Aged 70+ • Inactive	Tai chi intervention vs. stretching control	3x/week for 6 months (both intervention and control)	Untargeted, Group	After intervention, and 6 months postintervention	Number of falls, injurious falls, fear of falling	After intervention • RR moderate injurious falls, 0.31 (0.12–0.84) • RR severe falls, 0.28 (0.09–0.86) • Significant increase in time to first fall (*P* = .007) • HR falls, 0.46 (0.26–0.80), *P* = .006 • HR multiple falls, 0.45 (0.30–0.70), *P* < .001 • Fear of falling significantly reduced (*P* = .05) • Improvements maintained during the postintervention follow-up
Luukinen (2006) (159)	• Aged 85+ • High risk (recurrent falls or other risk factor)	Individual exercise plan (could be home or group-based) based on risk factors (low-intensity) vs. control (no exercise plan)	Varied	Targeted, group, and home depending on assessment	Median 16 months' intervention	Falls	Entire group: • HR for first 4 falls and for all falls, not significant Subgroup: able to move outdoors: • HR first 4 falls, 0.72 (0.59–0.88)

Study	Population	Intervention and Referent Group	Intensity (No. Times/Week)	Targeted or Untargeted	Follow-Up	Outcomes Measured	Results
							• HR all falls, 0.83 (0.69–1.00)
Means (2005) (160)	• Mean aged 73.5 years	Balance training (stretching, postural control, endurance) vs. control (attended seminars on non-health-related topics)	1x/week 6 weeks	Untargeted, Group (6–8 people)	6 months post-intervention	Falls, fall-related injuries	• Pre/post analysis: • Exercise group had fewer falls and fall-related injuries (*P* = .002 and .034). • No difference in control group pre/post
Robertson (2001)† (161)	• Aged 75+	Exercise program vs. control	Exercise at least 3x/week, walk 2x/week; 30 min For 1 year	Targeted, home	1 year	Number of falls, number injuries from falls	• IRR for fall, 0.54 (0.32–0.90), *P* = .019 • RR serious injury due to fall (control vs. intervention), 4.6 (1.0–20.7), *P* = .033 • Age stratification: • 80+: significant fall reduction, *P* < .001 • 75–79: no significant reduction
Rubenstein (2000) †(162)	• Men • Aged 70+ • High risk	Exercise (strength, endurance and balance) vs. control	3x/week for 12 weeks 1.5 h	Untargeted, group	12 weeks	Falls, self-rated health	• Higher self-rated global health (*P* = .005) • 6 falls/1000 h of activity vs. 16.2 falls/1000 h of activity, *P* = .027
Skelton (2005) (163)	• Women • Aged 65+ • High risk (≥3 falls in past year)	Falls management exercise (group and home) vs. regular home exercises	36 weeks of class Group: 1/week for 1 h Home: 2/week for 30 minutes	Targeted, Group, and Home (unsupervised)	36-wk intervention plus mean 49.7-wk follow-up	Falls, injurious falls, died/LTC home/hospital	• Whole trial period: IRR, 0.69 (0.50–0.96), *P* = .029 • Follow-up only (after intervention completed: IRR, 0.46 (0.34–0.63) • No difference for injurious falls (possibly due to lack of power) • Significant difference in # deaths or LTC home admission or hospital admission: *P* = .017
Suzuki (2004) (100)	• Women • Aged 73–90 • Participants in Tokyo Metropolitan Institute of Gerontology Longitudinal Interdisciplina	Exercise (tai chi, strength, balance, resistance) vs. control	Group: 1 h every 2 weeks for 6 months Home: 3/wk for ~30 minutes	Untargeted, Group and Home (unsupervised)	8 and 20 months	falls	• Proportion with fall: 54.5% in controls vs. 13.6% in intervention group, *P* < .05 at 20-month follow-up • No difference at 8-month follow-up

Study	Population	Intervention and Referent Group	Intensity (No. Times/Week)	Targeted or Untargeted	Follow-Up	Outcomes Measured	Results
	ry Study on Aging						
Voukelatos (2007) (164)	• Aged 60+ • Recruited in community	Tai chi vs. control	1 time/week for 16 weeks 1 hour	Untargeted, Group	4 and 6 months	Falls, ≥1 fall, ≥2 falls	• IRR # falls, 0.67, *P* = .02 • HR ≥1 fall, 0.66, *P* = .02 • HR ≥2 falls, 0.27, *P* = .001
Weerdesteyn (2006) (111)	• Aged 65+ • High risk (history of falls)	Nijmegen Falls Prevention Program: low-intensity exercise vs. control	2x/week for 5 weeks 1.5 h	Untargeted, Group	Unclear	Falls	• IRR fall incidence rate, 0.54 (0.34–0.86) • IRR number falls, 1.26 (0.60–2.64) *note: not completely randomized
Woo (2007) (165)	• Aged 65–74 • Recruited in community	1) Tai chi 2) Resistance exercise 3) Control	3 times/week for 12 months	Untargeted, Group	6 and 12 months	Falls	• No difference

*HR refers to hazard ratio; IRR, incidence rate ratio; RCT, randomized controlled trial; RR, relative risk.
†Also identified in Cochrane review

Vision Interventions – Summary of Evidence*

Study	Population	Intervention	Follow-Up	Outcomes Measured	Results
Cumming (2007) (166)	• Aged 70+ • No cataract surgery or new eyeglass prescription in previous 3 months	• Intervention (N=309) vs. control (N=307) • Vision tests and eye examinations by optometrist • New eyeglasses dispensed if required • If ocular pathology requiring treatment, referred to ophthalmologist or public hospital eye clinic • If substantial impairment, referred to OT for home modifications/assistive devices	12 months	Falls, fallers, multiple fallers, fractures	• Falls: RR, 1.35 (1.18–1.55) • Fallers: RR, 1.54 (1.25–1.91) • Multiple fallers: RR, 1.24 (0.99–1.54) • Fractures: RR, 1.74 (0.97–3.11) not blinded
Day (2002) (167)	• Aged 70+ • Healthy	• Vision improvement: assessed at baseline using dual visual acuity chart • Referred to eye care provider, GP or local optometrist where needed	18 months	Number of fallers	• Fallers: RR, 0.95 (0.79–1.14)
Foss (2006) (168)	• Aged 70+ • Women • Following one successful cataract operation with second operable cataract • About half patients recruited from Harwood (2005) trial	• Expedited surgery (N=120) vs. routine surgery (N=119) • Small incision cataract surgery and implantation of a folding silicone intraocular lens under local anaesthetic.	12 months	Falls, ADLs, QoL, Rate of falling	• No statistically significant results • First fall: HR, 1.06 (0.69–1.61) • Multiple fallers: HR, 0.85 (0.49–1.56) • Rate of falling: Rate ratio, 0.68 (0.39–1.19)
Harwood (2005) (169)	• Aged 70+ • Women • With cataracts with no previous ocular surgery, who were suitable for surgery	• Expedited surgery (N=154) vs. routine surgery (N=152) • Small incision cataract surgery and implantation of a folding silicone intraocular lens under local anaesthetic.	12 months	Falls, ADLs, QoL, Rate of falling	• Any falls: HR, 0.95 (0.69–1.35) • Multiple fallers: HR, 0.60 (0.36–0.98) • Rate of falling: Rate ratio, 0.66 (0.45–0.96) • Improvement in QoL measured using Euroqol (*P* = .02)

* ADLs refers to activities of daily living; GP, general practitioner; HR, hazard ratio; OT, occupational therapist; QoL, quality of life; RR, relative risk.

