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BMJ Open

A practical and validated fall risk screening instrument for the primary care setting: A systematic review

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2020-045431
Article Type:	Original research
Date Submitted by the Author:	05-Oct-2020

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Keywords:	GENERAL MEDICINE (see Internal Medicine), PRIMARY CARE, PREVENTIVE MEDICINE, PUBLIC HEALTH

A practical and validated fall risk screening instrument for the primary care setting: A systematic review

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Abstract

Objective: Several fall risk screening instruments are available, however it is unclear which instrument is validated and most suitable for GP practices. This systematic review aims to identify the most suitable fall risk screening instrument(s) for the primary care setting (i.e. requires limited time, no expensive equipment and no additional space) with good predictive performance to assess fall risk among independently living older people.

Design: A systematic review.

Methods: An extensive search was conducted in the databases Pubmed, EMBASE CINAHL, Cochrana and PsycINFO. Twenty-seven out of 2492 articles published between January 2000 and July 2020 were included.

Results: Six fall risk screening instruments were identified; Timed-Up-and-Go test, Gait Speed test, Berg Balance Scale, Performance Oriented Mobility Assessment, Functional Reach test, Fall History. Most articles reported AUCs ranging from 0.5-0.7 for these instruments. Sensitivity and specificity varied substantially across studies (e.g. TUG, sens.: 10-83.3%, spec.: 28.4-96.6%).

Conclusions: Since the results showed that the predictive performance of none of the included fall risk screening instruments was sufficient when taking the threshold of Šimundić for good diagnostic accuracy (AUC>0.7) into account, other ways of screening for high fall risk among independently living older people in the primary care setting should be investigated. As for now, the most suitable way for assessing fall risk in the primary care setting appears to be asking about patient's fall history. Compared to the other five instruments, Fall History requires the least amount of time, no expensive equipment, no training, and no space (adjustments).

Key words: Fall prevention, Screening instrument, Predictive Performance, Primary Care, Review

Strengths and Limitations of this study

- This review is built on extensive literature regarding fall risk screening instruments suitable for the primary care setting and presentation of their predictive performance.
- We endeavoured to reduce bias by only including fall risk screening instruments that have been validated at least three times in different studies and by conducting risk of bias assessment.
- As different studies used different cut-off scores, modified versions of the same tests and presented different outcome measures, it was difficult to combine the results and to make a convincing conclusion.

Introduction

Worldwide, falls are the second leading cause of accidental or unintentional injury deaths [1]. On average, one in three people aged 65 and older fall at least once a year [2] and yearly an estimated 646,000 people die due to the consequences of a fall [1]. These numbers are increasing as society is aging [3]. The consequences of a fall can vary from a scratch or bruise to a hip fracture, brain injury or even death. Falls can have a huge negative long-lasting impact on the quality of life and self-management of older people [4-6]. Treatment and rehabilitation of fall incidences correlate with high costs in the health care sector [5, 7]. Therefore, the provision of fall prevention is important for older people.

Society is aging and older people live longer independently at home [3]. Their first port of call for health problems are general practitioners (GPs). The approach between GPs differs, some provide no fall preventive care at all while others might be very active regarding fall prevention. Only 20% of the older patients inform their GP about their falls which means that GPs do not know about the occurrence of 80% of the falls among their patients [8, 9]. Consequently, GPs are often unaware which of their patients are at risk of falls. This results in delayed or no treatment of fall risk among older people even though potentially effective fall-preventive interventions are available [10-14].

Early identification of high fall risk among older people is a prerequisite to provide adequate care in time to reduce fall risk. There are numerous screening instruments available to assess fall risk such as the Timed-Up-and-Go (TUG) test, the Tinetti Balance, the Berg Balance Scale (BBS) and the AGS/BGS/AAOS Guidelines. However, it is unclear which fall risk screening instruments have good predictive performance.

Due to high workload, primary care health providers have limited time. Furthermore, they have limited resources for expensive equipment (e.g. platforms, sensors) and in general little space in their practice [15, 16]. Therefore, a suitable fall risk screening instrument for GP practices should require limited time, no expensive equipment and no space adjustments. Hence, this systematic review aims to identify the most suitable (quick:<5 min, no expensive equipment or specific resources required) fall risk screening instrument(s) for the primary care setting with good predictive performance to assess fall risk among independently living older people.

Methods

Study selection

A systematic literature search was conducted in the databases Pubmed, EMBASE, Cinahl, Cochrane and PsycINFO using the search keywords presented in Figure 1 (see Supplementary File 1). Mesh terms were used when possible. Additional articles were included after snowballing. Figure 2 shows the flowchart of the literature search.

Figure 1. Search keywords

Figure 2. Flowchart literature search

Eligibility criteria and study selection

Articles, published between January 2000 and July 2020, were eligible when they met the in- and exclusion criteria presented in Figure 3. This review only included prospective studies to be able to summarize the predictive performances of fall risk screening instruments [17]. Additionally, only the screening instruments that have been assessed in at least three different studies were included in the final analysis to ensure validity of the included instrument as studies may differ, for example in selected population in age, sex, or frailty.

The first exclusion based on title was performed by WM. All articles from the second exclusion based on abstract were reviewed by WM. Additionally, JK, CL and IG each reviewed 67 articles of a sample of 200 articles from the second exclusion. As there was high agreement between the reviewers only the sample of 200 articles was reviewed independently by two reviewers to check if there were differences in scoring. For the third exclusion, WM reviewed all full texts and JK or CL or IG reviewed each one third of all full texts. Differences between reviewers were discussed until consensus was reached. In total, 26 articles were included in this study.

Quality appraisal

Quality of the included studies was assessed independently by two reviewers (WM together with JK, CL or IG) by using the Quality in Prognosis Study (QUIPS) tool [18, 19]. Articles are classified as having low quality (*) referring to high potential bias, moderate quality (**) referring to moderate potential bias or high quality (***) referring to low potential bias. The reviewers resolved differences by discussion until consensus was reached.

Figure 3. Eligibility criteria

Analysis

This review investigates the predictive performance of prognostic tests that predict the likelihood of developing a fall. The predictive performance of a prognostic test is often described similarly as for diagnostic tests, by examining diagnostic accuracy [17]. Diagnostic accuracy refers in this review to being able to discriminate between fallers and non-fallers correctly by using measures such as sensitivity, specificity and Area Under the Curve (AUC) [20]. Therefore, data regarding sensitivity, specificity and AUC were extracted from the articles and described.

Sensitivity refers to classifying the individual correctly of being at risk of falls, while specificity refers to classifying the individual correctly of not being at risk of falls [21]. A diagnostic test has good predictive value if sensitivity and specificity are >70% [22]. The AUC is the area under the receiver operating characteristic (ROC) curve which represents the accuracy of the test. With help of the ROC curve, the best cut-off score for the most optimal sensitivity and specificity can be chosen. The larger the AUC, the better the test. The accuracy of a diagnostic test is good or excellent if the AUC is >0.7 [20]. We ranked the outcomes, taken the cut-off values for good sensitivity, specificity and AUC into consideration, to be able to value the outcomes [20, 22].

Furthermore, when analysing the results, also criteria regarding suitable of the fall risk screening instrument for the primary care setting were taking into account. Primary health care providers have limited time due to a high workload. Also, they have limited resources for expensive equipment (e.g. platforms, sensors) and in general little space in their practice [15, 16]. Therefore, when analysing the results, the following criteria for a suitable instrument were taking into account; limited time, no expensive equipment and no space adjustments.

