JAMA | US Preventive Services Task Force | EVIDENCE REPORT

Interventions to Prevent Falls in Older Adults
Updated Evidence Report and Systematic Review for the US Preventive Services Task Force

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IMPORTANCE Falls are the most common cause of injury-related morbidity and mortality in older adults.

OBJECTIVE To systematically review evidence on the effectiveness and harms of fall prevention interventions in community-dwelling older adults.

DATA SOURCES MEDLINE, Cumulative Index for Nursing and Allied Health Literature, and Cochrane Central Register of Controlled Clinical Trials for relevant English-language literature published between January 1, 2016, and May 8, 2023, with ongoing surveillance through March 22, 2024.

STUDY SELECTION Randomized clinical trials of interventions to prevent falls in community-dwelling adults 65 years or older.

DATA EXTRACTION AND SYNTHESIS Critical appraisal and data abstraction by 2 independent reviewers. Random-effects meta-analyses with Knapp-Hartung adjustment.

MAIN OUTCOMES AND MEASURES Falls, injurious falls, fall-related fractures, hospitalizations or emergency department visits, people with 1 or more falls, people with injurious falls, people with fall-related fractures, and harms.

RESULTS Eighty-three fair- to good-quality randomized clinical trials (n = 48 839) examined the effectiveness of 6 fall prevention interventions in older adults. This article focuses on the 2 most studied intervention types: multifactorial (28 studies; n = 27 784) and exercise (37 studies; n = 16 117) interventions. Multifactorial interventions were associated with a statistically significant reduction in falls (incidence rate ratio [IRR], 0.84 [95% CI, 0.74-0.95]) but not a statistically significant reduction in individual risk of 1 or more falls (relative risk [RR], 0.96 [95% CI, 0.91-1.02]), injurious falls (IRR, 0.92 [95% CI, 0.84-1.01]), fall-related fractures (IRR, 1.01 [95% CI, 0.81-1.26]), individual risk of injurious falls (RR, 0.92 [95% CI, 0.83-1.02]), or individual risk of fall-related fractures (RR, 0.86 [95% CI, 0.60-1.24]). Exercise interventions were associated with statistically significant reductions in falls (IRR, 0.85 [95% CI, 0.75-0.96]), individual risk of 1 or more falls (RR, 0.92 [95% CI, 0.87-0.98]), and injurious falls (IRR, 0.84 [95% CI, 0.74-0.95]) but not individual risk of injurious falls (RR, 0.90 [95% CI, 0.79-1.02]). Harms associated with multifactorial and exercise interventions were not well reported and were generally rare, minor musculoskeletal symptoms associated with exercise.

CONCLUSIONS AND RELEVANCE Multifactorial and exercise interventions were associated with reduced falls in multiple good-quality trials. Exercise demonstrated the most consistent statistically significant benefit across multiple fall-related outcomes.

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JAMA. doi:10.1001/jama.2024.4166
Published online June 4, 2024.

Falls are the leading cause of unintentional injury death for adults 65 years or older in the United States.[1] In 2018, 27.5% of community-dwelling older adults reported at least 1 fall in the past year (714 falls per 1000 older adults), and 10.2% reported a fall-related injury (170 fall-related injuries per 1000 older adults).[2] Since 2001, the age-adjusted fall-related death rate has been steadily increasing for older adults, increasing by 41% in the most recent decade (55.3/100 000 in 2012 to 78.0/100 000 in 2021). Given this large burden of morbidity, it is important to determine which fall prevention interventions addressing modifiable fall risk factors are effective.

In 2018, the US Preventive Services Task Force (USPSTF) recommended exercise interventions to prevent falls in older adults who are at increased risk for falls (B recommendation). The task force further recommended that physicians selectively offer multifactorial interventions to older adults at increased risk for falls (C recommendation). The USPSTF commissioned this systematic review to inform its updated recommendation for fall prevention in older adults.

Methods

Scope of Review

An analytic framework was developed with 2 key questions (KQs) (**Figure 1**) that examined the effect of fall prevention interventions on health outcomes (KQ1) and the harms of these interventions (KQ2). Compared with the previous review of this topic,[4,5] this update excludes interventions of vitamin D supplementation and allows for the inclusion of participants with mild dementia, osteoporosis, osteoarthritis, and sarcopenia. A draft of the analytic framework, review questions, and inclusion and exclusion criteria was posted on the USPSTF website from April 21, 2022, to May 19, 2022, to gather public input. Only minor changes were made to clarify the included populations and interventions. Detailed methods and results are available in the full evidence report.[6]

Data Sources and Searches

MEDLINE, Cumulative Index for Nursing and Allied Health Literature, and Cochrane Central Register of Controlled Trials were searched from January 1, 2016, to May 8, 2023, and supplemented with suggestions from experts and articles identified through news and table-of-contents alerts (eMethods in the Supplement). ClinicalTrials.gov was used to identify ongoing trials. Ongoing surveillance was conducted through March 22, 2024, via article alerts and targeted journal searches to identify major studies that might affect the conclusions of the review or understanding of the evidence.

Study Selection

Two reviewers independently reviewed titles, abstracts, and full-text articles against a priori eligibility criteria (eTable 1 in the Supplement). Studies were eligible for inclusion if they were randomized clinical trials (RCTs) of community-dwelling adults 65 years or older, including those unselected or selected for their increased risk of falling, and had a primary or secondary aim of preventing falls. Fall prevention interventions that were feasible for or referable from the primary care setting were included. This article focuses on 2 intervention types: multifactorial and exercise. The remaining intervention types (environmental, psychological, medication, education, and combinations of interventions) had limited data, and complete results are available in the full evidence report.[6] For KQ1, outcomes included falls (self-reported falls with a maximum recall of 6 months), people with 1 or more falls, mortality, fall-related injuries, people with fall-related injuries, hospitalizations or emergency department visits, people with hospitalizations or emergency department visits, fractures, people with fractures, institutionalizations, people institutionalized, instrumental activities of daily living and quality of life. For KQ2, any trial-reported harms were included.

