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A Systematic Review of Economic Evaluations of Fall Prevention Interventions for Community-Dwelling Older People

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ABSTRACT

The purpose of this article was to identify the best cost-effective fall prevention measures for 65-year-old and older community-dwelling older adults. Eligibility criteria included being 65 or older, residing in the community, experiencing primary or recurrent falls, and evaluating the cost-effectiveness of any fall prevention intervention. Web of Science, National Institute for Health and Care Excellence Compliance Database, Cinahl Plus, Ovid (Medline), PubMed, ProQuest, Wiley Online, National Health Services Economic Evaluation Databases, EBSCOhost, and PubMed databases were scanned for this study. The risk of bias in cost-effectiveness study reviews was assessed using the Consensus Health Economics Criteria checklist and the Review Manager software. Thus, twenty-two studies met the inclusion criteria (multifactorial program: 12, exercises program: 6, home assessment program: 3, vitamin D supplement: 1). Analyzing those research results, it was revealed that preventive interventions were cost-effective, cost-saving, or cost-beneficial in 17 of them. The Falls Rehabilitation Program, the Home Hazard Reduction Program, and the Community-Based Interventions Targeting Falls Prevention were identified as net cost savings in studies suggesting the assessment of treatments.

KEYWORDS: Fall Prevention; Older People; Community-Dwelling; Economic Evaluation; Systematic Review.

KEY PRACTITIONER MESSAGE

1. This study shows that fall prevention programs might lower and limit healthcare costs.
2. A limited number of interventions, such as home modifications, vitamin D supplementation, and Tai Chi were evaluated in many studies.
3. Further studies taking into account other interventions targeting exercise programs, medication compliance, cognitive behavioral therapy, podiatry intervention, and combinations of these programs might help decision-makers allocate the resources more efficiently.

INTRODUCTION

Falls are the second leading cause of injury deaths worldwide (World Health Organization, 2007). According to the data released by the World Health Organization (WHO), approximately one-third of the population aged 65 and over experience falls every year, and approximately half of them experience falls in the following year (Lim, 2010; World Health Organization, 2007). The high incidence, long-term effects, and costs of fatal injuries related to falls in each country constitute a significant burden for the health system and the social economy (Burns et al., 2016; Davis et al., 2010). Due to the increase in the aging population in the world, falls costs are expected to increase even further (Matchar et al., 2019). Although effective fall prevention programs are available, fall rates are still high among older people (Olij et al., 2018). The economic and social costs of falls are high in older people. Community-based fall prevention programs that are affordable and feasible should be implemented (Hoffman et al., 2016). The purpose of fall prevention programs is to improve health outcomes. However, cost-effectiveness is also critical (Isaranuwatchai et al., 2017).

Systematic reviews (SRs) can play a crucial role in assessing the cost-effectiveness of a healthcare intervention in creating an efficient healthcare system. In addition, the systematic review provides a clearer insight into the methodological aspects of such studies, their overall quality, and the issues related to the practical implementation of their results. The objective of this paper was to conduct a systematic review of the literature to identify and critically appraise economic evaluation studies on interventions/programs for fall prevention among community-dwelling older people.

METHOD

Protocol and Registration

The Systematic Reviews and Meta-Analysis standard for reporting systematic reviews (Preferred Reporting Items for Systematic Reviews and Meta-analyses -PRISMA) (Figure-1) guided this review (Moher et al., 2009) (Supplementary File-1). This review was registered with CRD42018110907 number of PROSPERO.

Search Strategy

Screenings were made according to the eligibility criteria. The following databases were used during the literature search process: Web of Science, National Institute for Health and Care Excellence Compliance Database, Cinahl Plus, Ovid (Medline), PubMed, ProQuest, Wiley Online, National Health Services Economic Evaluation Databases, EBSCOhost, PubMed (Search dates - from inception to September 10, 2018). The reference list of selected studies was screened for additional studies for critical appraisal. Keywords and subject headings/MeSH terms using