Patient and public involvement

Before conducting the systematic review, an informal focus group was conducted with primary care professionals, the end-users, to identify their needs and wishes regarding a fall risk screening instrument. In this study, their needs and wishes were taken into account when analysing the results regarding suitability of the fall risk screening instruments for the primary care setting.

Patients were not directly involved in this systematic review.

Results

The 27 included articles identified six fall risk screening instruments. All instruments are described below and presented in Table 1. More details about the included articles are provided in Supplementary File 2.

Timed Get up and Go test

The Timed Get Up and Go (TUG) test takes only a few minutes to complete and was described in 13 studies [23-36]. Participants are asked to stand up from a chair, walk 3 meters, turn, walk 3 meters back and to sit down again. The time measured to conduct this task indicates high or low fall risk. The reported cut-off scores varied from 10.9 to 13 seconds. Eleven studies described the AUC which varied from 0.46 to 0.89. Sensitivity varied from 10% to 83.3% and specificity varied from 28.4% to 96.6% in eight studies.

Gait Speed test

The Gait Speed test, on a distance of 4m, takes only a few minutes to complete and was evaluated in four studies [27, 37-39]. Participants are asked to walk 4m at usual pace. The time to complete the task is recorded and gait speed is calculated (m/s). The studies of Bongers et al. [37] and Tsutsumimoto et al. [38] showed AUCs of 0.5 and 0.77, respectively. Kang et al. [27] investigated the AUC for different follow up periods and for any or recurrent falls, which varied from 0.54 to 0.68. Sensitivity and specificity were reported in two studies [38, 39] which varied from 38.4% to 100% and 23.9% to 84.7% respectively, depending on the cut-off scores.

Berg Balance Scale

The Berg Balance Scale (BBS) evaluates the participants balance based on 14 items with a 5 point-Likert scale and takes 15-20 minutes to complete. The score for each item varies from 0-4 points with an overall maximum score of 56 points. Balance is evaluated by asking the participant to perform different sitting, transferring and standing positions. The study of Muir et al. [40] evaluated what cut-off scores of the BBS predicted the risk of falling the best by making a difference between a single and multiple falls. They found

162 **Table 1.** Included fall risk screening instruments

Instrument	Authors and year	Suitability	N	Cut-off score	AUC (95%CI)	Sens	Spec	Quality
TUG test	Kojima et al., 2015 [28]	Time: <5min. Space: ±4 m. Tools: Stopwatch, chair, tape-measure Training required: Yes	259	12.6 s	0.58	0.305	0.895	**
	Chow et al., 2019 [36]		192	12 s	0.54	0.706 (0.562-825)	0.284 (0.211-0.366)	**
	Alexandre et al., 2012 [23]		60	12.47 s	0.68 (0.54-0.83)	0.737	0.658	**
	Wrisley et al., 2010 [35]		35	12.34 s	0.89	0.833	0.966	***
	Pai et al., 2010 [32]		13		0.46	0.50 (0.09-0.91)	0.56 (0.40-0.96)	**
	Bongue et al., 2011 [24]		1759	10.9 s	0.54 (0.52-0.57)			**
	Lin et al., 2004 [29]		1200		0.61			**
	Russel et al., 2008 [33]		344		0.63 (0.57-0.69)			**
	Hofheinz et al., 2016 [25]		120		0.58			**
	Melzer et al., 2010 [30]		98		0.57			***
	Trueblood et al., 2001 [34]		180			0.1	0.95	**
	Ollsen Möller et al., 2012 [31]		153	≥12-13 s at 6 months follow up		0.67	0.50	*
				≥12-13 s at 12 months follow up		0.78	0.37	
	Kang et al., 2017 [27]		619	>10.2 s	0.603 (0.545-0.661)			**
	Kang et al. 2018 [26]			any falls	0.607 (0.549-0.665)			**
				any falls	0.642 (0.584-0.700)			
				recurrent falls	0.688 (0.602-0.773)			
			541	recurrent falls, cut-off 10.15 s	0.733 (0.645-0.821)	0.675	0.563	
Gait speed (4m)	Tsutsumimoto et al., 2013 [38]	Time: <5 min.	59	0.67m/s	0.77 (0.62-0.92)	0.82	0.71	**
	Bongers et al., 2015 [37]		352		0.5			**

	Verghese et al., 2002 [39]	Space: ± 5 m.	59	≥12 s		1	0.239	***
				≥14 s		0.769	0.565	
				≥18 s		0.384	0.847	
	Kang et al., 2017 [27]	Tools: Stopwatch, tape- measure Training required: Yes	541	any falls	0.563 (0.504-0.622)			**
				any falls	0.586 (0.526-0.647)			
				recurrent falls	0.542 (0.445-0.639)			
				recurrent falls	0.680 (0.593-0.768)			
Berg Balance Scale (BBS)	Muir et al., 2008 [40]	Time: 15-20 min. Space: ± 1-2 m. Tools: Stopwatch, 2 chairs, tape- measure, step bench Training required: Yes	187	≤53 (for multiple falls)	0.68	0.69 (0.50-0.81)	0.57 (0.47-0.66)	**
				≤54 (for any fall)	0.59	0.61 (0.50-0.72)	0.53 (0.43-0.63)	
				≤45 (for multiple falls)		0.42 (0.26-0.61)	0.87 (0.79-0.92)	
				≤45 (for any falls)		0.25 (0.16-0.36)	0.87 (0.79-0.92)	
	Melzer et al., 2010 [30]		98	≤52	0.47			***
	Ersoy et al., 2009 [41]		125	≤48		0.686	0.756	*
POMA-Balance	Faber et al., 2006 [43]	Time: ± 10 min. Space:	72	10		0.640 (0.445-0.798)	0.661 (0.530-0.771)	**
	Trueblood et al., 2001 [34]		180	10		0.24	0.91	**

	Bizovska et al., 2018 [42]	± 1-2 m. Tools: chair without handrails Training required: Yes	131	NR, multiple fallers vs non-fallers	0.659	0.89	0,47	**
	Verghese et al., 2002 [39]		59	≤8		0.076	0.913	***
				≤9		0.23	0.804	
				≤10		0.615	0.695	
POMA-Gait	Trueblood et al., 2001 [34]	Time: ±10 min. Space: ± 1-2 m. Tools: obstacle-free corridor or space Training required: Yes	180	9		0.21	0.95	**
	Faber et al., 2006 [43]		72	9		0.64 (0.445-0.798)	0.625 (0.494-0.74)	**
	Bizovska et al., 2018 [42]		131		NR because NS			**
Functional Reach (FR)	Lin et al., 2004 [29]	Time: <5 min. Space: ± 1-2 m. Tools: Tape-measure Training	1200		0.509			**
	Russel et al., 2008 [33]		344		0.60 (0.54-0.66)			**
	Murphy et al., 2003 [44]		50	8in.		0.73	0.88	*

		required: Yes						
Fall history	Tiedemann et al., 2010 [49]	Time: <2 min. Space: N.a. Tools: None Training required: No	362	≥1 fal in the previous year	0.71	0.69 (0.57-0.78)	0.63 (0.57-0.69)	**
	Nitz et al., 2013 [48]		449	History of multiple falls, n.f.s.	0.64			**
	Gerdhem et al., 2005 [46]		984	1 fall In the previous year		0.39	0.82	**
				≥2 falls in the previous year compared to ≤ 1 fall		0.46	0.8	
	Coll-Planes et al., 2006 [45]		192	≥1 fall in the previous year		0.595	0.645	**
	Lindemann et al., 2008 [47]		65	≥1 fall in the previous year		0.63	0.77	**

Quality assessed with QUIPS tool: * High bias, ** Moderate Bias, *** Low Bias an AUC of 0.68 for multiple falls with a cut-off score ≤53 and an AUC of 0.59 for a single fall with a cut-off score ≤54. Melzer et al. [30] found a lower AUC of 0.47. Muir et al. [40] and Ersoy et al. [41] also reported sensitivity and specificity which varied from 25% to 69% and 53% to 87% respectively.