Trials recruiting participants living in specialized settings or solely recruiting older adults with moderate to severe dementia were excluded. Social marketing, surgery, fluid or nutrition therapy, assistive technology, and vitamin D and other supplement interventions were excluded. Trials with 2 or more active intervention groups and no control group were excluded.

Data Extraction and Quality Assessment

Included trials were critically appraised by 2 independent reviewers using predefined criteria,[3] with disagreements resolved by a third reviewer (eTable 2 in the Supplement). One reviewer abstracted data from each included study into standardized evidence tables; a second checked for accuracy and completeness.

Data Synthesis and Analysis

All fall and fall-related injury outcomes were reported either as an incident event where a person could contribute more than 1 event to the analysis (eg, falls) or the number of people experiencing the event where a person could contribute only once to an analysis, regardless of the number of times the event occurred (eg, people with ≥1 falls). For injurious fall outcomes, minor or severe injuries resulting from a fall, falls resulting in medical care, or any fall-related outcome the author categorized as injurious were included. The most inclusive outcome was used in meta-analysis if multiple outcomes in that injury category were reported. For fracture outcomes, fall-related fractures were selected first, but if that outcome was not available, data on hip fractures and overall fractures were included.

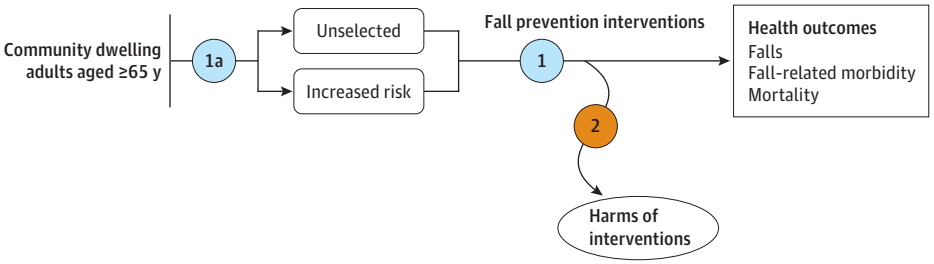
Random-effects meta-analyses with a Knapp-Hartung adjustment[7] were used to calculate the pooled relative risks (RRs). Data are summarized narratively for outcomes precluding meta-analysis (<5 studies). Within each study, the longest follow-up was selected for pooled analyses and figures. Data from other follow-up times are presented in tables. Only 1 intervention and 1 control group for each intervention category were abstracted and included in the analysis.

In cases in which a cluster RCT was used but the authors did not account for the nested nature of the data, the clustering effect was accounted for by applying a design effect, which was based on an estimated average cluster size and multiplied by an estimated intraclass correlation (estimated to be .05 based on reported intraclass correlations in other included studies).[8]

Statistical heterogeneity was examined among the pooled studies by applying standard χ^2 tests, and the proportion of total variability in point estimates was estimated using the I^2 statistic.[9] In addition, funnel plots were generated to evaluate small-study effects, and the Egger test was used to assess the statistical significance of imbalance in study size and findings that suggest a pattern.[10]

Heterogeneity was explored among the main outcomes (falls and people with ≥1 falls) in relation to any prespecified population

Figure 1. Analytic Framework and Key Questions: Interventions to Prevent Falls in Older Adults



Key questions

1 Do interventions to prevent falls in unselected or increased-risk community-dwelling older adults reduce falls, falls-related morbidity, or mortality?
a. How is "increased risk" defined in the included trials?

2 Do interventions to prevent falls in unselected or increased-risk community-dwelling older adults result in any adverse effects?

Evidence reviews for the US Preventive Services Task Force (USPSTF) use an analytic framework to visually display the key questions that the review will address to allow the USPSTF to evaluate the effectiveness and safety of a preventive service. The questions are depicted by linkages that relate interventions and outcomes. For additional details, see the USPSTF Procedure Manual.[3]

or intervention characteristics. Plots and tables were grouped or sorted by these characteristics. Meta-regression was conducted for visual displays suggesting patterns. Specifically, publication year, study quality, recruitment setting, duration of follow-up, mean age, percentage female, recruitment for increased fall risk, and fall rate or the percentage falling in the control group were examined. For exercise interventions, the presence of a behavior change component, presence of cognitive task exercises, individual exercise components (eg, balance, flexibility, strength), and format (group, individual, or both) were also examined.

Absolute reductions that could be expected in a hypothetical population were estimated for 4 outcomes: falls, people with 1 or more falls, fall-related injuries, and people with fall-related injuries. For multifactorial and exercise interventions, the pooled relative reduction point estimate, lower confidence interval, and upper confidence interval for each outcome were applied to a population of 1000 older adults with fall and fall-injury rates based on both national[2] and trial rates.

Stata version 16.1 (StataCorp) was used for all quantitative analyses. All significance testing was 2-sided. Results were considered statistically significant if $P \leq .05$.

Results

Benefits of Interventions

KQ1. Do interventions to prevent falls in unselected or increased-risk community-dwelling older adults reduce falls, falls-related morbidity, or mortality?

KQ1a. How is "increased risk" defined in the included trials?