Environmental Modifications: Summary of Evidence*

Study	Population	Intervention and Referent Group (N)	Number of Visits and Description of Intervention	Personnel (e.g., Nurse, OT)	Follow-Up	Outcomes Measured	Results
Gillespie: Cochrane Review (2003) (44)	• Elderly • RCTs • Community-dwelling Fallers in year prior (n=3 studies) No falls in year prior (n=1) Fallers and non-fallers in year prior (n=3)	Home safety intervention alone vs. control	• Varied	Varied	Varied	Number of people falling	Results from meta-analysis: Fallers in year prior RR: 0.66 (0.54–0.81) No falls in year prior, RR: 1.03 (0.75–1.41) Fallers and non-fallers in year prior RR: 0.85 (0.74–0.96)
Day (2002) †(170)	• Aged 70+	Home hazard intervention (n=135) vs. no intervention (n=137)	• One assessment visit, and one by home maintenance staff if labour and materials were required • Modifications included hand rails, modifications to floor coverings, contrast edging, and stair/ramp maintenance	Trained assessor	18 months	Number of falls, number of home hazards	• RR, 0.92 (0.78–1.08), *P* = .29 • % estimated reduction in annual fall rate, 3.1 (−2.0 to 9.7)
Nikolaus (2003)† (58)	• Mean age 81 • Recruited as inpatients in geriatric clinic	Home intervention team (N=140) vs. control (N=139)	• One home visit while inpatient to evaluate home and prescribe technical aids • After discharge, at least 1 more visit to inform patient of risks, give advice for modifications, facilitate modifications	Nurse, physiotherapist, occupational therapist, social worker	1 year	Death or nursing home placement, number of falls	• IRR falls, 0.69 (0.51–0.97), *P* = .032 • IRR falls in intervention group with at least 1 modification after 12 months, 0.64 (0.37–0.99, *P* = .047) • IRR falls in intervention group with no modification after 12 months, not significant • No difference between no. died vs. no. moved to LTC home
Pardessus (2002)† (171)	• Aged 65+ • Recruited after fall hospitalization	Home visit to assess environmental modifications (N=30) vs. control (N=30)	• Single home visit during hospitalization to assess home hazards and remove any with patient consent • Hospital social worker contacted to assess problems that were encountered	Physical medicine and rehabilitation doctor, ergotherapist and hospital social worker	Every month for 6 months, and at 12 months	Fall, hospital admission, LTC home admission, death	• No significant difference in recurring fall, number of recurring falls, LTC home admission or rehospitalization. • 40% controls rehospitalized, 23% cases. • May be a power problem because of small sample size

* IRR refers to incidence rate ratio; no., number; OT, occupational therapist; RCT, randomized controlled trial; RR, relative risk;
†Also identified in Cochrane review

Nutritional Supplementation: Summary of Evidence*

Study	Population	Intervention, dose	Follow-Up	Outcomes measured	Results
Gillespie: Cochrane Review (2003) (44)	• Elderly • RCTs • Community-dwelling	Vitamin D vs. control (2 studies)	Varied	Fallers, mean number of falls	Results from meta-analysis 1. Fallers: RR, 0.90 (0.71–1.13) 2. Mean falls: mean difference, 0.10 (−0.71 to 0.91)
Gillespie (2003): Cochrane Review	• Elderly • RCTs • Community-dwelling	Psychotropic medication withdrawal (1 study – Campbell 1999)	44 weeks	Fallers	1. Fallers: HR, 0.34 (0.16–0.74) 2. Note that one month after completion of study, 47% of medication withdrawal group had restarted taking psychotropic medication
Barr (2005) (172)	• Women • Aged 70+	• Intervention (screening + vitamin D/calcium) (N=726) vs. controls (N=1625) • In intervention group, screened for increased risk of hip fracture: broadband ultrasound attenuation (BUA) in lowest quartile of manufacturer normal range and/or presence of 2 or more clinical risk factors for hip fracture • Those with high risk were prescribed calcium and vitamin D supplement	1 to 3 years (median follow-up 28.9 months)	Fallers, number of people sustaining a fracture	1. Proportion of fallers in active group lower (25.3%) than in control group (29.7%), but not significant 2. Fracture: OR, 0.54 (0.33–0.87)
Bischoff (2006) (76)	• Aged 65+	• Intervention (vitamin D + calcium) (N=219) vs. placebo (N=226) • Intervention: cholecalciferol (vitamin D3; 700 IU/day) + calcium citrate malate (500 mg/day)	3 years	Faller (stratified by gender)	1. Total sample: OR, 0.77 (0.51–1.15) 2. Men: OR, 0.93 (0.50–1.72) 3. Women: OR, 0.54 (0.30–0.97)
Dhesi (2004) (173)	• Aged 65+ • At least 1 fall in last 8 weeks	• Intervention (N=70) vs. placebo (N=69) • Intervention included a single intramuscular injection of 600,000 IU of ergocalciferol (vitamin D) • Control: equivalent volume (2ml) of normal saline	6 months	Fallers, falls	1. No difference in mean number of falls (0.39 vs. 0.24, *P* = .28) 2. No difference in number of fallers (14 vs. 11, *P* = .52)
Dukas (2004) (174)	• Aged 70+	• Intervention (N=191) vs placebo (N=187) • Intervention received 1-µg capsules of alfacalcidol (vitamin D)	36 weeks	Fallers	1. Overall: OR, 0.69 (0.41–1.16) 2. Post-hoc subgroup of <512 mg and >512 mg daily calcium intake: <512 mg: OR, 1.00 (0.47–2.11) >512 mg: OR, 0.45 (0.21–0.97)

Greenspan (2005) (175)	• Women • Aged 65+	• HRT (N=187) vs. placebo (N=186) Intervention (HRT): • Women with hysterectomy given conjugated equine estrogen (0.625 mg/day) • Remaining women received conjugated equine estrogen 0.625 mg/day) and medroxyprogesterone (2.5 mg/day)	3 years	Falls	1. No difference in people who fell (50% intervention group vs. 51% in control), *P* = .92
Latham (2003) (176)	• Frail • Mean age 79	• Intervention (vitamin D) (N=108) vs. placebo (N=114) • Intervention: single oral dose of 6 1.25-mg calciferol (300,000 IU) or matching placebo tablets	6 months	Falls, time to first fall	Falls Outcome: • RR, 1.12 (0.79–1.59) Time to first fall: HR, 1.14 (0.80–1.62)
Porthouse (2005) (177)	• Women • Aged 70+ • At least one self-reported risk factor for fracture (low weight, previous fracture, maternal history of hip fracture, smoker, poor/fair health)	• Intervention (N=1321) vs. leaflet-only control (N=1993) • Intervention: nurse advice on reducing risk of fracture, 1000 mg calcium, 800 IU of vitamin D_3, leaflet • Control: leaflet only	Median follow-up 25 months	All fractures, hip fractures, falls, fear of falling	1. All fractures: OR, 1.01 (0.71–1.43) 2. Hip Fractures: OR, 0.75 (0.31–1.78) 3. Falls: OR, 0.98 (0.79–1.20)

* HR refers to hazard ratio; HRT, hormone replacement therapy; OR, odds ratio; RCT, randomized controlled trial; RR, relative risk.

Devices: Summary of Evidence*

Study	Device	Population	Intervention	Follow-Up	Outcomes Measured	Results
McKiernan (2005) (80)	Gait-stabilizing device (Yaktrax Walker®)	• Aged 65+ • Fall-prone people • Independently ambulatory	• Yaktrax Walker® (N=55) vs. usual winter footwear (N=54)	Winter 2003/2004: 10,724 observation-days	Number indoor and outdoor slip falls and injurious falls	• Footwear assignment did not influence indoor slip and fall rates All days: • outdoor slips: RR, 0.50 (P < .04) • outdoor falls: RR, 0.45 (P < .02) • non-serious injurious fall: RR, 0.10 (P < .02) Days walked on snow/ice: • outdoor slips: RR, 0.61 (P = .14) • outdoor falls: RR, 0.42 (P < .03) • non-serious injurious fall: RR, 0.13 (P < .02) • non-serious injurious fall: NNP, 6 outdoor fall: NNP, 3 outdoor slip: NNP, 1
Birks (2003) (82)	Hip protector (Safehip®)	• Aged 70+ • Had one previous hip fracture	• Intervention group given 3 pairs of hip protectors and general advice on fracture reduction (N=139) vs. controls who received advice (N=140)	Median follow-up 14 months	Number of second hip fractures, number falls, fear of falling, compliance	▪ Hip protector vs. control: OR, 3.5 (0.68–17.97) ▪ No difference in number of falls or fear of falling ▪ Low compliance (34%)