The Tinetti tests

The Tinetti tests are widely used tests to assess fall risk, however there are many variations. One is the Performance Oriented Mobility Assessment (POMA) - Total. This test consists of two components to assess balance (POMA-B) and gait (POMA-G) and takes about 20 minutes to complete. For the POMA-B test, which was assessed in four studies [34, 39, 42, 43], the participant is asked to perform nine different movements to assess balance. Depending on the cut-off scores, sensitivity and specificity varied from 23% to 89% and 47% to 91.3% respectively. An AUC of 0.66 was reported by Bizovska et al. [42], however the cut-off scores were not specified and the comparison was about multiple fallers, excluding single time fallers. The POMA-G asks the participant to perform six different movements to assess gait. The POMA-G suggests to conduct the test in a corridor. Only the study of Bizovska et al. [42] specified the space they used for this test, which was a 30 metre well-lit corridor. Faber et al. [43] and Trueblood et al. [34] reported sensitivities and specificities ranging from 21% to 64% and from 63% to 95% respectively. Bizovska et al. [42] did not report any specific results as they did not find any significant differences between the fallers and non-fallers in relation to the POMA-G.

The Functional Reach test

The Functional Reach (FR) test was validated in three studies [29, 33, 44]. Participants are asked to hold their arms in front of them in an angle of 90 degrees, stretch forward as far as possible and to go back to the beginning position. The distance between beginning position and stretched position is measured which indicates high or low fall risk. This test takes less than 5 minutes to complete. The AUC was reported in two studies [29, 33] and varied from 0.51 to 0.60. Murphy et al. [44] mentioned a sensitivity and specificity of 73% and 88% respectively.

Fall History

Five studies explored the accuracy of Fall History [45-49], which takes only a few minutes to assess. In these five studies, Fall History had different definitions. The most used definition was at least one fall in the previous year. The AUC was investigated by Tiedemann et al. [49] and Nitz et al. [48] which varied from 0.64 to 0.71. Sensitivity and specificity were explored in four studies and varied from 39% to 69% and from 63% to 82%, respectively.

Quality Appraisal

The methodological quality was assessed of all articles and is presented in Table 1. Three articles were classified as high quality, 21 articles as moderate quality and three articles as low quality.

Discussion

The aim of this study was to identify the most suitable fall risk screening instrument(s) for the primary care setting (i.e. requires limited time, no expensive equipment and no additional space) with good predictive performance to assess fall risk among independently living older people. This systematic review identified six fall risk screening instruments for the primary care setting. The fast majority of the included studies identified the fall risk among older people over a period of 12 months (range 6 month – 9 years). None of the six fall risk screening instruments appear to be adequate in discriminating between people with and without a high fall risk, when taking the thresholds of Šimundić [20] for good diagnostic accuracy (AUC>0.7) into account. These findings did not alter when only taking the moderate and high quality articles into account. Four studies did report an AUC > 0.7 for the TUG test [26, 35], Gait Speed test [38] and Fall History [49], indicating good diagnostic accuracy [20]. However, most articles reported AUC's ranging from 0.5 to 0.7, indicating insufficient diagnostic accuracy for all included instruments. Furthermore, sensitivity and specificity of the same instrument varied substantially across studies, refraining us from making a convincing conclusion.

The results of this review are also acknowledged by others. For example, even though the TUG test is widely used to assess fall risk, other studies also showed the lack of predictive ability of the TUG test regarding falls [50, 51]. Furthermore, the study of Gates et al. [52] stated "*At present, recommending any screening test for routine clinical use is not possible. Despite the number of studies that have been conducted, no strong evidence exists that any screening test is useful for identifying fallers.*" With the current systematic review, eleven years after the review of Gates et al. [52], we have to conclude the same. Conclusive evidence to identify a fall risk screening instrument with adequate predictive performance and accuracy is still lacking.

Since choice based on predictive performance ability is not possible, suitability for the primary care setting prevails as for now. Primary health care providers have limited time and lack resources for expensive equipment, room or training [15, 16]. Considering this, the most suitable instrument identified in this review appears to be patient's Fall History as it takes only a few minutes to conduct and requires no training, expensive equipment or space (adjustments). The BBS and the Tinetti test would not be suitable as they take 15-20 minutes to complete and require training to conduct. The TUG and Gait Speed tests both are quick (< 5min.), but they require training and space to conduct (>4 metre). The FR test is quick (< 5min.) and does not require much space, however it requires more training compared to Fall History and the reported AUCs are also lower compared to Fall History.

Even though the diagnostic accuracy of Fall History is insufficient, it is the same or even better than that of most of the other five fall risk screening instruments, see Table 1. Barker et al. [53] also found that Fall History appears to be a suitable screening instrument when exploring the clinometric evaluation of four fall risk assessment tools. They stated that "*the predictive validity of all tools was found to be low, with no tool offering greater ability to identify residents who would fall than a simple screening question 'has the resident fallen in the past 12 months?"*. In addition, Fall History is used in many multifactorial assessment tools and algorithms and appears to be an important risk factor for fall risk (OR: NS-14.02) [41, 46, 48, 54-61]. Nevertheless, by using only patient's Fall History as a screening instrument, first time fallers will not be discovered. This certainly is a huge disadvantage. However, older people might be less willing to start and complete fall prevention interventions when they did not experience a previous fall. They often do not associate themselves with having a high fall risk. Hence, the experience of a previous fall might influence motivation to start and complete a fall prevention intervention.

According to the study of Nordin et al. [62], screening for fall risk with clinical judgement as well as Fall History among their population of frail older people was superior to performance-based measures. Meyer et al. [63] even stated that fall risk screening instruments should be avoided "*since it has no clinical consequences other than the waste of scarce nursing resources*". Due to the increasing work pressure and lack of awareness, health care professionals might not assess a patient's fall risk when it is based on clinical judgement alone as it is not part of a systematic screening strategy. Systematically screening for fall risk by using patient's Fall History together with the health care professional's expertise might therefore be an adequate screening strategy.

Practice recommendations

In daily practice, GPs can ask their older patients during a consultation if they had a fall during the past 12 months. Even if the patient says 'no', the GP might still notice a high fall risk, e.g. due to walking or sitting difficulties etc. If the GP suspects high fall risk after this brief screening, (s)he can investigate the underlying cause of the fall risk by conducting a multifactorial assessment so adequate care can be offered. Depending on the organization of the GP practice, the GP could also refer the patient to another health care provider, such as the practice nurse specialized in elderly care, who might have more time to investigate the underlying cause of the fall risk. By conducting a brief fall risk screening that leads to a comprehensive multifactorial assessment, followed up with multifactorial interventions that tackle the identified risk factors, a patient's fall rate can be reduced [64-66].