Two independent reviewers evaluated 5142 abstracts and 403 full-text articles (**Figure 2**). Overall, 83 trials (reported in 145 publications) were included; 32 were newly identified trials, and 51 were carried forward from the previous review. Most of the included studies investigated the effectiveness of multifactorial (28 studies) and exercise (37 studies) interventions. Twenty trials were included for other intervention types (eg, home environment modifications, medication review, exercise interventions combined with other interventions); their results are available in the full evidence report.[6]

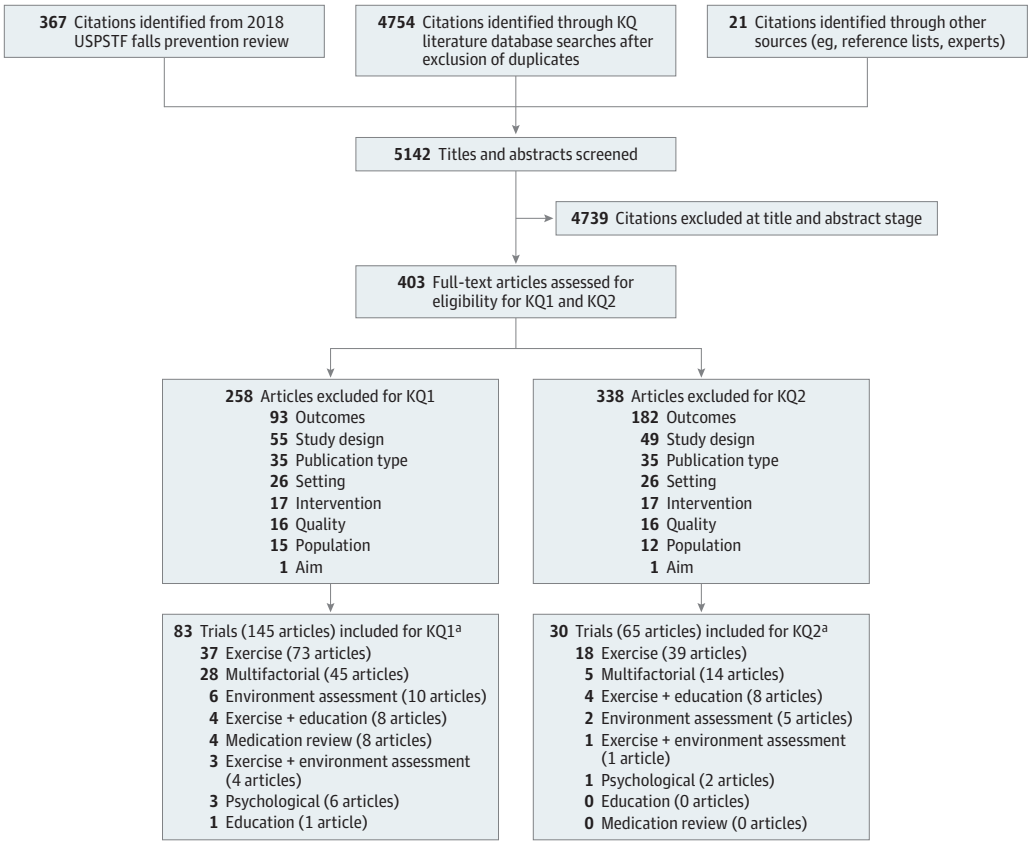
Multifactorial Interventions

Study and Population Characteristics | Nine good-quality[11-19] and 19 fair-quality[20-37] RCTs (n = 27 784) were identified (eTables 3-4 in the Supplement). Most trials were conducted in Europe; 4 took place in the United States.[16,19,22,37] The size of the trials ranged from 153 participants[32] to 6524 participants.[18] Mean age ranged from 72 years[20] to 85 years.[26] The proportion of women in the trials ranged from 53%[18] to 94%.[20] Fifteen trials recruited at least some proportion of participants from clinics,[11,12,15,18-20,24-26,29,30,32-34,36,38] and 6 trials exclusively recruited from the emergency department.[17,21,23,27,31,35] Sixteen trials excluded patients with cognitive impairment or dementia with varying criteria.[12,14-17,19,21,23-25,27,29,30,32,35,36] An additional 8 trials excluded those who could not understand instructions or provide their own informed consent.[11,13,24,25,29,31,33,34]

Increased-Risk Definition | Twenty-one trials[11-13, 15-17, 19-21, 23-25, 27, 28, 30-33, 35, 36, 38] solely recruited patients at increased risk for falls according to various definitions (eFigure 1 and eTable 5 in the Supplement); history of falls was the most common risk factor used for trial recruitment. Nearly half of the trials (13/28) defined increased risk with a sole criterion—having a history of falling.[15,22,25,28,29,34,36,37] The remainder of the trials recruited participants who met 1 or more risk factor criteria from a list of possible risk factors. Seven trials recruited participants unselected for their risk of falling, with 19% to 44% of those recruited at increased risk for falls.[14,18,22,26,29,34,37] Overall, participants in the multifactorial trials were at higher risk for falls (falls weighted mean: 1.46 falls per person-year; percentage of people with ≥1 fall weighted mean: 48.4%) compared with the national average (0.71 falls per person-year; 27.5% people with ≥1 fall).[2]

Intervention Details | The 28 multifactorial trial publications described a heterogeneous group of complex assessment and intervention components (eFigures 2-4 and eTable 6 in the Supplement).

Figure 2. Literature Search Flow Diagram: Interventions to Prevent Falls in Older Adults



Reasons for Exclusion: Outcomes: Study did not have relevant outcomes or had incomplete outcomes. Study design: Study did not use an included design. Publication type: Publication was not an included publication type. Setting: Study was not conducted in a country relevant to US practice. Intervention: Study used an excluded intervention/screening approach. Quality: Study did not meet criteria for fair or good quality. Population: Study was not conducted in a general primary care representative population or included age group. Aim: Primary or secondary study aim was not fall prevention.
KQ indicates key question; USPSTF, US Preventive Services Task Force.

[a]Studies may appear in more than 1 intervention category.