*RR refers to relative risk; NNP, number needed to prevent; OR, odds ratio

Multifactorial Interventions: Summary of Evidence*

Study	Population	Intervention	Follow-Up, Number Contacts During Follow-Up	Outcomes Measured	Results
Gillespie: Cochrane Review (2003) (44)	• Elderly • RCTs • Community-dwelling	○ Assessment plus multifactorial intervention – all elderly (n=4) ○ Assessment plus multifactorial intervention – high-risk populations/previous fallers (n=5)	Varied	Number fallers, number injurious falls, number fractures	All Elderly ▪ Fallers: RR, 0.73 (0.63–0.85) Injurious Fall: RR, 0.68 (0.51–0.93) High-risk Population ▪ Fallers: RR, 0.86 (0.76–0.98) Injurious Fall: RR, 0.93 (0.61–1.44)
Clemson (2004) (178)	• Aged 70+ • Fall in previous year or concern about falling	• Intervention (N=157) vs. control (N=153) Intervention: "Stepping On" • Small group learning environment • OT and content experts introduced areas of balance and strength exercises, coping with visual loss, regular visual screening, medication management, environmental and behavioral home safety, community safety.	• Seven 2-hour group sessions • One home visit by OT • 1 booster session 3 months after session 7 (1.5 h) • 14-month follow-up	Falls, falls efficacy scale (fear of falling), worry scale	• Significant reduction in all falls: RR, 0.69 (0.50–0.96) • Subgroup analyses showed effect in men (RR, 0.32, 95% CI, 0.17–0.59), persons aged ≥75 (RR, 0.62, 95% CI, 0.43–0.89), and persons with history of falls (RR, 0.66, 95% CI, 0.46–0.95)
Davison (2005) (179)	• Aged 65+ • Recruited at ED for fall or fall-related injury • Had 1 additional fall in preceding year	• Intervention (N=159) vs. control (N=154) • Hospital based medical assessment, home-based PT and OT assessment (medication, vision) • Assessment of carotid sinus hypersensitivity and vasovagal hypersensitivity • Gait and balance, assistive devices, environmental hazard assessment	• 1 year	Number of falls, number who fell, injury rates, hospital admission, mortality, fear of falling	• Falls: RR, 0.64, 95% CI, 0.46–0.90 • Fallers: RR, 0.95, 95% CI, 0.81–1.12 • Fracture: RR, 0.53, 95% CI, 0.20–1.39 • No difference in number of ED visits, hospital admissions due to fall, or mortality • Duration of hospital admission significantly less for intervention group: mean difference, 3.6 (0.1–7.6)

Huang (2005) (180)	• Aged 65+ • Hospitalized for hip fracture • Discharged to community	• Intervention (N=63) vs. control (N=59) • Intervention provided by master's-prepared gerontological nurse • First visit within 48 hours of admission • One home visit 3–7 days after discharge • Available by phone 7 days/week • Telephone contact 1/week • Brochures with information regarding medication and environment, nurse care and education, proper use of assistive devices, management of needed resources (including home care and assessment for rehabilitation facility)	• Hospital admission to 3 months after discharge	Length of initial hospital stay, rate of readmission to hospital, rate of repeat falls, rate of survival, QoL	• Hospitalized LOS (initial): significantly shorter (*P* = .002) • Time to next readmission shorter in intervention group (*P* = .02) • Survival time longer in intervention group (*P* = .04) • No difference in the number repeat falls • Mean QoL score significantly higher in intervention group (*P* < .05)
Lord (2005) (83)	• Aged 75+ • Stratified analysis by risk	• Extensive intervention (N=210) and minimal intervention (N=206) vs. control (N=204) Extensive Intervention Group (EIG): • Assessment, followed by counseling session where recommendations explained • Group exercises and individualized exercises, vision, peripheral sensation counseling Minimal intervention Group (MIG): • Provided with instruction sheets for home exercises, brief training sessions to teach exercises, list of group exercise programs near house, written advice on vision and precautions for loss of peripheral sensation Control group (CG): • No intervention	• 12 months	Falls, injurious falls	• No significant difference between EIG and CG and between MIG and CG EIG vs. CG • Fallers: RR, 1.03 (0.83–1.27) • Injuries: RR, 1.19 (0.92–1.54) MIG vs. CG • Fallers: RR, 1.08 (0.88–1.34) • Injuries: RR, 1.11 (0.85–1.46)
Mahoney (2007) (181)	• Aged 65+ • 2 falls in previous year, or 1 fall in previous 2 years with injury, or 1 fall in previous 2 years with gait or balance problems	• Intervention (N=174) vs. control (N=175) Controls: • home safety recommendations and advice to see doctor regarding falls Intervention • 2 home visits plus 11 monthly telephone calls • Link participants to existing medical care and service networks: e.g., home care, ophthalmology, podiatry • Could have included assessment of: medications, vision, balance and gait, cognition, mood, functional status, home hazard evaluation • Interventions include acquisition of assistive devices, exercise and medication review	• 1 year: 2 home visits followed by 11 monthly telephone calls	Accidental fall rate (denominator excluded any days in hospital or LTC home), all-cause hospitalization, LTC home admission, days in LTC home	• No significant difference in any outcomes for overall group: Falls: RR, 0.81 (0.57–1.17), *P* = .27 Hosp: RR, 1.05, *P* = .82) LTC: RR, 0.72 (0.38–1.35) Subgroup analyses • ≥2 falls in year prior: LTC admission rate: RR, 0.44 (0.21–0.91), *P* = .03 • 1 fall in year prior with gait or balance issues: hospitalization rate: RR, 4.02; *P* = .04 • 1 fall in year prior with injury: hospitalization rate: RR, 1.52; *P* = 0.30

Rubenstein (2007) (182)	• Aged 65+ • Veterans	• Intervention (N=380) vs. control (N=412) Phone assessment resulting in • Referral to geriatric assessment clinic (included physical exam, mental health, social and environmental status, and urinary incontinence evaluation and falls/gait impairment evaluation if necessary) • Home-based primary care program for homebound individuals • Primary care provider and other services • Individuals were followed up with after 1 month, and again every 3 months for next 3 years.	• 3 years • Phone contact every 3 months • Initial assessment requiring initial phone interview and sometimes geriatric assessment	Falls, UI, mental health, hospital and nursing home admission	• No significant differences in any target conditions between intervention and control groups at 1, 2, or 3 years follow-up • Hospital utilization didn't differ significantly between groups at 3 years' follow-up.
Tinetti (1994) (183)	• Aged 70+	• Targeted intervention based on measured risk factors (N=153) vs. control (N=148) • Interventions available include: behavioural recommendations for postural hypotension, medication review and withdrawal, environmental modifications, gait training, assistive devices, and exercise	• 1 year • Monthly contact for 6 months	Falls, serious injuries	• Adjusted incidence rate-ratio for falling: 0.69 (0.52–0.90)
Whitehead (2003) (93)	• Aged 65+ • Lived in community or low-care residential care (e.g., hostel) • Fall-related ED visit	• Intervention (N=70) vs. control (N=70) Intervention: • Fall risk profile determined from questionnaire • Potential interventions included medication review and withdrawal, environmental modifications, exercise, osteoporosis assessment	• 6 months • Monthly contact	Falls, uptake of interventions	• No significant reduction in fall incidence: OR, 1.7 (0.7–4.4) • 86% of intervention group had taken up a preventive strategy during follow-up compared with 48% of the control group
Sjosten (2007) (184) *In progress*	• Aged 65+ (stratified 65–74, 75+) • Fallen at least once in past year	• Intensive preventive programme (N=293) vs. counseling group (N=298) • Tailored intervention according to risk factors, functional abilities and health status	12 months	Fall incidence, injurious falls	• In progress
Elley (2007) (99) *In progress*	• Aged 75+ • Fallen in past year	• Intervention (≥155) vs. Control (≥157) Control Group: • Printed information on falls prevention and 2 social visits Intervention Group • Medical and home hazards assessment and referral • Otago exercise program for 1 year • 5 home visits	12 months	Fall incidence, self-efficacy (fear of falling) level of physical activity, ADLs	• In progress

Hendriks (2005) (185) *In progress*	• Aged 65+ • Visited hospital for fall	• Intervention (N=166) vs. control (N=167) • Examination by geriatrician, geriatric nurse and rehabilitation physician: comprehensive general examination, vision, mobility, balance, medication review • OT assesses home environment and recommends adaptations, assistive devices, home care and behavioural change	Maximum intervention of 3.5 months 1 year follow-up	Falls, recurrent falls (2 or more), injurious falls, QoL	• In progress (contacted and article has been submitted for publication)
Peeters (2007) (96) *In progress*	• Aged 65+ • Recently experienced a fall	• Intervention (N=100) vs. control (N=100) • Multifactorial risk assessment: general medical and drug history, fall and mobility history, physical examination, postural hypotension, visual impairment, parkinsonism, osteoporosis, gait disorders, psychotropic and cardiac drug use, environmental hazards • Treatment can consist of withdrawal of psychotropic drugs, balance and strength exercises (PT), home hazard reduction (OT), referral to ophthalmologist or cardiologist	12 months 2 home visits, with measurements taken at 3, 6, 9, and 12 months	Number of falls, time to first fall, QoL, ADLs	• In progress (follow-up completed in July 2008)

* ADLs refers to activities of daily living; CG, control group; CI, confidence interval; ED, emergency department; EIG, extensive intervention group; LTC, long-term care; LOS, length of stay; MIG, minimal intervention group; OR, odds ratio; OT, occupational therapist; PT, physical therapist; QoL, quality of life; RCT, randomized controlled trial; RR, relative risk; UI, urinary incontinence.