Strengths and Limitations

The results from this review were difficult to combine. Different studies used different cut-off scores, modified versions of the same tests and presented different outcome measures. These differences between studies made it difficult to give a convincing conclusion of the results.

Since we have included at least three studies for each instrument, conducting a meta-analysis for each instrument seems feasible. However, we did not conduct a meta-analysis for two reasons. First, the diversity between studies that assessed the same instrument was large, e.g. differences in cut-off scores, follow-up periods, study population (sex, age, in/exclusion criteria) and quality differences. This made a meta-analysis unsuitable for most instruments. Second, the results from our study are already clear without conducting a meta-analysis, namely none of the six identified instruments appear to be adequate in discriminating between people with and without a high fall risk, when taking the thresholds of Šimundić [20] for good diagnostic accuracy (AUC>0.7) into account. Another limitation is the possibility of publication bias of studies with worse outcomes, which might have led to an overestimation of the predictive performance of the included screening instruments. Nevertheless, these limitations support our conclusion that none of the included instruments has sufficient predictive performance.

Further Research

The underlying cause of falls is complex. This makes it difficult, if not impossible to adequately identify people with high fall risk with only a physical test or a short questionnaire. None of the fall risk screening instruments identified in this review are able to identify older people with high fall risk adequately. Therefore, other ways of screening for high fall risk among independently living older people in the primary care setting should be studied. To improve predictive performance of a fall risk screening instrument, it might help to develop an instrument that takes a person's behaviour and environment into account.

Overall, the results from this systematic review show that the predictive performance of the six identified fall risk screening instruments is insufficient. Overall, patient's Fall History appears to be the same or even better than the other five fall risk screening instruments. In addition, this instrument is most suitable for the primary care setting as it is quick and does not require equipment, space or training. Patients' Fall History together with a health care professional's clinical judgement, might be a promising strategy for the primary care setting to identify older people with high fall risk. When older people with a high fall risk are identified, they can be offered adequate fall preventive care. This could reduce falls and fear of falling, which might lead to maintained or improved quality of life and prolonged autonomy of older people.

List of abbreviations

GP: General Practitioner

QUIPS: Quality in Prognosis Study

AUC: Area Under the Curve

ROC: Receiver Operating Characteristic

TUG: Timed-Up-and-Go

BBS: Berg Balance Scale

POMA-B: Performance Oriented Mobility Assessment-Balance

POMA-G: Performance Oriented Mobility Assessment-Gait

FR: Functional Reach

Declarations

Ethics approval and consent to participate

Ethics approval is not required for this literature review.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors have no conflicts of interests to declare.

Funding

This work was supported by ZonMw ,the Netherlands organization for health research and development [grant number 531001210]. The funder had no role in the creation of the research question, design of the study, data collection, analysis, interpretation, or in the writing of this manuscript.

Author Contributions

WM conducted the systematic review and wrote the manuscript. JK, CL and IG reviewed articles for inclusion, reviewed the quality check, and provided feedback on the manuscript. All authors read and approved the final manuscript.

Acknowledgements

Not applicable.

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Figure Legends

Figure 1. Search keywords

Figure 2. Flowchart literature search

Figure 3. Eligibility criteria

Figure 1. Search keywords

(Frail Elderly[Mesh] OR Aged[Mesh] OR Frail Elderly* OR Aged*)
AND
(Accidental Falls[Mesh] OR Accidental Falls*OR Falls*)
AND
(Risk Assessment[Mesh] OR Prognosis[Mesh] OR Diagnosis[Mesh] OR Risk Assessment* OR Prognosis* OR Diagnosis* OR Screening* OR Prediction*)
AND
(Specificity and Sensitivity[Mesh] OR Data Accuracy[Mesh] OR Sensitivity* OR Specificity* OR Accuracy* OR Validity*)

Figure 1. Flowchart Literature Review

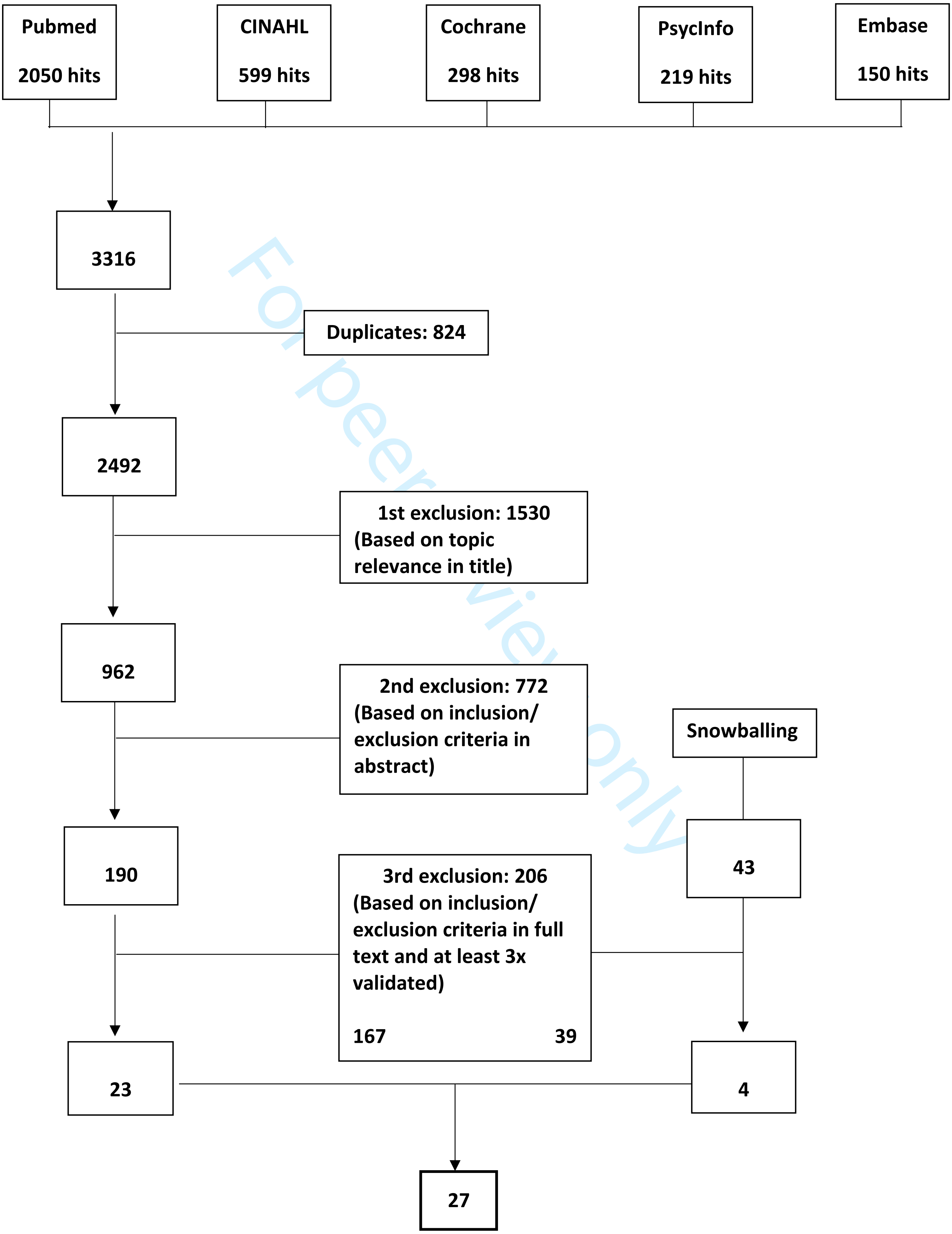

Figure 3. Eligibility criteria

Articles were included when they met the following inclusion criteria:

1. Prospective studies in which the primary or secondary purpose was to evaluate the performance of one or more fall risk instruments for predicting fallers.
2. The participants were older people living in the community or substantially independently
3. Full articles published in English, Dutch or German

Articles were excluded when they met one or more of the following exclusion criteria:

1. Fall risk screening instruments which require expensive computer software programs, other advanced expensive software or instruments not available in usual primary care units (e.g. sensors, electronical platforms, force plates).
2. Literature reviews and studies with no follow up of fall incidents.
3. No reported Area Under the Curve (AUC), sensitivity or specificity of the fall risk screening instruments.
4. Screening instruments specifically developed for or only tested on populations with a specific disease (e.g. cancer, diabetes, Parkinson etc.)
5. The participants were living in hospital or other institutionalised settings

Additional file 1

Recent queries in pubmed
Search,Query,Items found,Time

#1,"Search (((((""Aged""[Mesh]) OR ""Frail Elderly""[Mesh] OR Aged* OR Frail Elderly* OR Elderly*)) AND (""Accidental Falls""[Mesh] OR Accidental Falls* OR Falls*)) AND (((""Risk Assessment""[Mesh]) OR ""Diagnosis""[Mesh]) OR ""Prognosis""[Mesh] OR Risk Assessment* OR Diagnos* OR Prognos* OR Screen* OR Predict*)) AND (((""Sensitivity and Specificity""[Mesh]) OR ""Reproducibility of Results""[Mesh]) OR ""Data Accuracy""[Mesh] OR Sensitivity* OR Specificity* OR Accuracy* OR Reliab* OR Valid*) Filters: Full text Publication date from 2000/01/01 to 2020/07/01 Field: Title/Abstract",1956,03:40:44

Additional file 2.

Overview characteristics included articles

Author	N	Age	Gender	Exclusion	Inclusion	Follow up in months	Included instrument
Alexandre et al., 2012 [23]	60	≥60 (60-82)	29 men/ 31 women	PD, history of transitory ischemic attack, stroke, cognitive impairment, wheelchair, fall in the previous 6 months	n.a.	12 months	TUG test
Bizovska et al., 2018 [42]	131	≥60 (mean 70.8, SD 6.7)	23 men/ 108 women	Any injury or surgery on the musculoskeletal system during the last two years before the baseline measurement	Aged ≥60; ii) no known neurological or musculoskeletal problem that may affect gait or balance abilities; iii) ability to stand and walk without any assistance and assisting device	12 months	POMA-B POMA-G
Bongers et al., 2015 [37]	352	≥70 (mean 76.2 (SD 4.3)	all women	too ill to be screened by GP, currently receiving treatment from geriatrician or received comprehensive geriatric assessment in past 3 months	n.a.	12 months	Gait speed
Bongue et al., 2011 [24]	1759	≥65 (65-95, 70.7 (SD 4.6))	862 men/ 897 women	neurological disease, cognitive impairment, unable to understand French or follow simple commands	n.a.	12 months	TUG test
Chow et al., 2019 [36]	192	≥65 (average: 74.4)	81 men/ 111 women	n.a.	aged ≥65, being discharged from the ED, English speaking, had capacity to give consent, and personally identified a risk factor for falling (if a patient reported that they had either fallen in the last year, worried about falling, or admitted that they felt unsteady when standing or walking)	6 months	TUG test
Coll-Planas et al., 2006 [45]	192 (268 with 76 drop-outs)	≥65 (89 >83 years, 103 ≤83 years)	34 men/ 158 women	living in nursing home	Community dwelling elderly aged ≥65	12 months	Fall History
Ersoy et al., 2009 [41]	125	≥50 (50-79, 61.4 (SD 7.9)	all women	unable to walk without assistance or aids	postmenopausal community dwelling women aged 50+	6 months	BBS

Faber et al., 2006 [43]	72 (total 245)	84.9 (SD 6.0) (of total 245)	14 men/ 58 women	in ability to walk 6m with(out) aids, capacity to understand instructions, medical contraindications to participate, cognitive impairment	n.a.	10 months	POMA-B POMA-G
Gerdhem et al., 2005 [46]	984	75 (75.01-75.99)	all women	n.a.	community dwelling women aged 75 in Malmö	12 months	Fall History
Hofheinz et al., 2016 [25]	120	≥60 (60-87, 72.2 (SD 6.8)	26 men/ 94 women	cognitive limitations, neurological or musculoskeletal diagnose	able to walk 10m with(out) aid, able to understand instructions, able to carry glass in one hand	12 months	TUG test
Kang et al., 2017 [27]	541	≥60 (67.4 (SD 5.6))	234 men/ 307 women	Inability to perform the basic activities of daily living and thus could not complete performance-based assessments; visual impairments; current use of drugs (psychotropic drugs, cardiovascular drugs, hypoglycemic agents, non-steroidal anti-infammatory drugs, analgesics, dopaminergic drugs, PD's drugs or more than four kinds of complex drugs).	Aged ≥60 years and joined the China's national free physical examination programs	12 months	TUG test Gait Speed
Kang et al., 2018 [26]	619	≥60 (60-86, 67.4 (SD 5.6))	262 men/ 357 women	Severe functional impairment, current use of sedative drugs, antiepileptic drugs ans so on, refusal to participate in the follow-up of this study	Aged ≥60, who joined the free physical examination program	12 months	TUG test
Kojima et al., 2015 [28]	259	≥65 (72.6 (SD 5.9)	95 men/ 164 women	≥3 falls in past year, unstable medical conditions, already exercising 150min/week	aged ≥65 able to walk independently and participate in group exercise	6 months (24 weeks)	TUG test
Lin et al., 2004 [29]	1200	≥65 (73.4 (SD=NR)	709 men/ 491 women	NR	NR	12 months	TUG test FR test
Lindeman et al., 2008 [47]	65	≥65 (67.7 (SD 6.0))	33 men/ 32 women	use of walking aid, self-reported neurological disorders, or spinal or lower extremity joint pain interacting with stepping performance, inability to come to the research department without help, cognitive impairment	community dwelling elderly aged ≥65	12 months	Fall History

Melzer et al., 2010 [30]	98	≥65 (65-91, 78.4 (SD 5.7))	26 men/ 72 women	serious visual impairment; inability to ambulate independently; cognitive impairment; severe focal muscle weakness or paralysis; severe peripheral or compression/entrapment neuropathies; symptomatic orthostatic hypotension, respiratory, cardiovascular, musculoskeletal or neurological disorders that might have interfered with participation in the exercise program; cancer, metastatic or under active treatment; and use of medication known to impair balance or strength.	n.a.	12 months	TUG test BBS
Muir et al., 2008 [40]	187	≥47 (47-90, 79.4 (SD 5.83))	122 men/ 65 women	n.a.	community dwelling veterans of WWII and the Korean War residing in 3 regions of southwestern Ontario	12 months	BBS
Murphy et al., 2003 [44]	50	≥60 (72.3 (SD 8.6))	13 men/ 37 women	no exclusion based on disease	community dwelling elderly aged ≥60	14 months	FR test
Nitz et al., 2013 [48]	449	≥40 (40-80, 59.3 (SD 10.6))	all women	n.a.	independently mobile and cognitively competent women from the electoral rool in North Brisbane Health district	108 months (9 year)	Fall History
Ollsen Möller et al., 2012 [31]	153	≥65 (66-94, 81.5 (SD 6.3))	51 men/ 102 women	n.a.	Age ≥65, living in the municipality where the study was conducted; needing help with at least two activities of daily living (ADL); admitted to hospital at least twice or with at least four contracts with outpatient or primary healthcare during the previous 12 months; being able to communicate verbally and have not cognitive impairments (i.e. ≥25 MMSE)	12 months	TUG test