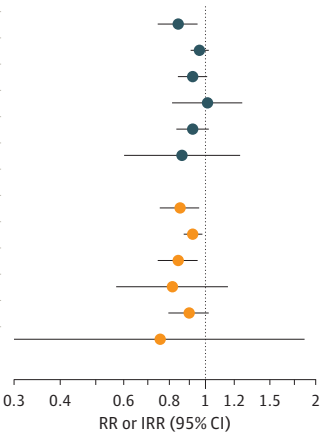
All trials administered an initial assessment with multiple components such as medical history, medication review, clinical and laboratory tests, and patient questioning to assess and plan for fall risk mitigation (eFigure 2 in the Supplement). Most trials (24/28) provided outside referrals (eFigure 3 in the Supplement) and administered some research team–delivered intervention components (eFigure 4 in the Supplement). The referrals and study-delivered treatment interventions were largely individualized and based on the risk factors identified in the initial assessment. They generally targeted multiple intervention components, such as exercise, psychological interventions, nutrition therapy, education, medication management, urinary incontinence management, environment assessment or modification, and referral to physical or occupational therapy, social or community services, and clinical specialists. Most often referrals were for environment assessment or modification, exercise, medication management, and vision/auditory care. Nineteen trials included 1 or more home visits for the initial assessment, environment interventions, or exercises.[12,13,15,16,20-23,25,27-35,38] Most interventions, however, occurred in the outpatient setting. All interventions were in-person, with some trials additionally including some telephone coaching.[19,22,29,32,37]

The majority (19/28) of trial control groups received no intervention or usual care.[11-14,17,20,21,23-27,29-32,35-38] The remaining 9 trials had a control group that received usual care plus a minimal intervention or attention control.[15,16,18,19,22,28,30,33,34]

Intervention Effects on Falls and Fall-Related Outcomes | Pooled results from 20 trials of multifaceted interventions (n = 22 115) demonstrated that multifactorial interventions were associated with a lower risk of falling at the longest follow-up (6-28 months), with substantial heterogeneity in the effect size (incidence rate ratio [IRR], 0.84 [95% CI, 0.74-0.95]; I^2 = 85.0%) (**Figure 3**; eFigure 5 in the Supplement). However, pooled results at the longest follow-up demonstrated no statistically significant association of multifactorial interventions with the risk of people with 1 or more falls (RR, 0.96 [95% CI, 0.91-1.02]; I^2 = 48.2%; 26 studies; n = 23 626), the number of injurious falls (IRR, 0.92 [95% CI, 0.84-1.01]; I^2 = 21.8%; 12 studies; n = 10 563), number of fall-related fractures (IRR, 1.01 [95% CI, 0.81-1.26]; I^2 = 34.0%; 7 studies; n = 15 211), people with injurious falls (RR, 0.92 [95% CI, 0.83-1.02]; I^2 = 47.3%; 13 studies; n = 13 460), and people with fall-related fractures (RR, 0.86 [95% CI, 0.60-1.24]; I^2 = 49.0%; 7 studies; n = 13 912) (Figure 3, eFigures 6-10 in

Figure 3. Pooled Analyses for Multifactorial and Exercise Interventions

Intervention and outcome	No. of studies	No. of participants	RR or IRR (95% CI)
Multifactorial			
No. of falls	20	22 115	0.84 (0.74-0.95)
People with ≥1 fall	26	23 626	0.96 (0.91-1.02)
No. of injurious falls	12	10 563	0.92 (0.84-1.01)
No. of fall-related fractures	7	15 211	1.01 (0.81-1.26)
People with injurious falls	13	13 460	0.92 (0.83-1.02)
People with fall-related fractures	7	13 912	0.86 (0.60-1.24)
Exercise			
No. of falls	29	14 475	0.85 (0.75-0.96)
People with ≥1 fall	25	13 384	0.92 (0.87-0.98)
No. of injurious falls	12	3984	0.84 (0.74-0.95)
No. of fall-related fractures	8	8537	0.81 (0.57-1.15)
People with injurious falls	9	3924	0.90 (0.79-1.02)
People with fall-related fractures[a]	4	7994	0.75 (0.30-1.86)



IRR indicates incidence rate ratio; and RR, relative risk.

[a]Pooled for illustrative purposes.

the Supplement). The high heterogeneity could not be explained by any single variable, including number of falls by country, date of publication, recruitment setting, fall rate of the control group, recruitment inclusion criteria of unselected or increased risk of falls, mean age, follow-up period, and study quality. Visual examination of the funnel plot for the 20 pooled trials (not shown) did not suggest a publication bias, and the Egger test result was not statistically significant (P = .17).

Absolute Benefits | In a hypothetical population of 1000 older adults, based on national fall rates, multifactorial interventions would be expected to prevent 114 falls (lower bound, 36 falls; upper bound, 186 falls) (**Figure 4**). These absolute benefits would be greater in populations at higher risk for falls.

Exercise Interventions

Study and Population Characteristics | Thirty-two fair-quality[39-70] and 5 good-quality[18,71-74] RCTs (n = 16 117) were identified (eTable 3 and eTable 7 in the Supplement). Trials were primarily conducted in Europe, Australia, or New Zealand; 5 trials took place in the United States.[41,47,60,66,69] Trial sizes ranged from 35 participants[55] to 6502 participants.[18] The mean age ranged from 68 years[71] to 88 years.[46] Ten trials were conducted exclusively with women,[42-44,63,66-68,70-72] while in 3 trials less than one-half of the participants were female.[59,62,65] The majority of participants in the remaining trials were women.[18,39-41,45-58,60,61,64,69,73,74] Nineteen trials recruited from a community or population-based setting only,[39,43,44,46,48,51,52,55,56,60,61,66,68-74] and 13 trials recruited from a clinic setting (with or without additionally using community-based recruitment).[18,40,42,45,47,49,53,54,57-59,62,63] Three trials recruited participants with mild to moderate cognitive impairment,[57,59,62] and 1 trial was limited to participants with Alzheimer disease.[65]

Increased-Risk Definition | Among the 35 trials reporting the proportion of those at risk, 58% of participants were determined to be at increased risk of falling. Twenty trials required all participants to be at increased risk for falls.[40,43,45-48,50,51,53-56,58,63,65-69,72] Fifteen trials[18,39,41,42,49,52,57,60-62,64,70,71,73,74] included populations with 6% to 59% of participants at increased risk for falls. The definitions of increased risk for falls varied among the trials (eFigure 11 and eTable 8 in the Supplement). Most trials (22/37) included history of falls as either the sole criteria[39,49,52,60-62,64,72,73] or one of several risk factors.[18,41,42,45,46,51,53,55,57,63,65,71,74] Overall, participants in the exercise trials were at higher risk for falls than the national average (falls weighted mean, 1.16 falls per person-year; percentage of people with ≥1 falls weighted mean, 41.4%).