Appendix 4: Forest Plots

Figure 1: Evidence Surrounding the Risk of Falls After an Exercise Program

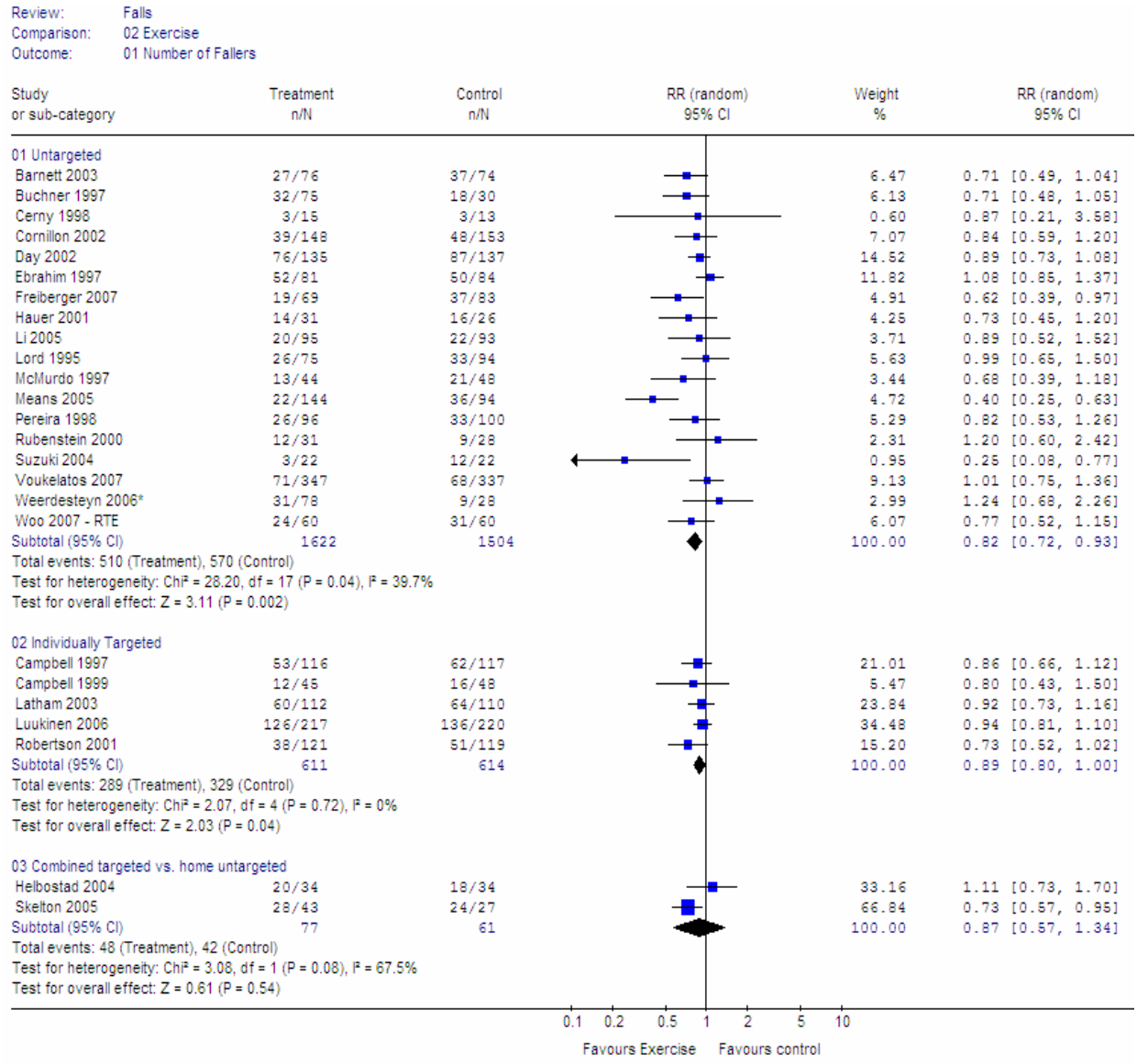


Figure 2: Evidence Surrounding the Risk of Falls After an Exercise Program: High-Risk Population

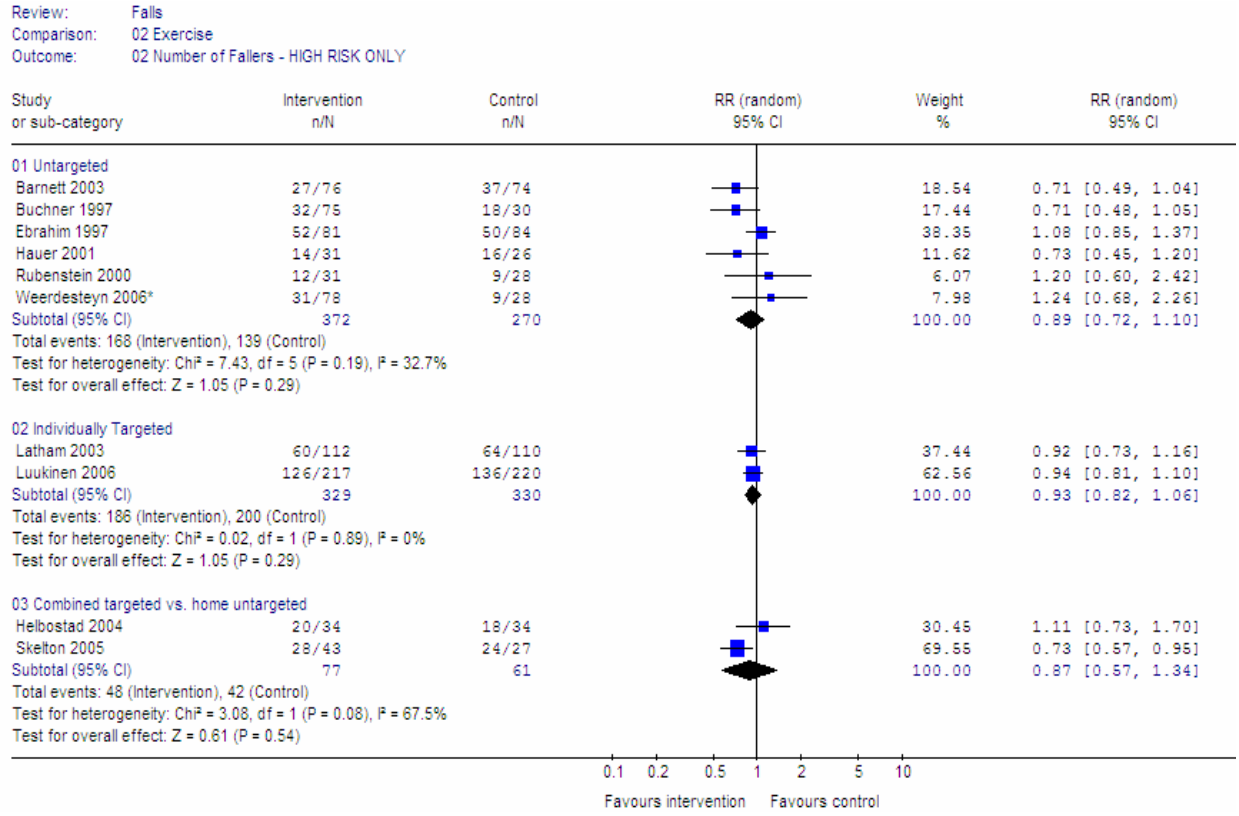


Figure 3: Evidence Surrounding the Risk of Falls After an Exercise Program: General Population