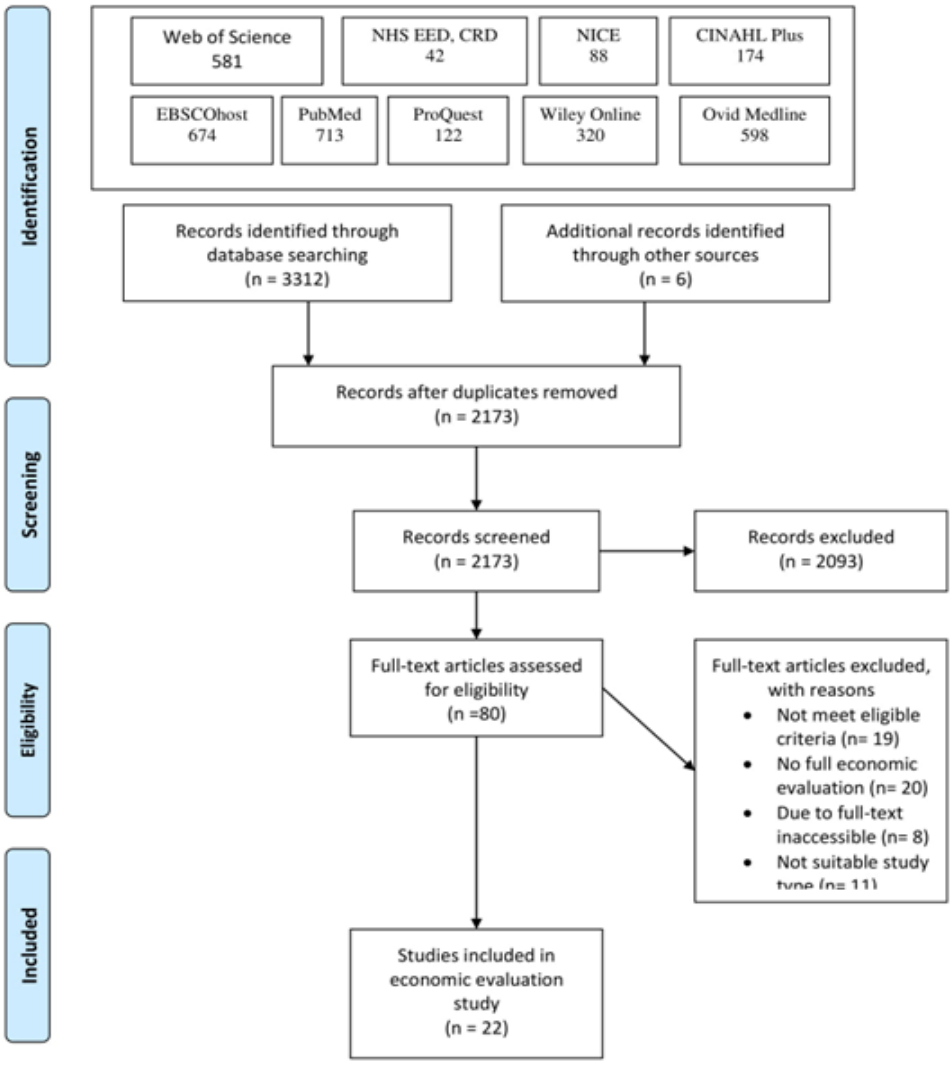

Figure-1. PRISMA Flow

BOOLEAN operators were searched in titles and abstracts using various combinations, including falls/faller, fall prevention/intervention, falls prevention, accidental falls, community-dwelling, elder, elderly, senior, older, aged, old, ICER, cost, cost-effectiveness, cost-benefit, cost-utility, cost-minimization analysis, cost and cost analysis, cost-consequences analysis. It can be examined from Prospero records how search terms are used according to databases. The first search was conducted in January 2017; it was repeated and finalized in September 2018 for updates of studies made after the initial search.

Study Selection

The protocol defined eligibility criteria a priori using the PICOS (Population, Intervention, Comparison, Outcomes, Study type) (Table-1). The full text of selected studies was retrieved and assessed in detail based on the inclusion criteria. The review included

Table-1. Eligibility Criteria (PICOS)

Population	Inclusion: Men and women aged 65 and over, older people with a primary/recurrent fall in the community (such as environment/home, street). Exclusion: Studies conducted only for women or men only, older people in nursing homes or hospital.
Intervention	Any intervention for the prevention of fall.
Comparison	Alternative forms of fall prevention intervention programs will be evaluated and compared with standard/usual care alone.
Outcome	Main Outcome: Incremental cost-effectiveness ratio (ICER) Additional outcome(s): Probability of cost-effectiveness, total costs, and total QALYs (or alternative measure of health benefit).
Study Type	Cost-Effectiveness Analysis, Cost-Benefit Analysis, Cost-Utility Analysis.

full economic evaluation studies such as Cost-Effectiveness Analysis (CEA), Cost-Benefit Analysis (CBA), and Cost-Utility Analysis (CUA). The studies must provide information on both costs and outcomes. In CEA studies, the effects of interventions and comparators are measured in the same outcome units. Costs are expressed in monetary terms such as dollars and euros. In the CBA, health care benefits are expressed by equal consumption. Both the costs and the results obtained measure impacts on health on a currency basis (Drummond et al., 2015). In the CUA, the effects of interventions and comparators are most commonly expressed and measured in Quality Adjusted Life Years (QALY) or Disability Adjusted Life Years (DALY) units (Gomersall et al., 2015; Munn et al., 2014; Ruger & Emmons, 2008; Thielen et al., 2016; van Mastrigt et al., 2016; Wijnen et al., 2016). In addition, these studies must compare the intervention to another intervention or control. Both trial-based economic evaluations (TBEEs) and model-based economic evaluations (MBEEs) were included in this study. The burden of illness studies and quality-of-life studies were excluded.

In studies, perspectives for the calculations (such as societal, national health service, and all-payer) and discount rates were assessed. After the first search round, full texts of the remaining articles were taken into account. In cases when the original articles' full text could not be located online, the authors were contacted through email and asked for the article's full text. Elimination of the full texts during the second round was conducted, and the reasons for exclusion were documented.

Data Extraction

There are two data extraction tables. The first data extraction table includes the following: authors, country, economic evaluation, analysis, perspective, and time horizon (Table-2). The second data extraction

Table-2. Main Characteristics of Economic Evaluations of Interventions/Programs for Prevention of Falls