Pai et al., 2010 [32]	13	≥65 (65-85, 72 (SD 5))	9 men/ 4 women	musculoskeletal, neurological, cognitive or other systemic disorders, osteopenic or osteoprotic, cognitive impairment, symptomatic postural hypotension	ambulatory community dwelling elderly	29-32 months	TUG test
Russell et al., 2008 [33]	344	≥60 (75.9 (SD 8.5)	106 men/ 238 women	n.a.	community dwelling elderly aged ≥60 presented to an ED as a result of a fall being directly discharged home following emergency care and able to walk independently	12 months	TUG test FR test
Tiedemann et al., 2010 [49]	362	≥74 (74-98, 80.25 (SD=4.5))	128 men/ 234 women	blindness, minimal English language skills, and cognitive impairment	community dwelling elderly aged 63-95 resided in Sydney, Australia	12 months	Fall History
Trueblood et al., 2001 [34]	180	≥60 (60-96, 77.9 (SD 7.26))	37 men/ 143 women	cognitive deficits, underlying neurological problems	aged ≥60, able to stand for 5 min. without aid, able to walk 40 feet at one time without aid.	6 months	TUG test POMA-B POMA-G
Tsutsumimoto et al., 2013 [38]	59	≥65 (Non-fallers 84.0 (SD 1.1) 85.5 (SD 1.4))	11 men/ 48 women	very severe cardiac, pulmonary, musculoskeletal, or neuropathological disorders associated with inability to step safely, cognitive impairment	community-dwelling older people receiving long-term care services aged ≥65, able to walk independently, and having adequate hearing and vision	12 months	Gait Speed
Verghese et al., 2002 [39]	59	≥65 (Nonfallers 79.7 (SD 6.6) Fallers 79.4 (SD 5.7))	25 men/ 34 women	severe visual loss interfering with completion of neuropsychological tests, non-English or non-Spanish speaking, institutionalization, healthy enough to make a clinic visit	community dwelling elderly aged ≥65	12 months	Gait Speed POMA-B

Wrisley et al., 2010 [35]	35	60-90 (72..9 (SD 7.8))	17 men/ 18 women	cognitive impairment, history of osteoporosis, recent fractures, or lower-extremity surgery; history of progressive neuromuscular disorder; history of whiplash, neck injury, or current complaints of neck pain; history of unstable agina or uncontrolled cardiorespiratory problems; taking any medications that might affect balance; history of any fall in past 6 months and more than one fall in the last year; pain in any segment greater than 2/10 on a 10-point verbal analog scale; not returning the monthly fall calendar	community dwelling elderly aged 60-90 able to stand independently longer than 1 min.	6 months	TUG test

PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	Title, page 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.	Abstract, page 2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	Background, page 3
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	PICO: Background, page 3 S: Methods, Analysis/Figure 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.	N/A
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.	Methods, Figure 3
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	Methods, Study selection
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	Methods, Figure 1
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	Methods, Eligibility criteria and study selection
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	Methods, Eligibility

PRISMA 2009 Checklist

			criteria and study selection
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	Methods, Analysis
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	Methods, Quality appraisal
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	N/A
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.	N/A

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	N/A
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	N/A
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	Methods, Figure 2
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	Additional File 2
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	Results, Table 1
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	N/A
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	N/A
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	N/A
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	N/A
DISCUSSION			

PRISMA 2009 Checklist

Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	Discussion, page 8-10
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	Discussion, Limitations
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	Discussion, page 8-10
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	Declarations, Funding

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

For more information, visit: **www.prisma-statement.org**.

Page 2 of 2

A practical and validated tool to assess fall risk in the primary care setting: A systematic review

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2020-045431.R1
Article Type:	Original research
Date Submitted by the Author:	12-Mar-2021
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Primary Subject Heading:	General practice / Family practice
Secondary Subject Heading:	Public health
Keywords:	GENERAL MEDICINE (see Internal Medicine), PRIMARY CARE, PREVENTIVE MEDICINE, PUBLIC HEALTH

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A practical and validated tool to assess fall risk in the primary care setting: A systematic review

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Abstract

Objective: Several fall risk assessment tools are available, however it is unclear which tool is validated and most suitable for GP practices. This systematic review aims to identify the most suitable fall risk assessment tool(s) for the primary care setting (i.e. requires limited time, no expensive equipment and no additional space) with good predictive performance to assess fall risk among independently living older people.

Design: A systematic review based on prospective studies.

Methods: An extensive search was conducted in the databases Pubmed, EMBASE, CINAHL, Cochrane and PsycINFO. Tools were excluded when they require expensive and/or advanced software not available in usual primary care units and if they were not validated in at least three different studies. Twenty-seven out of 2492 articles published between January 2000 and July 2020 were included.

Results: Six fall risk assessment tools were identified; Timed-Up-and-Go test, Gait Speed test, Berg Balance Scale, Performance Oriented Mobility Assessment, Functional Reach test, Fall History. Most articles reported AUCs ranging from 0.5-0.7 for these tools. Sensitivity and specificity varied substantially across studies (e.g. TUG, sens.: 10-83.3%, spec.: 28.4-96.6%).

Conclusions: Since the results showed that the predictive performance of none of the included fall risk assessment tools was sufficient (AUC<0.7), other ways of assessing high fall risk among independently living older people in the primary care setting should be investigated. As for now, the most suitable way for assessing fall risk in the primary care setting appears to be asking patients about their fall history. Compared to the other five tools, Fall History requires the least amount of time, no expensive equipment, no training, and no space (adjustments). Nonetheless, the health care professional's clinical judgement remains most important as (s)he can still identify a high fall risk based on clinical judgement even though the patient has no fall history.

Key words: Fall prevention, Fall risk assessment tools, Predictive Performance, Primary Care, Review

Strengths and Limitations of this study

- This review is built on extensive literature regarding fall risk assessment tools suitable for the primary care setting and presentation of their predictive performance.
- We endeavoured to reduce bias by only including fall risk assessment tools that have been validated at least three times in different studies and by conducting risk of bias assessment.
- As different studies used different cut-off scores, modified versions of the same tools and presented different outcome measures, it was difficult to combine the results and to make a convincing conclusion.

Introduction

Worldwide, falls are the second leading cause of accidental or unintentional injury deaths [1]. On average, one in three people aged 65 and older fall at least once a year [2] and yearly an estimated 646,000 people die due to the consequences of a fall [1]. These numbers are increasing as society is aging [3]. The consequences of a fall can vary from a scratch or bruise to a hip fracture, brain injury or even death [4, 5] . Falls can have a huge negative long-lasting impact on the quality of life and self-management of older people [4-6]. Treatment and rehabilitation of fall incidences correlate with high costs in the health care sector [5, 7]. Therefore, the provision of fall prevention is important for older people.