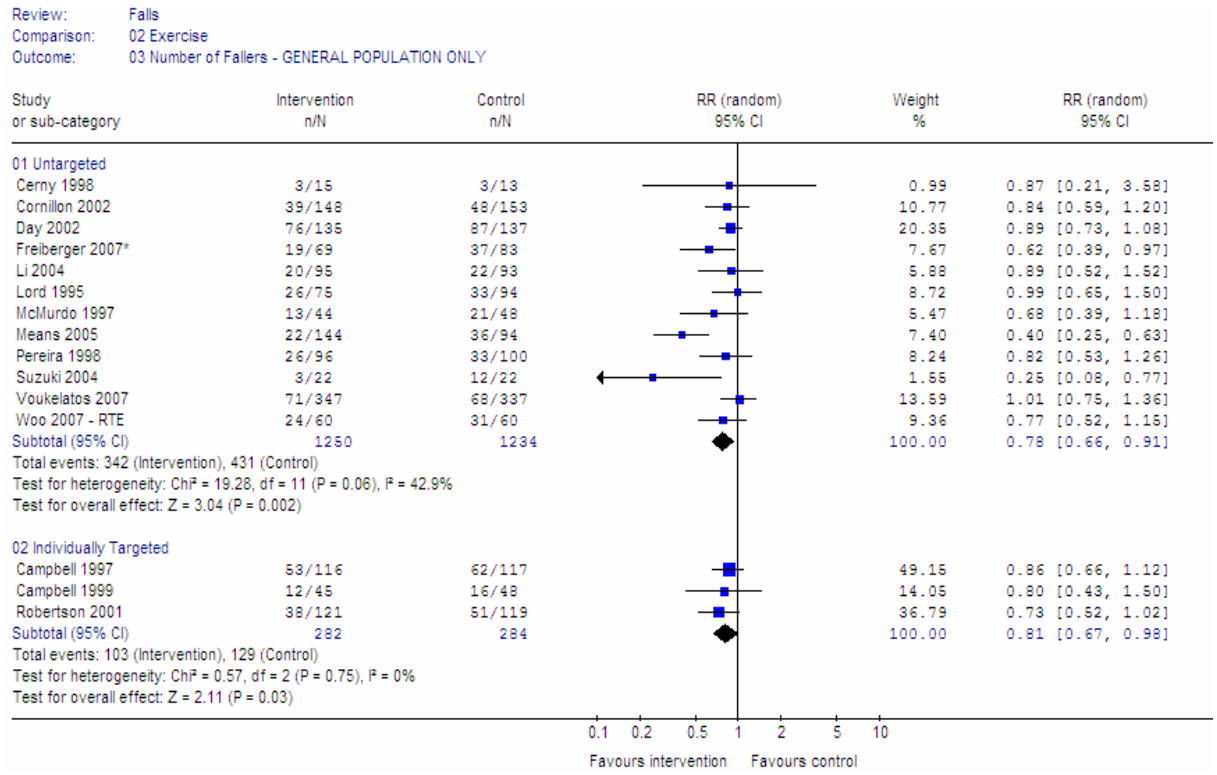


Figure 4: Evidence Surrounding the Risk of Fall-Related Injuries After an Exercise Program: General Population

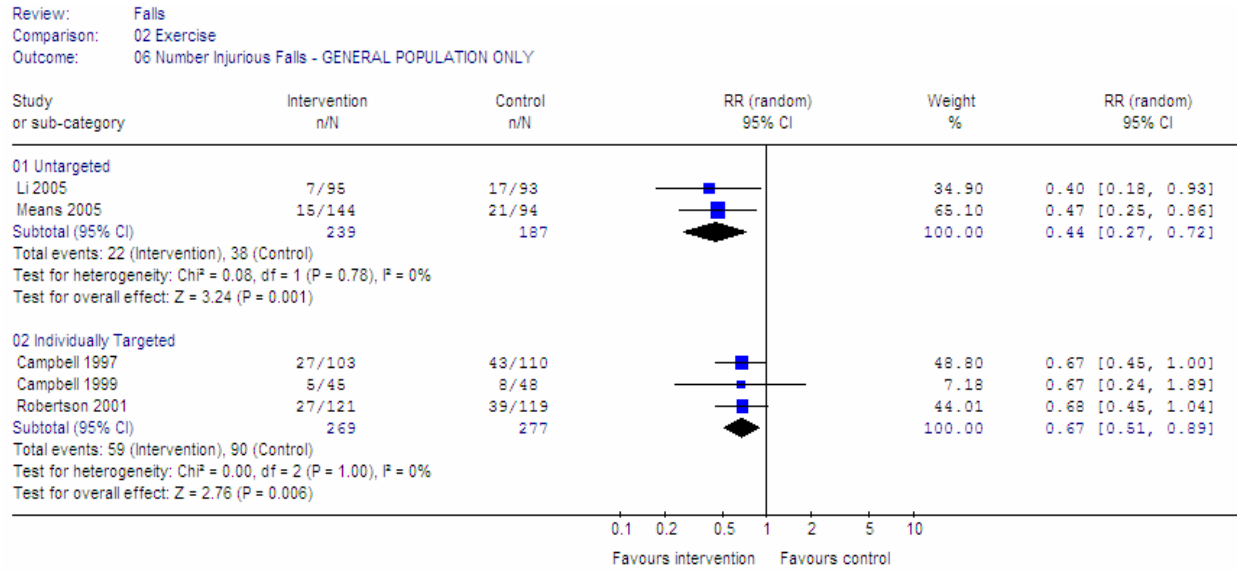


Figure 5: Evidence Surrounding the Risk of Falls After an Exercise Program: Short Intervention (<6 months)

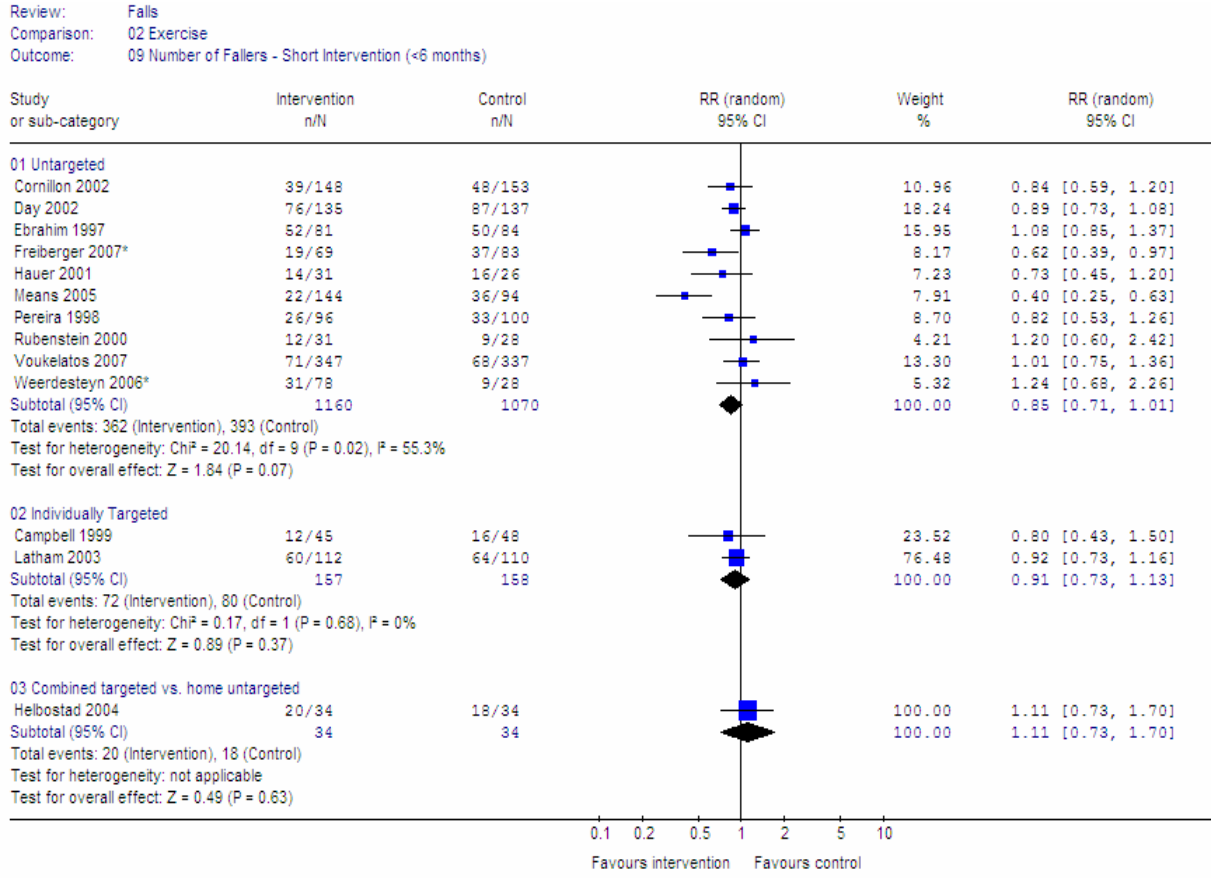


Figure 6: Evidence Surrounding the Risk of Falls After an Exercise Program: Long Intervention (≥6 months)