ID	Reference	Country	Economic Evaluation	Analysis	Perspective	Time Horizon
1	Tinetti et al. (1994)	USA	TBEE	CEA	Medicare	Three months
2	Smith et al. (1998)	Australia	MBEE	CEA	-	1 year & 10 years
3	Salkeld et al. (2000)	Australia	MBEE	CEA	Societal	12 months
4	Beard et al. (2006)	Australia	MBEE	CBA	-	-
5	Hendriks et al. (2008)	Netherlands	TBEE	CEA, CUA	Societal	12 months
6	Day et al. (2010)	Australia	MBEE	CEA	-	26 weeks
7	Frick et al. (2010)	USA	MBEE	CEA, CUA	Healthcare system	Lifetime
8	Wu et al. (2010)	USA	TBEE	CEA	All-payer	12 months
9	Peeters et al. (2011)	Netherlands	TBEE	CEA, CUA	Societal	3, 6, and 12 months
10	Church et al. (2012)	Australia	MBEE	CEA, CUA	-	One year
11	Lee et al. (2013)	USA	MBEE	CEA, CUA	Societal	-
12	van Haastregt et al. (2013)	Netherlands	TBEE	CEA	Societal	14 months
13	Carande-Kulis et al. (2015)	USA	TBEE	CBA	A third-party payer	One year and 14 months
14	Farag et al. (2015)	Australia	MBEE	CEA, CUA	Health funder	Five years
15	McLean et al. (2015)	Australia	MBEE	CEA, CUA	Healthcare system	18 months
16	Li et al. (2016)	USA	TBEE	CEA	-	Six months
17	Polinder et al. (2016)	Netherlands	TBEE	CUA	-	12 months
18	Cockayne et al. (2017a)	England and Ireland	TBEE	CEA	NHS and societal	12 months
19	Cockayne et al. (2017b)	England and Ireland	TBEE	CEA	NHS and societal	12 months
20	Isaranuwatchai et al. (2017)	Canada	TBEE	CEA, CBA	Societal	6 months
21	Wilson et al. (2017)	New Zealand	MBEE	CEA, CBA	Health system	-
22	Corbacho et al. (2018)	England and Ireland	TBEE	CEA, CUA	NHS and personal social services	12 months

Note: USA: United States of America, MBEE: Model-Based Economic Evaluation, TBEE: Trial-Based Economic Evaluation, CEA: Cost-Effectiveness Analysis, CUA: Cost-Utility Analysis, CBA: Cost-Benefit Analysis, NHS: National Health Service

table includes the following: intervention, comparator, discount rates, reporting of cost, outcome measurement, Incremental cost-effectiveness ratio (ICER), and health economic result.

Quality Assessment

The Consensus Health Economic Criteria (CHEC) list was used for the quality identification of both the TBEE and MBEE studies included in the search (Evers et al., 2005). Each question in the CHEC list was scored as "Yes" (1), "No" (0), "NA" (not applicable), or "indefinite" (no scoring). The "indefinite" option is only used when the information in an item is not completely clear. Studies scoring more than 14 (>75%) were graded as high quality, studies scoring between 10 and 14 (50-75%) were graded as moderate, and those with scores below 10 (<%50) were graded as poor quality (Hamberg-van Reenen et al., 2012; Winser et al., 2019).

Using Mendeley, the two researchers (MY, GAK) studied blinded and independently at each stage (search strategy, study selection, data extraction, and quality assessment). In cases where between-researcher disagreements could not be resolved by discussion to achieve consensus, a third reviewer (MKS) arbitrated.

Outcomes

Incremental costs, cumulative effects, and incremental cost-effectiveness ratio (ICER) were extracted from each research. Under the Consolidated Health Economic Evaluation Reporting Standards (CHEERS), the healthcare and societal viewpoints for calculations were examined (Husereau et al., 2013). Due to heterogeneity in outcome parameters, a meta-analysis could not be conducted.

The threshold value for cost-effectiveness is a tool that indicates how much a country or organization is willing to invest per additional QALY gained. The threshold value varies from one country to another depending on the assumptions and methods used. Cost-effectiveness thresholds commonly used in some countries are reported as 50,000 USD in the USA, 80,000 Euro in the Netherlands, and £ 20,000 / QALY in the UK, and these values are constantly updated (Cameron et al., 2018). In countries where the threshold is not formally stated, the World Health Organization considers it cost-effective if it is up to 3 times the gross national product per capita. If an intervention was below the threshold values, it was considered cost-effective (Health Committee of the UK Parliament, 2012). All monetary values were given in the currencies presented in the article or USD-Euros.

Risk of Bias Assessment

The risk of bias in reviews of cost-effectiveness studies was evaluated using the Consensus Health Economics Criteria (CHEC) checklist and the Review Manager software (Evers et al., 2005).

RESULTS

Study Selection and Characteristics

The results of the systematic study were presented in the PRISMA Flow Diagram (Figure-1). Twenty-two studies were identified as full-text papers. These studies were published between 1994 and 2018. The majority of the studies (17 out of 22) were published in or after 2010. The studies were conducted with samples in developed countries (Table-2). The economic evaluation methods, time horizon, and perspectives used in the studies are shown in Table-2. In 10 of the studies included in the study (Study S2, S3, S4, S6, S8, S11, S13, S15, S16, S21), an economic evaluation of a single fall prevention intervention was performed. In the remaining 12 studies, multiple interventions were evaluated. Supplementary File-2 provides information about the characteristics of these studies, details about interventions, and economic evaluation methods used for these interventions. Five out of 22 studies compared the interventions with a control group (S1, S6, S14, S18, S19), ten compared with usual care (S3, S4, S5, S7, S9, S12, S15, S17, S20, S22), and seven had status quo or no intervention group.

The authors of the studies used many different cost classification approaches. Of these cost classification approaches, the most commonly used ones are outcome measures of the cost of hospital admission (S4, S7, S9, S10, S15, S17, S18, S19, S21, S22) and the number of falls prevented (S3, S5, S12, S16, S20) followed by per fall prevented (S1, S2, S6, S7), per injury prevented (S2, S11) and cost per participation (S13, S14).