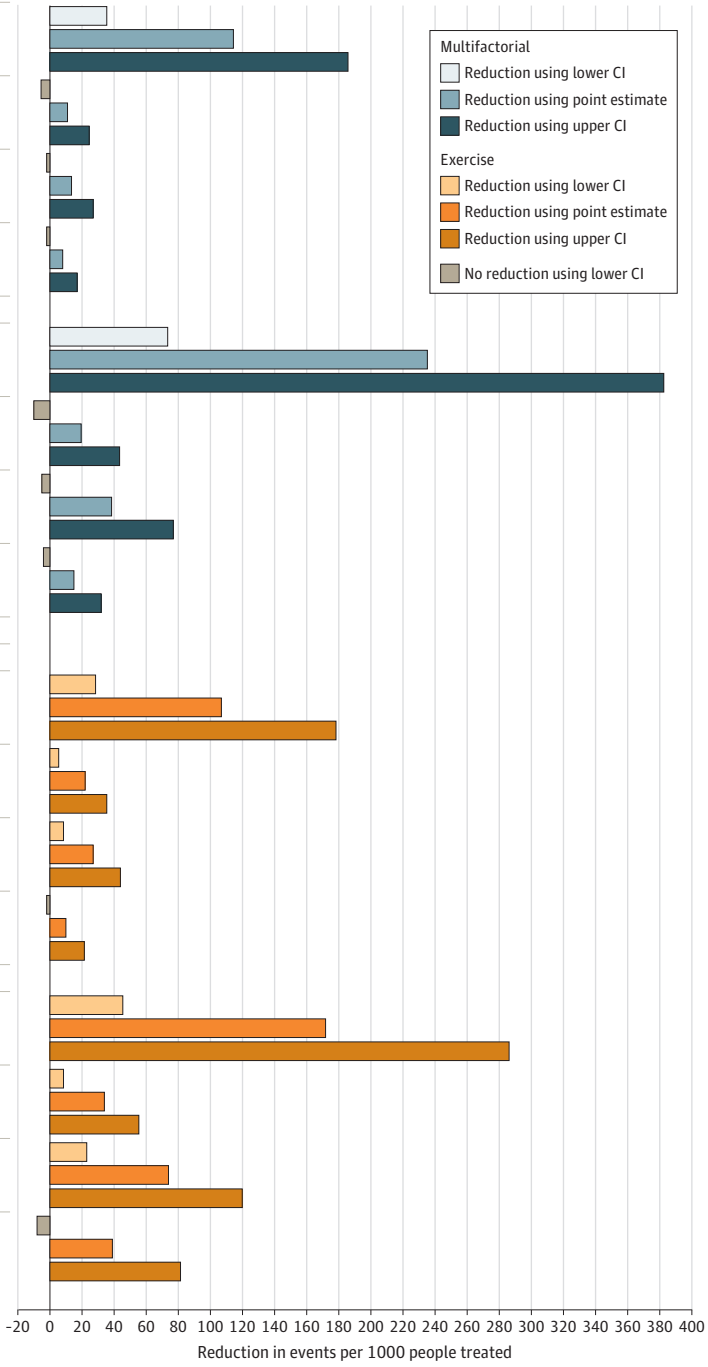
Intervention Details | The interventions generally included multiple exercise components in a supervised group setting with varying frequencies and durations (eFigures 12-13 and eTable 9 in the Supplement).[18] Exercise interventions varied in content, delivery format, intensity, and duration. Some examples included individuals being asked to walk 30 minutes at least twice per week, individual home sessions with a physical therapist of varying intensity, and group exercise sessions multiple times per week for a year.

Control groups were instructed to maintain usual activity levels and/or received usual care, no intervention, minimal written information, or other minimal education about health or preventing falls, or a social visit.

Intervention Effects on Falls and Fall-Related Outcomes | Pooled analysis at longest follow-up demonstrated that exercise interventions were associated with a significant reduction in the rate of incident falls (IRR, 0.85 [95% CI, 0.75-0.96]; I^2 = 82.7%; 29 studies; n = 14 475), a reduced risk of people with 1 or more falls (RR, 0.92 [95% CI, 0.87-0.98]; I^2 = 24.3%; 25 studies; n = 13 384), and a reduction in the number of injurious falls (IRR, 0.84 [95% CI, 0.74-0.95]; I^2 = 14.6%; 12 studies; n = 3984) (Figure 3; eFigures 14-16 in the Supplement). Exercise interventions were not statistically significantly associated with a reduction in the risk of an individual having an injurious fall (RR, 0.90 [95% CI, 0.79-1.02]; I^2 = 26.7%; 9 studies; n = 3924) or a fall-related fracture (RR range, 0.36 [95% CI, 0.15-0.89] to 1.95 (95% CI, 0.22-17.3]; 4 studies; n = 7994), or the number of fall-related fractures (IRR, 0.81 [95% CI, 0.57-1.15];

Figure 4. Absolute Reduction in Falls and Falls Resulting in Injury[a]

Intervention	No. of people or falls	Risk reduction, %	Reduction in events per 1000 people treated
Multifactorial			
National rate			
No. of falls	714	5	36
		16	114
		26	186
People with ≥1 fall	275	-2	-6
		4	11
		9	25
No. of falls resulting in injury	170	-1	-2
		8	14
		16	27
People with injurious falls	102	-2	-2
		8	8
		17	17
Trial rate			
No. of falls	1471	5	74
		16	235
		26	382
People with ≥1 fall	486	-2	-10
		4	19
		9	44
No. of falls resulting in injury	481	-1	-5
		8	38
		16	77
People with injurious falls	188	-2	-4
		8	15
		17	32
Exercise			
National rate			
No. of falls	714	4	29
		15	107
		25	179
People with ≥1 fall	275	2	6
		8	22
		13	36
No. of falls resulting in injury	170	5	9
		16	27
		26	44
People with injurious falls	102	-2	-2
		10	10
		21	21
Trial rate			
No. of falls	1145	4	46
		15	172
		25	286
People with ≥1 fall	428	2	9
		8	34
		13	56
No. of falls resulting in injury	462	5	23
		16	74
		26	120
People with injurious falls	389	-2	-8
		10	39
		21	82



[a]In a hypothetical population of 1000 older adults with a fall rate of 714 falls/1000 person-years, 27.5% older adults with a fall, fall injury rate of 170 fall injuries/1000 person-years, and 10.2% older adults with a fall injury (based on 2018 Behavioral Risk Factor Surveillance System data[2]) and using the lower confidence interval, point estimate, and upper confidence interval from the pooled results, this figure shows estimated reductions in the fall-related events/people.