Society is aging and older people live longer independently at home [3]. Their first port of call for health problems are general practitioners (GPs). The approach between GPs differs, some provide no fall preventive care at all while others might be very active regarding fall prevention. Only 20% of the older patients inform their GP about their falls which means that GPs do not know about the occurrence of 80% of the falls among their patients [8, 9]. Consequently, GPs are often unaware which of their patients are at risk of falls. This results in delayed or no treatment of fall risk among older people even though potentially effective fall-preventive interventions are available [10-14].

Early identification of high fall risk among older people is a prerequisite to provide adequate care in time to reduce fall risk. There are numerous tools available to assess fall risk such as the Timed-Up-and-Go (TUG) test, the Tinetti Balance, the Berg Balance Scale (BBS) and the American Geriatrics Society/British Geriatrics Society clinical practice guidelines. Gates et al. (2008) summarized in a previous review the accuracy of screening tools for predicting risk of falling in community-living older adults. Gates et al. concluded that there was insufficient evidence to show that any screening instrument was adequate for predicting falls. Also, no implications for practice were provided or taken into account when reporting the results. Therefore, it is still unclear which fall risk assessment tools have good predictive performance and might be suitable for practice.

Due to high workload, primary care health providers have limited time [15, 16]. Furthermore, they have limited resources for expensive equipment (e.g. platforms, sensors) and in general little space in their practice [17-20]. Therefore, a suitable fall risk assessment tools for GP practices should require limited time, no expensive equipment and no space adjustments. Hence, this systematic review aims to identify the most suitable (quick:<5 min, no expensive equipment or specific resources required) fall risk assessment tool(s) for the primary care setting with good predictive performance to assess fall risk among independently living older people.

Methods

Study selection

A systematic literature search was conducted in the databases Pubmed, EMBASE, CINAHL, Cochrane and PsycINFO using the search keywords presented in Figure 1 (see Additional File 1). Mesh terms were used when possible. Additional articles were included after snowballing. Figure 2 shows the flowchart of the literature search.

Figure 1. Search keywords

Figure 2. Flowchart literature search

Eligibility criteria and study selection

The proportion of older people is increasing and the current population of older people age differently compared to 20 years ago (e.g. people get older, more chronic diseases) [21, 22]. Because it is important that suitable fall risk assessment tools are validated in the current population of older people, articles published between January 2000 and July 2020 were included when they met the in- and exclusion criteria presented in Figure 3.

This review only included prospective studies to be able to summarize the predictive performances of fall risk assessment tools [23]. Additionally, only the tools that have been assessed in at least three different studies were included in the final analysis to ensure validity of the included tool as studies may differ, for example in selected population in age, sex, or frailty.

The first exclusion based on title was performed by WM. All articles from the second exclusion based on abstract were reviewed by WM. Additionally, JK, CL and IG each reviewed 67 articles of a sample of 200 articles from the second exclusion. As there was high agreement between the reviewers only the sample of 200 articles was reviewed independently by two reviewers to check if there were differences in scoring. For the third exclusion, WM reviewed all full texts and JK or CL or IG reviewed each one third of all full texts. Differences between reviewers were discussed until consensus was reached. In total, 26 articles were included in this study.

Quality appraisal

Quality of the included studies was assessed independently by two reviewers (WM together with JK, CL or IG) by using the Quality in Prognosis Study (QUIPS) tool [24, 25]. Articles are classified as having low quality (*) referring to high potential bias, moderate quality (**) referring to moderate potential bias or high quality (***) referring to low potential bias. The reviewers resolved differences by discussion until consensus was reached.

Figure 3. Eligibility criteria

Analysis

This review investigates the predictive performance of prognostic tests that predict the likelihood of experiencing a fall. The predictive performance of a prognostic test is often described similarly as for diagnostic tests, by examining diagnostic accuracy [23]. Diagnostic accuracy refers in this review to being able to discriminate between fallers and non-fallers correctly by using measures such as sensitivity, specificity and Area Under the Curve (AUC) [26]. Therefore, data regarding sensitivity, specificity and AUC were extracted from the articles and described.

Sensitivity refers to classifying the individual correctly of being at risk of falls, while specificity refers to classifying the individual correctly of not being at risk of falls [27]. A diagnostic test has good predictive value if sensitivity and specificity are >70% [28]. The AUC is the area under the receiver operating characteristic (ROC) curve which represents the accuracy of the test. With help of the ROC curve, the best cut-off score for the most optimal sensitivity and specificity can be chosen. The larger the AUC, the better the test. The accuracy of a diagnostic test is good or excellent if the AUC is >0.7 [26]. We ranked the outcomes, taking the cut-off values for good sensitivity, specificity and AUC into consideration, to be able to value the outcomes [26, 28].

Furthermore, when analysing the results, criteria regarding suitability of the fall risk assessment tool for the primary care setting were taking into account. Primary health care providers have limited time due to a high workload [15, 16, 19, 20]. Also, they have limited resources for expensive equipment (e.g. platforms, sensors) and in general little space in their practice [17, 18]. Therefore, when analysing the results, the following criteria for a suitable tool were taking into account; limited time, no expensive equipment and no space adjustments.

Patient and public involvement

Before conducting the systematic review, an informal focus group was conducted with primary care professionals (4 GPs, 2 practices nurses and 3 district nurses), the end-users, to identify their needs and wishes regarding a fall risk assessment tools. The results from this informal focus group, together with previous literature, defined the suitability criteria used in this study. Hence, the needs and wishes of the primary care professionals were taken into account when analysing the results in this review.

Patients were not directly involved in this systematic review.

Results

The 27 included articles identified six fall risk assessment tools. All tools are described below and presented in Table 1. More details about the included articles are provided in Additional File 2.

Timed Get up and Go test

The Timed Get Up and Go (TUG) test takes only a few minutes to complete and was described in 14 studies [29-42]. Participants are asked to stand up from a chair, walk 3 meters, turn, walk 3 meters back and to sit down again. The time taken to conduct this task indicates high or low fall risk. The reported cut-off scores varied from 10.9 to 13 seconds. Eleven studies described the AUC which varied from 0.46 to 0.89. Sensitivity varied from 10% to 83.3% and specificity varied from 28.4% to 96.6% in eight studies.

Gait Speed test

The Gait Speed test, on a distance of 4m, takes only a few minutes to complete and was evaluated in four studies [33, 43-45]. Participants are asked to walk 4m at usual pace. The time to complete the task is recorded and gait speed is calculated (m/s). The studies of Bongers et al. [43] and Tsutsumimoto et al. [44] showed AUCs of 0.5 and 0.77, respectively. Kang et al. [33] investigated the AUC for different follow up periods and for any or recurrent falls, which varied from 0.54 to 0.68. Sensitivity and specificity were reported in two studies [44, 45] which varied from 38.4% to 100% and 23.9% to 84.7% respectively, depending on the cut-off scores.