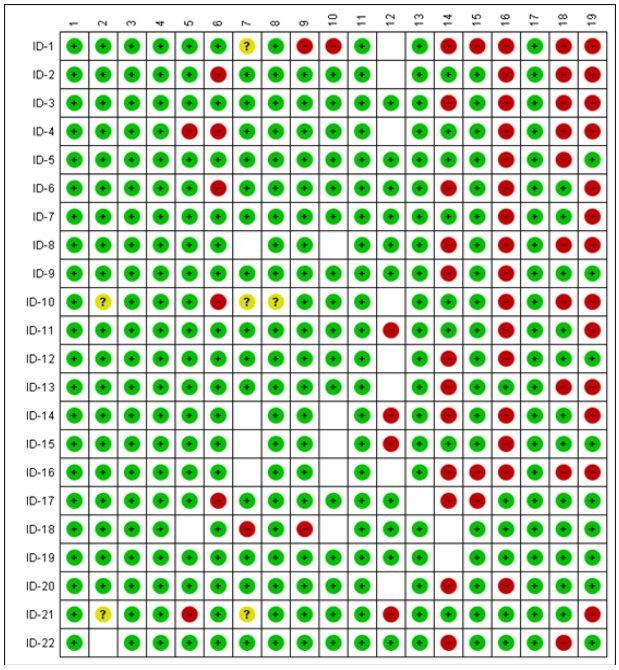

Figure-2. The Methodological Quality of The Studies

Risk of Bias Within Studies

The CHEC list details the scoring instructions in the supplementary files (Supplementary File-3). The methodological quality of the studies was investigated in the Revman program, and the risk of bias was given in Figure-2 and Figure-3. None of the included studies met all the CHEC criteria. Four items (S14, S16, S18, and S19) received the lowest scores. Item 16, "the conclusions followed from the data reported," was not included in most articles. The other items with the lowest scores were "discounting issue" (item 14), "generalizability of the results and

other groups" (item 18), and "ethical and distributional issues" (item 19). Four items received full scores (1, 3, 4, 11) (Figure-3). According to the analysis of the results of the study, prevention interventions were cost-effective, cost-saving, or had a positive net monetary benefit in 17 studies (S1, S2, S3, S4, S6, S7, S8, S10, S11, S12, S14, S15, S16, S18, S19, S21, S22).

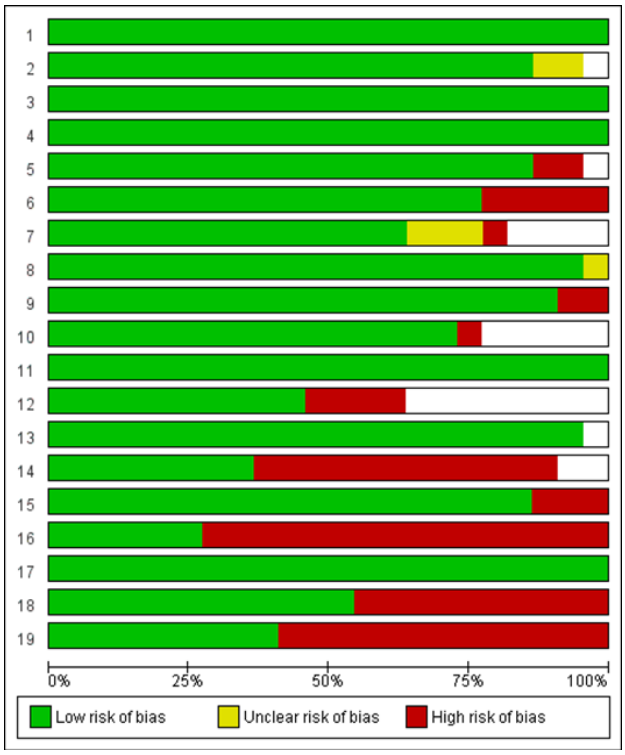

Figure-3. Risk of Bias

Results of Individual Studies

The interventions in the systematic review were grouped into separate titles and examined. In the last part, interventions were evaluated through outcomes.

Exercise Programs

The community-based *"Stay on Your Feet"* program aimed to prevent falls among old individuals was reported as highly cost-effective (S4). Group-based Tai-Chi program modeling study reported limited effectiveness on the population; however, if the cost per participant could be substantially reduced and covered by the individual out-of-pocket expenditure, it might be cost-saving. (S6). The "No Falls Exercise Program" (S15) was cost-effective for women. Tai Ji Quan: Moving for Better Balance (TJQMBB) Program (S16) was cost-effective per fall prevented.

Home Assessment Programs

The home hazard reduction program, which was applied to individuals who experienced falls in the previous year, was cost-saving (S3). Home Safety Assessment and Modification (HSAM) program targeted people aged 65+ or 75+ with a history of previous injurious falls and was estimated to be cost-effective (ICERs: NZ$700 and NZ$832, respectively) and lower confidence intervals for ICERs were cost-saving (S21).

Multifactorial Programs

Multifactorial interventions (S1) implemented by the nurse and physiotherapist have found net cost savings. A study examined fall prevention programs in seven groups (S7). The cost of Vitamin D supplementation was less than the home modifications; home modifications were more costly and more effective, with an ICER of $14,794/QALY. A study comparing multiple interventions for the general population (S10) determined Tai Chi as the most cost-effective

intervention. While the multicomponent cognitive behavioral group intervention (S12) significantly reduced the fear of falling, it increased costs slightly. The Public Health program, implemented in Australia, was costlier and more effective, with an ICER of $A28 (S14). The multifaceted podiatry intervention was cost-effective for fall prevention, with an incremental cost per QALY ranging between £19,494 and £20,593 (S18). A multifaceted podiatry intervention was more costly and more beneficial in terms of health-related quality of life years gained (S19). The benefits of the Multifaceted Podiatry Intervention were cost-effective, and the probability for CE was 65% for the NICE willingness to pay threshold, which is GBP 30000 (S22). Some programs (Interdisciplinary intervention program, multifactorial transmural intervention, Fall Risk Increasing Drugs (FRIDs) assessment combined with FRIDs-withdrawal or modification, plus monthly in-home visits) were not regarded as cost-effective (S5, S9, S17, S20).