I^2 = 39.1%; 8 studies; n = 8537) (Figure 3; eFigures 17 and 18 in the Supplement). The high heterogeneity could not be explained by any single variable after adjusting for multiple comparisons. Variables included country where the trial took place, publication year, study quality, recruitment setting, selective recruitment for increased fall risk, control group event rate, mean age, duration of follow-up, specific exercise components, behavior change component as part of the intervention, cognitive task exercises as part of the intervention, group vs individual exercise sessions, and intervention duration. Visual examination of the funnel plot for the 29 pooled trials (not shown) did not suggest a publication bias, and the Egger test result was not statistically significant (P = .68).

Absolute Benefits | Based on national fall rates, exercise interventions would be expected to prevent 107 falls (lower bound, 29; upper bound, 179), 22 people experiencing a fall (lower bound, 6; upper bound, 36), and 27 falls resulting in injury (lower bound, 9; upper bound, 44) per 1000 people treated (Figure 4).

Harms of Interventions

Key Question 2. Do interventions to prevent falls in unselected or increased-risk community-dwelling older adults result in any adverse effects?

Multifactorial Interventions

Adverse events were sparsely reported for multifactorial interventions but when reported were rare, minor, and associated with the exercise components of these interventions. Five trials (n = 4199) reported harms associated with multifactorial interventions (eTable 10 in the Supplement).[12,15,16,18,27] One trial[27] reported no adverse events in the intervention or control groups. Four trials[12,15,16,18] reported adverse events in the intervention groups but did not provide comparative data from the control group. One of these trials[15] reported 3 falls without injuries during the exercise sessions of the interventions, 1 reported back pain that either restricted activities of daily living for 2 or more days or resulted in medical attention in 2 intervention participants,[12] 1 reported musculoskeletal symptoms in 10 intervention participants,[16] and the other reported no adverse events in the intervention group.[18]

Exercise Interventions

One-half of the trials (19/37) reported harms, with generally minor musculoskeletal adverse effects being most common; serious adverse effects were rare. Overall, the description of harms ascertainment was sparse; measurement varied from capturing spontaneous, self-reported comments to repeated questionnaires asking about harms (eTable 11 in the Supplement). Nineteen trials[18,43,44,48,50,51,53,54,56-58,60-64,70,72,74] (n = 6985) reported harms in the intervention groups at 6 to 24 months (eTable 17 in the Supplement). Five of these trials[51,54,60,62,72] also reported harms in the control group.

Seventeen trials[18,43,44,48,50,51,53,56-58,61-64,70,72,74] reported any adverse events occurring during the exercise intervention sessions, ranging from 0%[18,51,53,63,64] to 58%.[56] These adverse events were largely musculoskeletal discomfort and pain symptoms, particularly in the trial reporting high rates of adverse events (1 trial[56] reporting 58% in the intervention group and no adverse event reporting in the control group). Zero percent[58] to 11%[56] reported falls during the intervention exercise program. Serious adverse events related to the exercise intervention were measured in 7 trials,[18,43,54,57,62,70,72] with one-half of these trials[18,57,70,72] reporting zero serious adverse events related to the intervention and 1 trial[62] reporting less than 1% serious adverse events related to the exercise intervention (2/281). One trial[43] reported a fall-related wrist fracture (1/352). One trial reported angina pectoris–like chest pain (2/457) and presyncopal symptoms (2/457) during the intervention.[70] Another trial[54] reported overall adverse events as 18% in the intervention group and 12% in the control group; however only 1 adverse event (1/334), a hip fracture, was attributed to the exercise session.

Discussion

Summary

This review updated the 2018 review conducted for the USPSTF[4,75] and included 3 new multifactorial trials and 19 new exercise trials. The overall conclusions (**Table**) are generally consistent with the previous review,[75] with the addition of newly published trials as well as several trials that solely recruited specific populations with mild dementia, osteoporosis, osteoarthritis, and sarcopenia.[57,59,62,63,65-67] This review's findings align with other reviews.[76-84]

For multifactorial interventions, the only outcome with a statistically significant benefit in the pooled analysis was the incidence rate of falls. There were 3 new fair- or good-quality trials[18,19,30] added to the evidence for this update; however, these trials had null findings. One hypothesis is that the contemporary standard of care may provide a level of risk modification in the control group that may diminish the interventions' relative benefits. In some trials, all participants in the intervention group received an exercise intervention,[15,22,25,33,34] while in other trials only some participants received exercise referrals based on risk assessment.[12,14,16-20,23-26,28,32,33,35-37] Furthermore, the systematic multifactorial interventions in these trials were extensive in their assessment and referrals; there was adherence drop-off at each step of the process, which may have diminished potential effectiveness. Optimal evaluation of the effectiveness of such multistep interventions may require more intensive monitoring and follow-up.