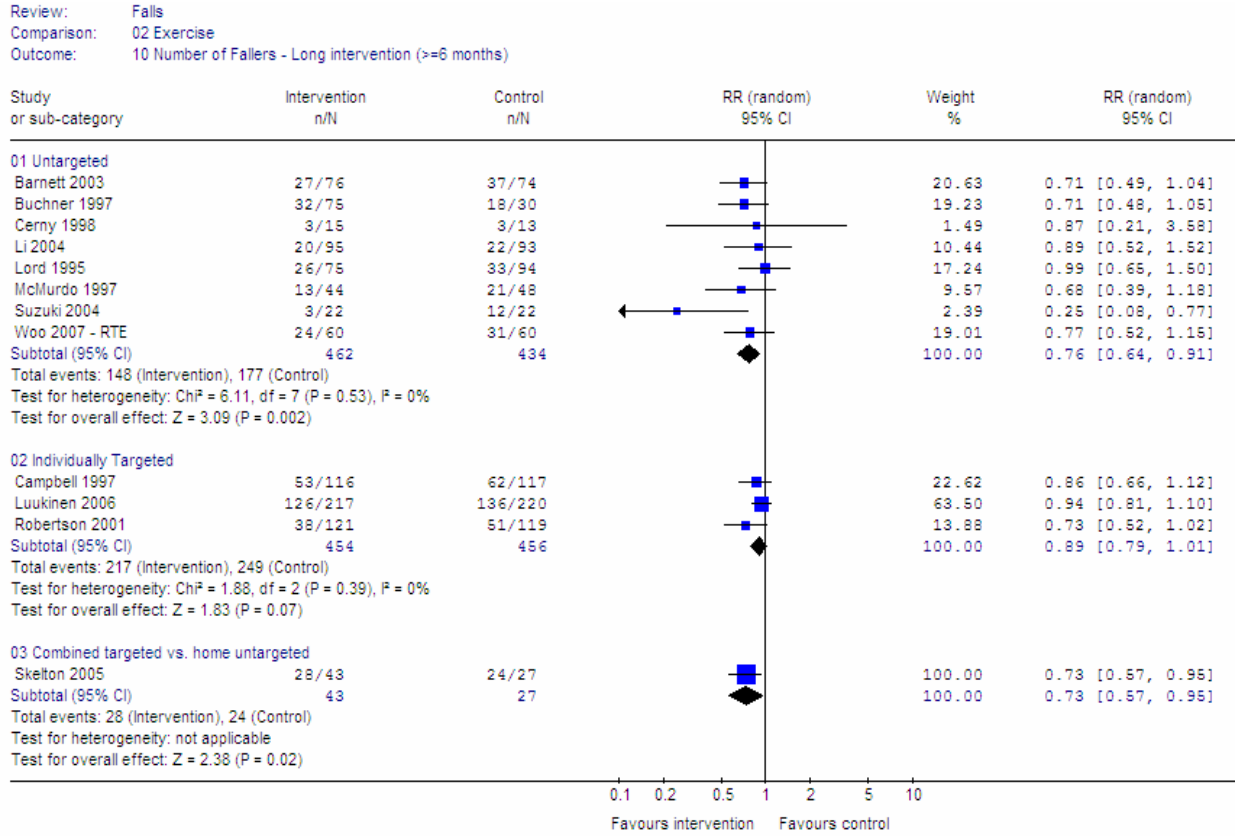


Figure 7: Evidence Surrounding the Risk of Fall-Related Injuries After an Exercise Program: Long Intervention (≥6 months)

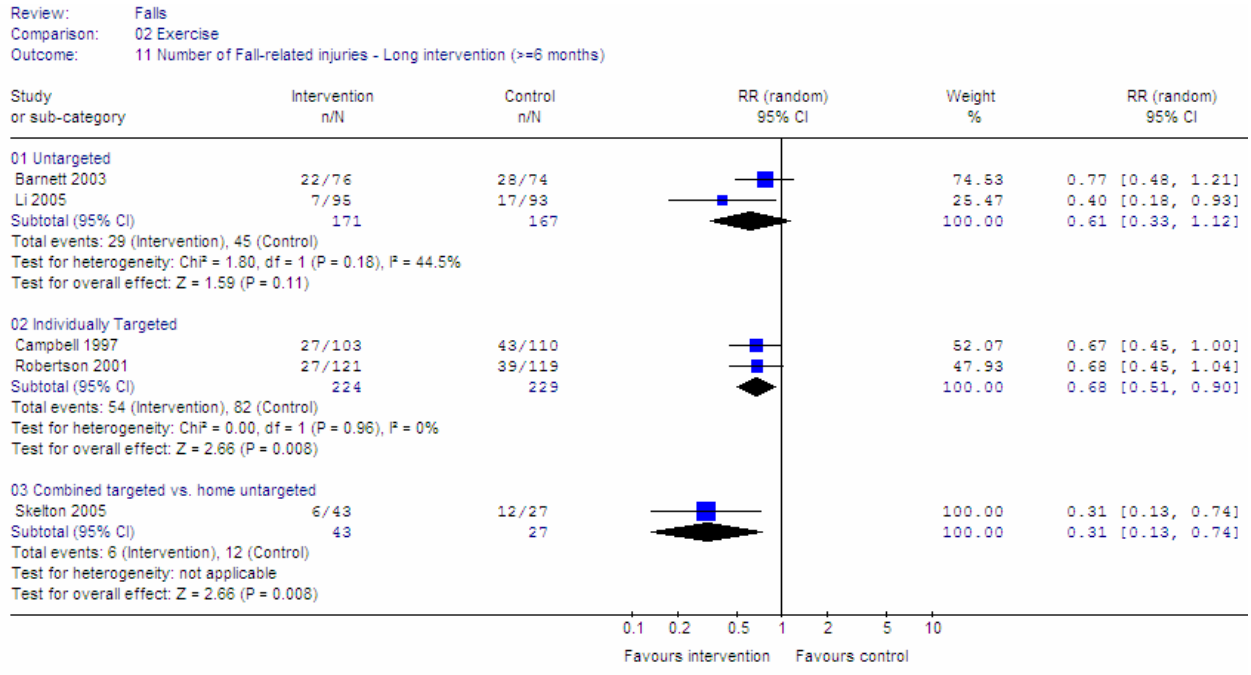


Figure 8: Evidence Surrounding the Risk of Falls After Vision Interventions

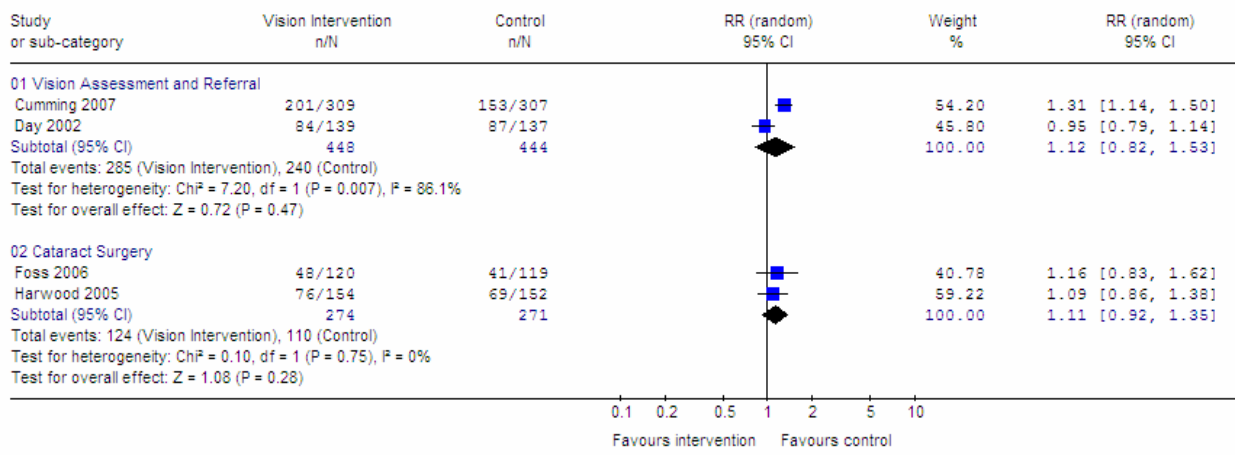


Figure 9: Evidence Surrounding the Risk of Falls After Environmental Modifications