Outcomes

Comparing studies with different types of interventions on different target populations for the cost-effectiveness of fall prevention strategies is not easy. Most studies provided mean values and estimated an incremental cost-effectiveness ratio (ICER). It is calculated by dividing the difference in costs of two programs by differences in effects such as QALYs. In nine studies (CUA studies), QALY results were provided. According to research conducted in the USA, the cost for falls prevented ranged between USD 850-1947(S1, S8, S16), ICER was reported in 2 studies, and the cost of Vitamin D supplementation per QALY gained was 8758 USD (S11), and it was cost-saving in another study (S7). ICER for home modification compared to Vitamin D supplementation was USD 14,794, which was cost-effective. Four studies were conducted in the Netherlands, and two randomized controlled trials, in which multidisciplinary fall prevention programs were applied. The ICERs were not cost-effective as the interventions yielded a higher cost and lower effectiveness when compared with usual care (S5, S9). Improving medication prescription resulted in lower costs and higher effectiveness with an ICER: of EUR 2400 (S17). The study, aimed to reduce the fear of falling, provided an ICER: of EUR 1070. These values are lower than the Dutch cost-effectiveness threshold (EUR 80.000). The randomized controlled trial of multifaceted podiatry intervention with a duration of 12 months conducted in England and Ireland had ICER values ranging between 19.494 and 20.593 pounds and were below the national cost-effectiveness threshold (S18, S19, S22). According to research conducted in Australia, the cost of falls prevented ranged between Australian Dollars 1721 and 4986 (S2, S3, S6). According to research, conducted in Australia, the cost of falls

prevented ranged between Australian Dollars 1721 and 4986 (S2, S3, S6). According to research, Home Assessment Programs were considered cost-saving (S2, S3).

DISCUSSION

In this systematic review of twenty-two studies, we present information on current economic assessments of fall prevention treatments for community-dwelling persons aged 65 and older in this vital public health sector. These findings clearly suggest the need for a study assessing the costs of fall prevention initiatives, particularly in industrialized nations. Conducting model-based research to measure the impact of fall prevention interventions on quality of life will also contribute substantially to the existing body of knowledge.

According to the results of the 17 studies, prevention interventions were cost-effective, cost-saving, or had a positive cost-benefit (S1, S2, S3, S4, S6, S7, S8, S10, S11, S12, S14, S15, S16, S18, S19, S21, S22). In two studies (S5, S9), interventions were less effective and more costly; they were not cost-effective in this respect. In a study conducted in Canada, the fall prevention program in the whole community was not cost-profitable; however, the intervention was considered acceptable if the willingness to pay a fall (WTP) in the 75-84 age group was C$ 25000 or C$5000 in those aged ≥85 years. In a systematic review investigating the economic evaluation of WTP for fall prevention programs in older people over 60 years of age receiving community or residential care (Olij et al., 2018), home assessment and medication adjustment programs had the most favorable results due to lower ICER values. According to a review published in 2010, the medication adjustment program, Vitamin D supplementation, and cataract surgery were reported as cost-effective (Davis et al., 2010).

In almost one-third of the studies, the assessment was made from the perspective of the payer/health care provider (S2, S4, S6, S10, S16, S17), whereas in seven of the studies, evaluation was made from a societal perspective (S3, S5, S9, S11, S12, S18, S19, S20). However, there are also studies in which the perspective was not clearly defined. It is recommended that studies from all perspectives be performed to guide decision-makers.

In more than half of the studies, the time horizon was between 1 and 5 years. There were few studies in which the time horizon was less than one year. In some studies, the time horizon was not reported. Physical and psychological disabilities due to aging will increase health problems, increasing risks for falls in older people and incurring high health care costs. Given this situation, conducting studies with a longer time horizon would be valuable in identifying costs covering advanced ages.

While eight studies reported a discounting rate ranging between 3% and 8%, some studies did not report any discounting rate. In the studies, the authors used various cost classification approaches. Of them, the most commonly used ones were outcome measures of the cost of hospital admission (S4, S7, S9, S10, S15, S17, S18, S19, S21, S22) and several falls prevented (S3, S5, S12, S16, S20) followed by per fall prevented (S1, S2, S6, S7), per injury prevented (S2, S11) and cost per participation (S13, S14).

The methodological quality of the studies was assessed using a validated checklist for the methodological quality assessment of economic evaluations named the CHEC-list (Evers et al., 2005); according to the CHEC list scores of the studies, the risk of bias was low in five studies and high (≥50%) in four studies. According to the CHEC list scores, fourteen studies had high quality (S3, S5, S6, S7, S9, S11, S12, S13, S15, S17, S19, S20, S21, S22), six studies (S2, S4, S8, S10, S14, S18) had moderate quality and two studies (S1, S16) had low quality.

Multifactorial interventions performed by various multidisciplinary team members, the Falls Rehabilitation Program, Home Hazard Reduction Program, and Community-Based Interventions Targeting Falls Prevention, were determined to be net cost saving. In the other study (S2) in which the two-stage intervention (home hazard diagnosis and fall prevention devices presentation) was implemented, the intervention was considered dominant in terms of both cost per fall and cost per injury prevented. Vitamin D supplementation was less costly and less effective compared to home modifications. Both universal supplementation and population screening for vitamin D deficiency among older people, women, and men were cost-effective from a societal perspective. All three fall interventions (The Otago Exercise Program, Tai Chi: Moving for Better Balance, Stepping On) provided positive net monetary benefits (S13). Tai-chi, No Falls Exercise Program, Tai Ji Quan: Moving for Better Balance Program, and multifaceted podiatry intervention were reported as cost-effective. Home Safety Assessment and Modification (HSAM) only for people age 65+ or 75+ with previous injurious falls was estimated to be particularly cost-effective (ICERs: $700 and $832, respectively), with the latter intervention being cost-saving (S21).