The trials of exercise interventions produced the most consistent evidence across multiple fall-related outcomes. The included exercise trials doubled in number compared with the previous review, and the conclusions are mostly similar.[75] There remained a statistically significant benefit of exercise to prevent falls, people with 1 or more falls, and injurious falls. In contrast to the previous review, there was no longer a statistically significant benefit of exercise to reduce the risk that an individual had an injurious fall. This change in conclusion for this 1 fall-related outcome and the discordance across falls-related outcomes cannot be readily explained, because the clinical and statistical heterogeneity in this body of evidence was substantial. Heterogeneity was explored by various trial, population, and intervention characteristics; these explorations found no patterns that suggested that any of these variables altered treatment effectiveness. Furthermore, 2 exercise trials reported within-study subgroup analyses for falls and/or fracture,

Table. Summary of Evidence for Multifactorial and Exercise Interventions

Intervention	No. of studies (No. of randomized participants)	Summary of findings	Consistency and precision	Strength of evidence[a]	Other limitations	Applicability
KQ1: Benefits of interventions						
Multifactorial	28 (27 784)	Falls: IRR, 0.84 (95% CI, 0.74-0.95); I^2 = 85.0% 20 Studies (n analyzed = 22 115)	Consistent, precise	Moderate for benefit	Heterogeneous assessment interventions and referrals Heterogeneous populations as reflected in wide variation in baseline falls risk; heterogeneous interventions; trials typically powered for falls and not other outcomes	Populations studied were older community-dwelling adults at both average and increased risk for falls; most participants were at increased risk based on history of previous fall Most studies took place outside the US, but results are generalizable Implementation of this multistep, complex intervention would be challenging in any setting Populations studied were largely those at increased risk of falls based on history of previous fall
		People with ≥1 falls: RR, 0.96 (95% CI, 0.91-1.02); I^2 = 48.2% 26 Studies (n analyzed = 23 626)	Inconsistent, imprecise	Low for no benefit		
		Injurious falls: IRR, 0.92 (95% CI, 0.84-1.01); I^2 = 21.8% 12 Studies (n analyzed = 10 563)	Inconsistent, imprecise	Low for no benefit		
		People with injurious falls: RR, 0.92 (95% CI, 0.83-1.02); I^2 = 47.3% 13 Studies (n analyzed = 13 460)	Inconsistent, imprecise	Low for no benefit		
		Fall-related fractures: IRR, 1.01 (95% CI, 0.81-1.26); I^2 = 34.0% 7 Studies (n analyzed = 15 211)	Inconsistent, imprecise	Low for no benefit		
		People with fall-related fractures: RR, 0.86 (95% CI, 0.60-1.24); I^2 = 49.0% 7 Studies (n analyzed = 13 912)	Inconsistent, imprecise	Low for no benefit		
Exercise	37 (16 117)	Falls: IRR, 0.85 (95% CI, 0.75-0.96); I^2 = 82.7% 29 Studies (n analyzed = 14 475)	Consistent, precise	Moderate for benefit	Heterogeneous populations as reflected in wide variation in baseline falls risk; heterogeneous interventions; trials typically powered for falls and not other outcomes Heterogeneous exercise interventions: individual vs group; multiple different exercise components administered; different program frequencies and durations	Applicable to older community-dwelling populations at both average and increased risk for falls; most participants in trials were at increased risk based on history of previous fall Applicable to interventions (individual physical therapy and exercise classes) typically available in the US No single exercise/physical therapy program protocol appears as a "best" model Nearly all programs include gait/balance/functional training and strength/resistance Adherence to exercise classes may be variable in real-world settings
		People with ≥1 falls: RR, 0.92 (95% CI, 0.87-0.98); I^2 = 24.3% 25 Studies (n analyzed = 13 384)	Consistent, precise	Moderate for benefit		
		Injurious falls: IRR, 0.84 (95% CI, 0.74-0.95); I^2 = 14.6% 12 Studies (n analyzed = 3984)	Consistent, precise	Low for benefit		
		Fall-related fractures: IRR, 0.81 (95% CI, 0.57-1.15); I^2 = 39.1% 8 Studies (n analyzed = 8537)	Inconsistent, imprecise	Low for no benefit		
		People with injurious falls: RR, 0.90 (95% CI, 0.79-1.02); I^2 = 26.7% 9 Studies (n analyzed = 3924)	Consistent, imprecise	Low for no benefit		
		People with fall-related fractures: RR range, 0.36 (95% CI, 0.15-0.89) to 1.95 (95% CI, 0.22-17.3) 4 Studies (n analyzed = 7994)	Inconsistent, imprecise	Insufficient		
KQ2: Harms of interventions						
Multifactorial	28 (27 784)	Harms: rare, minor, and associated with the exercise components 5 Studies (n analyzed = 4199)	Inconsistent, imprecise	Insufficient	Harms sparsely reported and often only reported in intervention group	Applicable to older community-dwelling populations at both average and increased risk for falls
Exercise	37 (16 117)	Harms: generally minor musculoskeletal adverse effects; serious adverse effects were generally very rare (<1%) 19 Studies (n analyzed = 6985)	Consistent, imprecise	Low for harm	Harms were sparsely reported and often only reported for the intervention group	Applicable to older community-dwelling populations at both average and increased risk for falls; most participants in trials were at increased risk based on history of previous fall Applicable to interventions (individual physical therapy and exercise classes) typically available in the US

Abbreviations: IRR, incidence rate ratio; KQ, key question; RR, relative risk.

[a] The review-of-reviews method adopted the strength of the overall body of evidence assigned within the primary systematic review. In most cases, these grades were based on the Grading of Recommendations Assessment, Development and Evaluation (GRADE) working group definitions, which consider study limitations, consistency of effect, imprecision, indirectness, and publication bias. Where strength of evidence grades were not available, the Evidence-based Practice Center approach was adapted to assign an overall strength of evidence grade based on consensus discussions involving at least 2 reviewers.

reporting no interaction by age, sex, history of falls, frailty, and/or cognitive impairment.[18,74]

Implementation Issues

Several factors should be considered in applying these findings to actual implementation in the US health care system. First, identifying persons at increased risk of falls who would be candidates for interventions remains a challenge. Simplified self-administered questionnaires are ideal for efficiency, such as history of falls or other primary care–feasible questionnaires/functional tests.[85,86] However, the use of falls history alone precludes prevention of the first fall. The trial populations were generally at increased risk for falls compared with national averages. Furthermore, the multifactorial trial populations were at even higher risk for falls compared with the exercise trial populations.