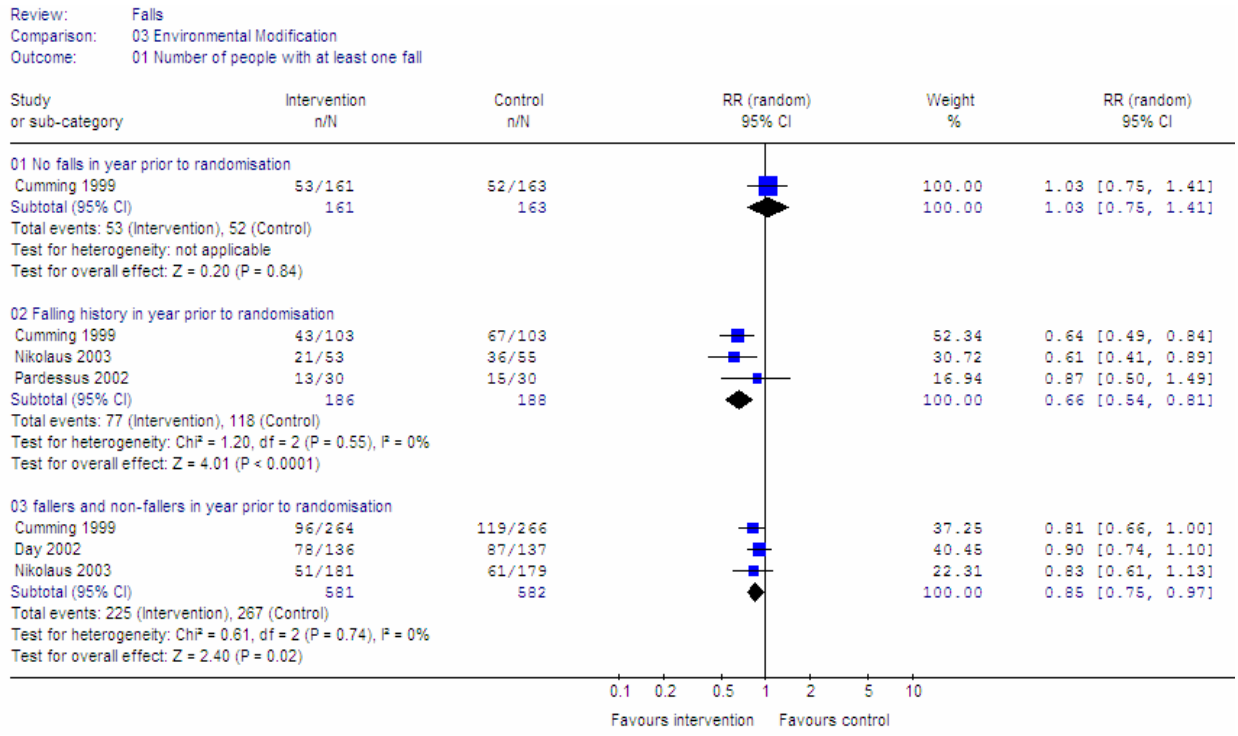


Figure 10: Evidence Surrounding the Risk of Falls After Vitamin D Supplementation

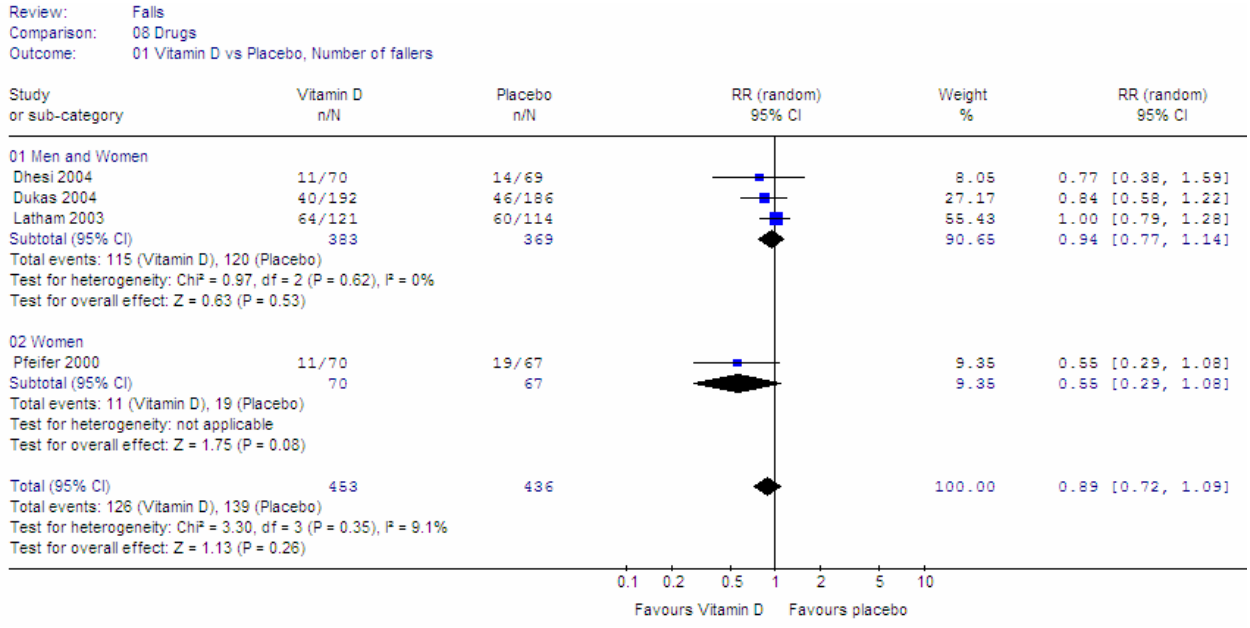


Figure 11: Evidence Surrounding the Risk of Falls After Vitamin D and Calcium Supplementation

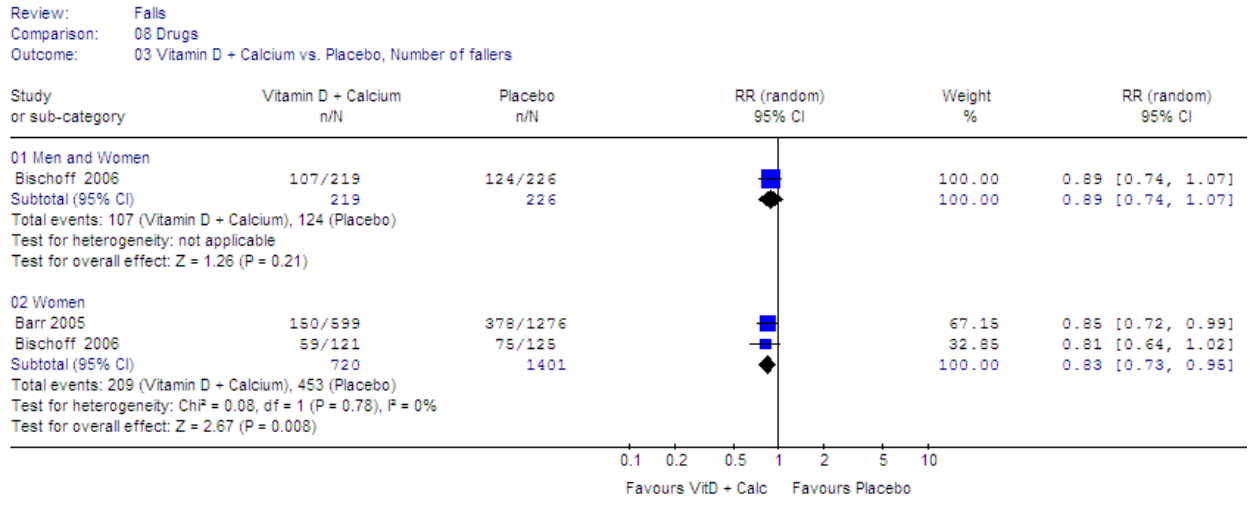


Figure 12: Evidence Surrounding the Risk of Fall-Related Fractures After Vitamin D and Calcium Supplementation

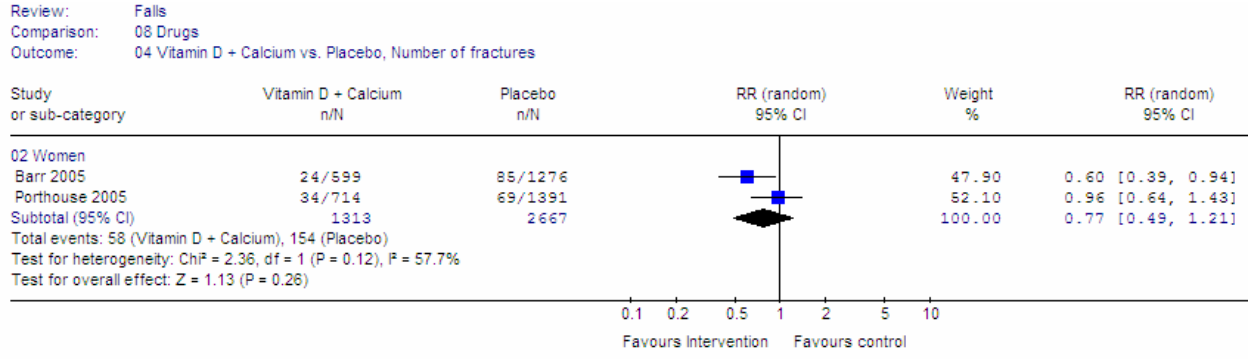


Figure 13: Evidence Surrounding the Risk of Falls After Hormone Replacement Therapy