LIMITATIONS

There are also several limitations to be noted regarding this review. We did not include the studies published other than in the English language, which limited the number of research evaluated in this study; however, we believe that this problem is limited as the majority of the health economics research on this topic was conducted in English-speaking countries.

We had difficulties comparing the study findings as they used different health economic evaluation methodologies and outcome measures. Variations in currencies, inflation rates, discount rates, and the time horizon of the studies made it more difficult to combine the results. The provision of health services for older people might show the difference between countries, limiting the generalizability of the findings. However, we tried to solve this issue by subgrouping the same countries, such as the USA, the Netherlands, and Australia, and comparing within-country cost-effectiveness results.

CONCLUSION

This systematic review indicates that most fall prevention programs were cost-effective, cost-saving, or cost-beneficial. Most of the studies were conducted in developed countries; hence, data is needed from developing countries that experience epidemiological transition with an aging population. Variations in the economic evaluation methods and the differences in the overall quality of the studies limited the comparability and generalizability of the results. This problem can be solved by conducting studies and presenting the findings under health economics guidelines (Husereau et al., 2013). Clearly, fall prevention initiatives might reduce healthcare expenditures.Many studies evaluated a limited number of interventions, such as home modifications, vitamin D supplementation, and Tai-Chi; thus, further studies examining other interventions targeting exercise programs, medication compliance, cognitive behavioral therapy, podiatry intervention, and combinations of these programs might help decision-makers for allocating the resources more effectively.

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Supplementary File-1. Prisma 2009 Checklist

Section/Topic	#	Checklist Item	Reported on Page #
Title			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
Abstract			
Structured Summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	1
Introduction			
Rationale	3	Describe the rationale for the review in the context of what is already known.	2-3
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	2-3
Methods			
Protocol and Registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information, including registration number.	3
Eligibility Criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	4
Information Sources	7	Describe all information sources (e.g., databases with coverage dates, contact with study authors to identify additional studies) in the search, and the date last searched.	3
Search	8	Present a full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	3
Study Selection	9	State the process for selecting studies (i.e., screening, eligibility, included in a systematic review, and, if applicable, included in the meta-analysis).	4
Data Collection Process	10	Describe a data extraction method from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming investigator data.	5
Data Items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	4
Risk of Bias in Individual Studies	12	Describe methods used for assessing the risk of bias in individual studies (including specification of whether this was done at the study or outcome level) and how this information will be used in any data synthesis.	6
Summary Measures	13	State the principal summary measures (e.g., risk ratio, the difference in means).	-
Synthesis of Results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	-

Supplementary File-2. Main Characteristics of Economic Evaluations of Interventions

ID	Ref	Intervention	Comparator	Discount Rates	Reporting of Cost	Outcome Measurement	ICER	Health Economic Result
1	Tinetti et al., 1994	A multifactorial intervention By a nurse and physical therapist	Control group	-	Dollars, USA	Per fall prevented	The cost of preventing one fall that required medical care was $12,392. The cost per fall prevented was $1,947.	A complete analysis of total and fall-related healthcare costs may show that the intervention results in net cost savings.
2	Smith and Widiatmoko, 1998	The intervention has two stages. (First: assessment of home hazards and appropriate suggestions. Second, provide fall-prevention devices for those identified with such home hazards).	No intervention	5 %	1996 Australian dollars	- cost per fall prevented - cost per injury prevented	The incremental cost per fall prevented is $1,720.80. The incremental cost per injury prevented is $17,208 Over one year of ICER, the intervention was $172 per person per fall, which prevented $1,721, cost per injury, and $1 7,208. Over ten years: cost saving of $92 per person	The intervention is dominant.
3	Salkeld et al., 2000	Home hazard reduction program	Usual care	-	1997 prices Australia	-number of falls prevented -SF 36	For all subjects, the average cost per fall prevented is $4,986. For falls in the last year, the average cost per fall prevented is $3,980.	The program was cost-saving for subjects who had fallen in the 12 months prior to randomization
4	Beard et al., 2006	Stay on Your Feet (SOYF)	Usual care	8%	1995/96 Australian dollars	- the cost of hospital admissions		Well-designed community-based interventions targeting fall prevention among older people are highly cost-effective.
5	Hendriks et al., 2008	Interdisciplinary intervention program	Usual care	4%	Dutch manual	-number of people sustaining a fall during one year of follow-up -QALYs -the Dutch version of the EuroQol (EQ-5D)	27 % of the ICERs were in the dominant quadrant (representing the probability of the intervention having more effective and lower costs compared with usual care)	The multidisciplinary intervention program to prevent falls was not cost-effective compared with usual care. According to probabilistic sensitivity analysis, only 27 percent of the ICERs were on the dominant quadrant.
6	Day et al., 2010	Group-based tai-chi	Control group	-	2009 Australian dollars	-Total falls -fall-related hospitalization	This equates to $A4414 and $A220 712 per fall, and fall-related hospital admission prevented, respectively.	Tai-chi programs may present good value for falls- prevention resources if the cost per participant can be substantially reduced compared to treatment cost estimates
7	Frick et al., 2010	Fall-prevention interventions are into seven groups: medical management (withdrawal) of psychotropics, group tai chi, vitamin D supplementation, muscle and balance exercises, home modifications, multifactorial individualized programs for all older people, and multifactorial individualized treatments for high-risk frail elderly people	Usual care	3%	Medical care inflation 1998 to 2007 General economic inflation rate before 1998	-Prevention of falls -QALYs	ICER for vitamin D supplementation and home modifications is $14,794 Medical management of psychotropics and group tai chi was the least-costly, most-effective option. Excluding these interventions, the least-expensive, most-effective options are vitamin D supplementation and home modifications. ICER for home modifications was $14,794/quality-adjusted life year (QALY) gained. In probabilistic sensitiv-ity analyses excluding psychotropics and tai chi management, home modification is most likely to have the highest economic benefit when the cost-effectiveness threshold for QALYs was valued at $50,000 or $100,000.	Management of psychotropics and tai chi reduces costs the most. Of more studied interventions, home modifica-tions provide the best value.
8	Wu et al., 2010	The Falls Rehabilitation Program (FRP)	No intervention	-	2008 dollars, USA	-Per recurrent fall prevented	The FRP would have a net cost to Medicare of about $435 million, or equivalently, $850 per person prevented from experiencing a recurrent fall.	Such a program could potentially be cost-saving from an all-payer perspective, as the total reduction in annual healthcare costs ($2.67 billion in the base case, with 54% charged to Medicare) is estimated to outweigh the program cost ($1.88 billion).
9	Peeters et al., 2011	The multifactorial transmural intervention The multifactorial transmural intervention started with a visit to the geriatric outpatient clinic. The geriatrician conducted a multifactorial fall risk assessment to identify modifiable fall risk factors. The assessment of fall risk factors and the treatment plan design was based on the Dutch Institute for Healthcare Improvement (CBO) guideline "Prevention of fall incidents in older persons."	Usual care	-	2007 Euros	-Fallers -Recurrent fallers - Utility (quality of life).	The mean costs were Euro 7,740 (SD 9,129) in the intervention group and Euro 6,838 (SD 8,623) in the usual care group (mean difference Euro 902, bootstrapped 95% CI: −1,534 to 3,357).	Multifactorial evaluation and treatment of persons with a high risk of recurrent falling were not cost-effective com-pared to usual care.