Second, implementation of exercise and multifactorial interventions in practice is predicated on replicability of trial intervention protocols. The exercise trials mostly consisted of multicomponent group exercise programs (24/36 trials); 9 trials involved individual programs similar to what is commonly available in the United States in the form of physical therapy referral. Most exercise trials included an additional unsupervised physical activity component. Exploration of heterogeneity suggested that primary care referrals for group community exercise programs and traditional office-based physical therapy are both effective. The types of exercise programs provided varied across the interventions; however, the most commonly evaluated program was the Otago Exercise Program, which was delivered fully or partially in 6 studies.[18,25,56,58,63,87] The next most commonly evaluated exercise programs delivered were tai chi exercise programs,[45,60,66,73] the Weight-bearing exercise for Better Balance program,[50,87,88] and the StandingTall program.[57,74]

Third, the multistep nature of multifactorial interventions makes adherence a logistical challenge. In the multifactorial trials, the individual treatment interventions—including physician specialty referrals, physical therapy/exercise, and environment interventions—were largely reflective of what patients could receive piecemeal in US primary care. The exercise interventions included in the multifactorial trials are similar to what US patients receive in their customized design; physical therapist delivery; and balance, gait, strength components. However, given time constraints in real-life practice, these referrals may or may not be delivered in such a comprehensive fashion, despite the introduction of the Medicare Initial and Annual Preventive Visits.[89] Adherence with multiple referrals and recommendations provided in a single visit may require case management for adherence.

Limitations of the Literature and Future Research Needs

Future research addressing multifactorial risk assessment interventions should evaluate interventions feasible in primary care and should provide detailed protocol descriptions. All future research studies need to monitor adverse effects consistently in the control and intervention groups. Several implementation issues need to be addressed, including equity issues affecting best practices for implementing multifactorial and exercise interventions in historically marginalized and medically underserved communities, and the need for methods to improve adherence in all populations. Future trials should recruit diverse participants representative of the US population. Additional trials are needed for multifactorial and exercise interventions in community-dwelling adults with mild cognitive impairment and mild dementia, osteoporosis, osteoarthritis, and sarcopenia. Any future research for multifactorial and exercise interventions in mixed-risk populations should report results stratified by risk category.

Limitations

This review had several limitations. First, the review was limited to trials with a primary or secondary aim to prevent falls and in which a falls outcome was reported, both to select interventions with biologic plausibility of reducing falls and for pragmatic purposes. Second, there are many subgroups of older adults to which these results may not apply. This review did expand the scope beyond the 2018 review to include older adults with mild cognitive impairment or mild dementia, osteoporosis, osteoarthritis, and sarcopenia. However, trials solely recruiting participants with major neurologic diagnoses (eg, moderate to severe dementia, Parkinson disease, stroke) were excluded because those populations may require specialized approaches to fall prevention. Third, consistent with the USPSTF methodology, health outcomes were prioritized. Intermediate functional outcomes (such as changes in balance, endurance, or walking speed), fall-efficacy scales, and fear of falling were excluded. Fourth, other non–fall-related health outcomes associated with these interventions were not examined (eg, the effect of exercise on cardiovascular or mental health outcomes).

Conclusions

Multifactorial and exercise interventions were associated with reduced falls in multiple good-quality trials. Exercise demonstrated the most consistent statistically significant benefit across multiple fall-related outcomes.

ARTICLE INFORMATION

Accepted for Publication: March 2, 2024.

Published Online: June 4, 2024. doi:10.1001/jama.2024.4166

Author Contributions: Dr Guirguis-Blake had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.
Concept and design: All authors.
Acquisition, analysis, or interpretation of data: All authors.
Drafting of the manuscript: All authors.
Critical review of the manuscript for important intellectual content: Guirguis-Blake, Perdue.
Statistical analysis: Guirguis-Blake, Perdue.
Administrative, technical, or material support: Perdue, Coppola, Bean.
Supervision: Guirguis-Blake.

Conflict of Interest Disclosures: None reported.

Funding/Support: This research was funded under contract HHSA75Q80120D00004, Task Order 75Q80121F32004, from the Agency for Healthcare Research and Quality (AHRQ), US Department of Health and Human Services.

Role of the Funder/Sponsor: Investigators worked with US Preventive Services Task Force (USPSTF) members and AHRQ staff to develop the scope, analytic framework, and key questions for this review. AHRQ had no role in study selection, quality assessment, or synthesis. AHRQ staff provided project oversight; reviewed the report to ensure that the analysis met methodological standards and distributed the draft for peer review. Otherwise, AHRQ had no role in the conduct of the study; collection, management, analysis, and interpretation of the data; and preparation, review, or approval of the manuscript findings. The opinions expressed in this document are those of the authors and do not reflect the official position

of AHRQ or the US Department of Health and Human Services.

Additional Contributions: We gratefully acknowledge the following individuals for their contributions to this project: Howard Tracer, MD, at the Agency for Healthcare Research and Quality; current and former members of the USPSTF who contributed to topic deliberations; and Melinda Davies, MAIS, and Jill Pope, BS, for technical and editorial assistance at the Center for Health Research. USPSTF members, peer reviewers, and federal partner reviewers did not receive financial compensation for their contributions.

Additional Information: A draft version of this evidence report underwent external peer review from 3 content experts (David Ganz, MD, PhD [VA Greater Los Angeles Healthcare System, UCLA, and RAND]; Manuel Montero-Odasso, MD, PhD [University of Western Ontario]; and Elizabeth Phelan, MD, MS [University of Washington; Harborview Medical Center]) and 4 federal partners (National Institute on Aging, National Institute on Minority Health and Health Disparities, National Institute of Child Health and Human Development, and the Office of Research on Women's Heath). Comments were presented to the USPSTF during its deliberation of the evidence and were considered in preparing the final evidence review.

Editorial Disclaimer: This evidence report is presented as a document in support of the accompanying USPSTF Recommendation Statement. It did not undergo additional peer review after submission to *JAMA*.

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