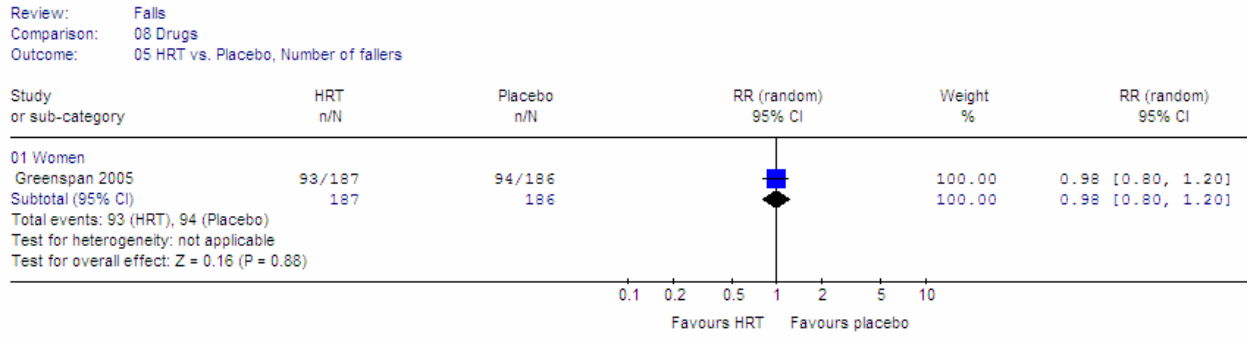


Figure 14: Evidence Surrounding the Risk of Falls After Multifactorial Interventions (Excluding Study by Whitehead et al. (93))

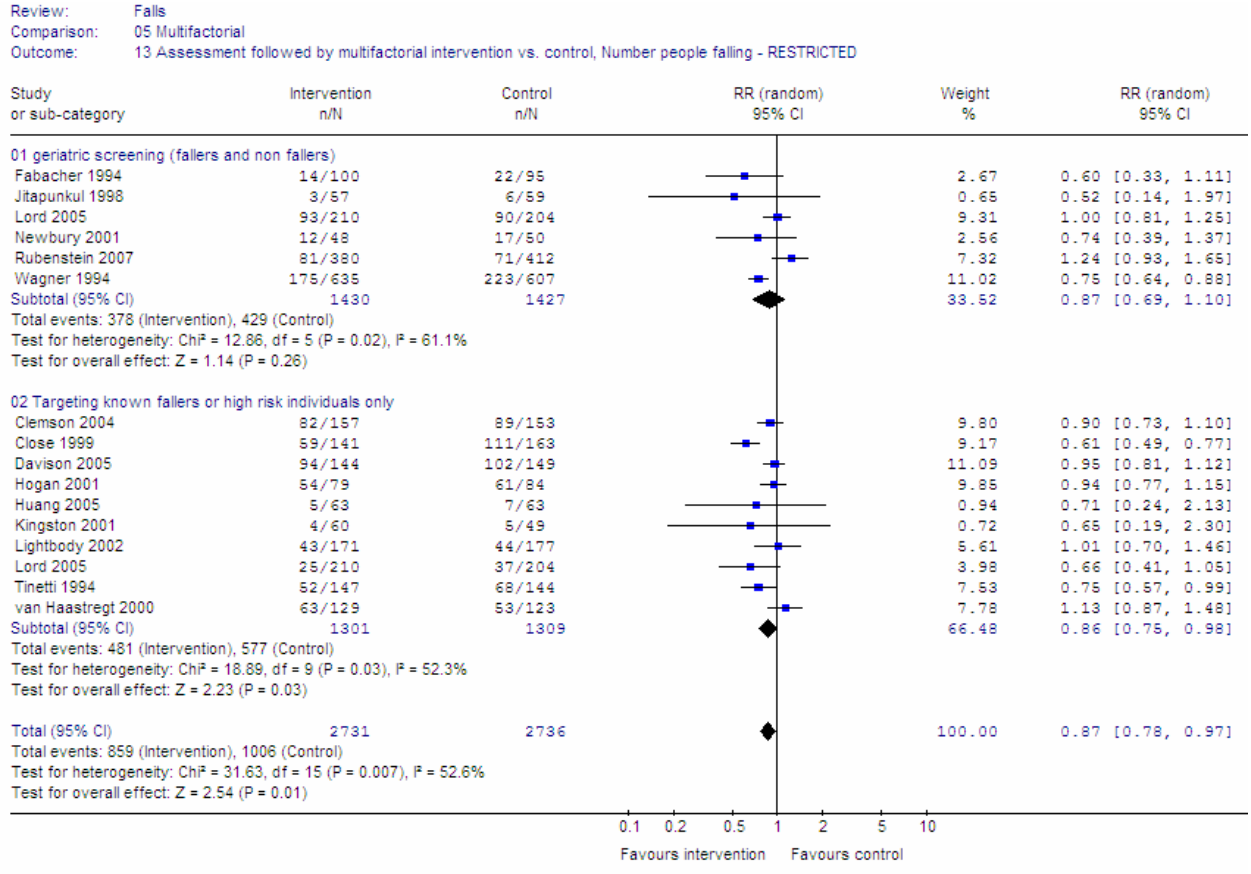
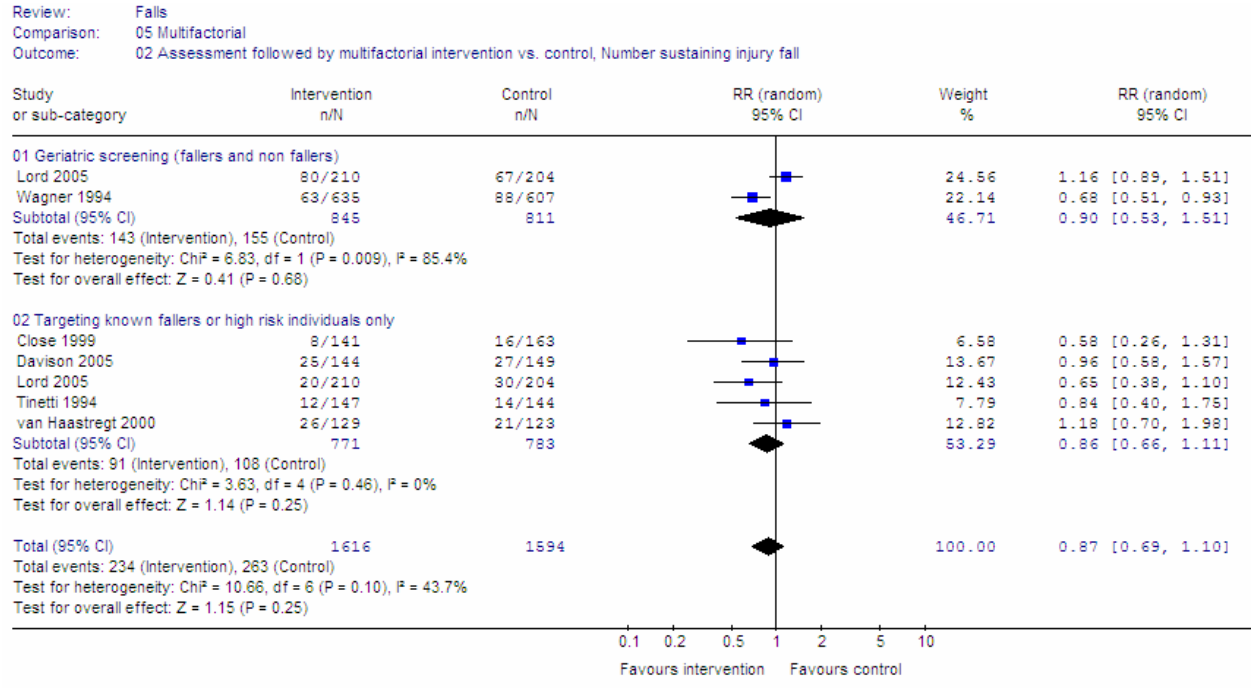


Figure 15: Evidence Surrounding the Risk of Fall-Related Injuries After Multifactorial Interventions



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(11) O'Loughlin JL, Robitaille Y, Boivin JF, Suissa S. Incidence of and risk factors for falls and injurious falls among the community-dwelling elderly. Am J Epidemiol 1993; 137(3):342-54.

(12) Close JC, Lord SL, Menz HB, Sherrington C. What is the role of falls? Best Pract Res Clin Rheumatol 2005; 19(6):913-35.

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