Supplementary File-2. *continues...*

ID	Ref	Intervention	Comparator	Discount Rates	Reporting of Cost	Outcome Measurement	ICER	Health Economic Result
10	Church et al., 2012	The interventions (home exercise, group exercise, tai chi, multiple and multifacto-rial interventions) aimed at the general population; high-risk populations (group exer-cise, home hazard assess-ment/modification, and multifactorial interventions); and specific populations (cardiac pacing, expedited cataract surgery, and psy-chotropic medication with-drawal).	No intervention	5%	-	-QALY -Fall-Related Injuries -Fear Of Falling	In the general population, compared with no intervention, the ICERs were tai chi ($44,205), group-based exercise ($70,834), multiple interventions ($72,306), home exercise ($93,432), multifactorial interventions with only referral ($125,868) and multifactorial interventions with an active component ($165,841).	Tai chi remained the only cost-effective intervention for the general population.
11	Lee et al., 2013	Population screening strategy and universal supplementation strategy of vitamin D	No intervention	3%	2011 dollars, USA	-No Injury, -Injurious Fall Without Hospitalization, -Injurious Fall with Hospitalization.	For females, universal supplementation resulted in incremental costs of $51.44 and an effectiveness of 0.005 QAL-Ys. For males, universal supplementation resulted in incremental costs of $52.55 and incremental effectiveness of 0.006 QALYs.	Both universal supplementation and population screening for vitamin D deficiency among older adult women and men are cost-effective from a societal perspective.
12	van Haastregt et al., 2013	The multicomponent cognitive behavioral group intervention	Usual care	NA	2004 Euros, Netherlands	- Fear of Falling or Avoiding Activity	The base-case analysis for fear of falling revealed that the cost for every additional patient who is no longer afraid of falling is €1,070 (ICER = 4,925–4,828 / 0.235–0.144), and the cost for every additional patient who is no longer avoiding activity due to fear of falling is €683 (ICER = 4,925–4,828 / 0.374–0.232).	A multicomponent nurse-led cognitive behavioral group intervention significantly reduced fear of falling and asso-ciated activity avoidance while only slightly increasing costs.
13	Carande-Kulis et al., 2015	The Otago Exercise Program, Tai Chi: Moving for Better Balance, Stepping On	No intervention	-	2012 dollars, USA	-Cost Per Participant Per Year	For the Otago Exercise Pro-gram (>65), the net benefit was $121.85 per participant; the return on investment (ROI) was 36%; for the Otago exercise program (>80), the net benefit was $429.18, the ROI was 127%. Tai chi: Moving for Better balance had a net benefit of $529.86 and an ROI of 509% Stepping On had a net benefit of $134.37 and an ROI of 64%.	All three fall interventions provided positive net benefits. The ROIs showed that the benefits covered the implemen-tation costs and exceeded the expected direct program delivery costs.
14	Farag et al., 2015	Public Health Program	Control group	-	2011 Australian dollars	-QALY -Hospital Admission -Emergency Department Consultations.	The program was more costly and more effective with an ICER of $A28,931; however, the probability for being cost-effective was 57% when the cost-effectiveness threshold was set to $A50,000 per QALY gained	This ICER would be considered cost-effective at a threshold value of $A50,000 per QALY gained.
15	McLean et al., 2015	No Falls Exercise Program	Usual care	3%	2010 Australian Dollars And British Pound Sterling (GBP)	-QALY -Falls Prevention	The ICER of GBP£51,483 per QALY for the base case analysis was well above the accepted cost-effectiveness threshold of GBP£20,000 to £30,000 per QALY; the ICER value in the base case analysis was GBP£99,664 per QALY and GBP£50,549 per QALY in the lower cost analysis.	The exercise program is cost-effective for women only.
16	Li et al., 2016	Tai Ji Quan: Moving for Better Balance (TJQMBB) Program	No intervention	-	-	-Number of falls	The average cost-effectiveness ratio for implementing the 48-week program was $917 per fall prevented; for partic-ipants who reported multiple falls at baseline and during the 48-week intervention period, the ratio was an estimated $676 per fall prevented	TJQMBB is an effective public health program that can be broadly im-plemented in senior community centers for the primary prevention of falls
17	Polinder et al., 2016	FRIDs assessment combined with FRIDs-withdrawal or modification	Usual Care	-	Dutch cost prices	-HRQoL -the Dutch versions of the EuroQol-5D (EQ-5D) -Short Form-12 (SF-12) version 2	The mean cost of the FRIDs intervention was €120 per patient. The withdrawal of FRIDs reduced medication costs with a mean of €38 per participant.	The mean QALY differ-ence between both groups was 0.05 QALY. For the total fall-related healthcare costs, no sig-nificant differences be-tween both study groups could be detected.

Supplementary File-2. *continues...*

ID	Ref	Intervention	Comparator	Discount Rates	Reporting of Cost	Outcome Measurement	ICER	Health Economic Result
18	Cockayne et al., 2017a	The multifaceted podiatry intervention	Control group	NA	-	-Self-reported falls per participant -The proportion of fallers -Those reporting multiple falls.	The cost per fall averted was £1,254.	This multifaceted intervention program could be a cost-effective option for fall prevention, with the incremental cost per QALY (based on health-related quality of life) ranging between £19,494 and £20,593.
19	Cockayne et al., 2017b	A multifaceted podiatry intervention	Control group	NA	UK pounds sterling (£) at 2015 prices	-Falls per participant	The intervention was more costly but marginally more beneficial in terms of health-related quality of life (mean quality-adjusted life year (QALY) difference 0.0129, 95% CI -0.0050 to 0.0314) and had a 65% probability of be-ing cost-effective at a threshold of £30,000 per QALY gained.	The intervention may be cost-effective.
20	Isaranuwatchai et al., 2017	The intervention group received usual care, plus monthly in-home visits by an interprofessional team with special-ized training in the area of fall prevention.	Usual care	-	2006 Canadian dollars.	-The number of falls at six-months	For young-old to prevent one fall willingness-to-pay< $25,000 CAD, For the old-old group, the intervention was cost-effective at willingness-to-pay < $5000 CAD to prevent falls.	The multifactorial fall prevention intervention was not cost-effective compared to usual care. The cost-effectiveness of the intervention depends on age and decision-makers' willingness to pay to prevent falls.
21	(Wilson et al., 2017)	HSAM (Home Safety Assessment and Modification)	No intervention	3%	2014 New Zealand Dollar	-QALY	ICER was estimated at NZ$5480, suggesting HSAM is cost-effective (95%UI: cost saving to NZ$15,300 [equivalent to US $10,300]).	The program was estimated to be cost-effective (ICERs: NZ$700 and NZ$832, respectively), and lower confidence intervals for ICERs were cost-saving
22	(Corbacho et al., 2018)	Multifaceted Podiatry Intervention-REFORM	Usual care	-	UK pounds sterling, 2015, England and Ireland	-Incidence of falls -the proportion of fallers -EQ-5D-3L -QALYs	Incremental cost-effectiveness ratios ranged between GBP 19,494 and GBP 20,593 per QALY gained, which is be-low the conventional National Health Service cost-effectiveness thresholds (GBP 20,000 to GBP 30,000) per addi-tional QALY.	The benefits of the intervention justified the moderate cost.

Supplementary File-3. CHEC-List

CHEC/ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
2	Y	Y	Y	Y	Y	Y	Y	Y	Y	U	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	U	NA
3	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
4	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
5	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	NA	Y	Y	Y	Y
6	Y	N	Y	N	Y	N	Y	Y	Y	N	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y
7	U	Y	Y	Y	Y	Y	Y	NA	Y	U	Y	Y	Y	NA	NA	NA	Y	N	Y	Y	U	Y
8	Y	Y	Y	Y	Y	Y	Y	Y	Y	U	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
9	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y
10	N	Y	Y	Y	Y	Y	Y	NA	Y	Y	Y	Y	Y	NA	NA	NA	Y	NA	Y	Y	Y	Y
11	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
12	NA	NA	Y	NA	Y	Y	Y	Y	Y	NA	N	NA	NA	N	N	NA	Y	Y	Y	NA	N	Y
13	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	NA	Y	Y	Y	Y	Y
14	N	Y	N	Y	Y	N	Y	N	N	Y	Y	N	N	N	Y	N	N	NA	N	N	Y	N
15	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y
16	N	N	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	Y	Y	Y	N	Y	Y
17	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
18	N	N	N	N	N	Y	Y	N	Y	N	Y	Y	N	Y	Y	N	Y	Y	Y	Y	Y	N
19	N	N	N	N	Y	N	N	N	Y	N	N	Y	N	N	Y	N	Y	Y	Y	Y	N	Y
Total	10	14	15	13	17	15	17	13	17	11	16	16	15	13	15	10	15	14	18	16	15	16

Note: Y: Yes, N: No, NA: Not Applicable