Berg Balance Scale

The Berg Balance Scale (BBS) evaluates the participants balance based on 14 items with a 5 point-Likert scale and takes 15-20 minutes to complete. The score for each item varies from 0-4 points with an overall maximum score of 56 points. Balance is evaluated by asking the participant to perform different sitting, transferring and standing positions. The study of Muir et al. [46] evaluated what cut-off scores of the BBS predicted the risk of falling the best by making a difference between a single and multiple falls. They found

173 **Table 1.** Included fall risk assessment tools

Tools	Authors and year	Suitability	N	Cut-off score[1]	AUC (95%CI)	Sens	Spec	Quality[2]
Timed Get Up and Go test	Kojima et al., 2015 [28]	Time: <5min. Space: ±4 m. Tools: Stopwatch, chair, tape-measure Training required: Yes	259	12.6 s	0.58	0.305	0.895	**
	Chow et al., 2019 [36]		192	12 s	0.54	0.706 (0.562-825)	0.284 (0.211-0.366)	**
	Alexandre et al., 2012 [23]		60	12.47 s	0.68 (0.54-0.83)	0.737	0.658	**
	Wrisley et al., 2010 [35]		35	12.34 s	0.89	0.833	0.966	***
	Pai et al., 2010 [32]		13		0.46	0.50 (0.09-0.91)	0.56 (0.40-0.96)	**
	Bongue et al., 2011 [24]		1759	10.9 s	0.54 (0.52-0.57)			**
	Lin et al., 2004 [29]		1200		0.61			**
	Russel et al., 2008 [33]		344		0.63 (0.57-0.69)			**
	Hofheinz et al., 2016 [25]		120		0.58			**
	Melzer et al., 2010 [30]		98		0.57			***
	Trueblood et al., 2001 [34]		180			0.1	0.95	**
	Ollsen Möller et al., 2012 [31]		153	≥12-13 s at 6 months follow up		0.67	0.50	*
				≥12-13 s at 12 months follow up		0.78	0.37	
	Kang et al., 2017 [27]		619	>10.2 s	0.603 (0.545-0.661)			**
	Kang et al. 2018 [26]			any falls	0.607 (0.549-0.665)			**
				any falls	0.642 (0.584-0.700)			
				recurrent falls	0.688 (0.602-0.773)			
			541	recurrent falls, cut-off 10.15 s	0.733 (0.645-0.821)	0.675	0.563	
Gait speed test (4m)	Tsutsumimoto et al., 2013 [38]	Time: <5 min.	59	0.67m/s	0.77 (0.62-0.92)	0.82	0.71	**
	Bongers et al., 2015 [37]		352		0.5			**

	Verghese et al., 2002 [39]	Space: ± 5 m. Tools: Stopwatch, tape-measure Training required: Yes	59	≥12 s		1	0.239	***
				≥14 s		0.769	0.565	
				≥18 s		0.384	0.847	
	Kang et al., 2017 [27]		541	any falls	0.563 (0.504-0.622)			**
				any falls	0.586 (0.526-0.647)			
				recurrent falls	0.542 (0.445-0.639)			
				recurrent falls	0.680 (0.593-0.768)			
Berg Balance Scale	Muir et al., 2008 [40]	Time: 15-20 min. Space: ± 1-2 m. Tools: Stopwatch, 2 chairs, tape-measure, step bench Training required: Yes	187	≤53 (for multiple falls)	0.68	0.69 (0.50-0.81)	0.57 (0.47-0.66)	**
				≤54 (for any fall)	0.59	0.61 (0.50-0.72)	0.53 (0.43-0.63)	
				≤45 (for multiple falls)		0.42 (0.26-0.61)	0.87 (0.79-0.92)	
				≤45 (for any falls)		0.25 (0.16-0.36)	0.87 (0.79-0.92)	
	Melzer et al., 2010 [30]		98	≤52	0.47			***
	Ersoy et al., 2009 [41]		125	≤48		0.686	0.756	*
Performance Oriented Mobility Assessment -	Faber et al., 2006 [43]	Time: ± 10 min. Space:	72	10		0.640 (0.445-0.798)	0.661 (0.530-0.771)	**
	Trueblood et al., 2001 [34]		180	10		0.24	0.91	**

Balance	Bizovska et al., 2018 [42]	± 1-2 m. Tools: chair without handrails Training required: Yes	131	NR, multiple fallers versus non-fallers	0.659	0.89	0,47	**
	Verghese et al., 2002 [39]		59	≤8		0.076	0.913	***
				≤9		0.23	0.804	
				≤10		0.615	0.695	
Performance Oriented Mobility Assessment - Gait	Trueblood et al., 2001 [34]	Time: ±10 min. Space: ± 1-2 m. Tools: obstacle-free corridor or space Training required: Yes	180	9		0.21	0.95	**
	Faber et al., 2006 [43]		72	9		0.64 (0.445-0.798)	0.625 (0.494-0.74)	**
	Bizovska et al., 2018 [42]		131		NR because NS			**
Functional Reach test	Lin et al., 2004 [29]	Time: <5 min. Space: ± 1-2 m. Tools: Tape-measure Training	1200		0.509			**
	Russel et al., 2008 [33]		344		0.60 (0.54-0.66)			**
	Murphy et al., 2003 [44]		50	8in.		0.73	0.88	*

		required: Yes						
Fall History	Tiedemann et al., 2010 [49]	Time: <2 min. Space: N.a. Tools: None Training required: No	362	≥1 fall in the previous year	0.71	0.69 (0.59-0.78)	0.63 (0.57-0.69)	**
	Nitz et al., 2013 [48]		449	History of multiple falls (not further specified)	0.64			**
	Gerdhem et al., 2005 [46]		984	1 fall in the previous year		0.39	0.82	**
				≥2 falls in the previous year compared to ≤ 1 fall		0.46	0.8	
	Coll-Planes et al., 2006 [45]		192	≥1 fall in the previous year		0.595	0.645	**
	Lindemann et al., 2008 [47]		65	≥1 fall in the previous year		0.63	0.77	**

[1] s: seconds / m: meters / in: inch

[2]Quality assessed with QUIPS tool: * High bias, ** Moderate Bias, *** Low Bias

an AUC of 0.68 for multiple falls with a cut-off score ≤53 and an AUC of 0.59 for a single fall with a cut-off score ≤54. Melzer et al. [36] found a lower AUC of 0.47. Muir et al. [46] and Ersoy et al. [47] also reported sensitivity and specificity which varied from 25% to 69% and 53% to 87% respectively.

The Tinetti tests

The Tinetti tests are widely used tests to assess fall risk, however there are many variations. One is the Performance Oriented Mobility Assessment (POMA) - Total. This test consists of two components to assess balance (POMA-B) and gait (POMA-G) and takes about 20 minutes to complete. For the POMA-B test, which was assessed in four studies [40, 45, 48, 49], the participant is asked to perform nine different movements to assess balance. Depending on the cut-off scores, sensitivity and specificity varied from 23% to 89% and 47% to 91.3% respectively. An AUC of 0.66 was reported by Bizovska et al. [48], however the cut-off scores were not specified and the comparison was about multiple fallers, excluding single time fallers. The POMA-G asks the participant to perform six different movements to assess gait. The POMA-G suggests to conduct the test in a corridor. Only the study of Bizovska et al. [48] specified the space they used for this test, which was a 30 metre well-lit corridor. Faber et al. [49] and Trueblood et al. [40] reported sensitivities and specificities ranging from 21% to 64% and from 63% to 95% respectively. Bizovska et al. [48] did not report any specific results as they did not find any significant differences between the fallers and non-fallers in relation to the POMA-G.

The Functional Reach test

The Functional Reach (FR) test was validated in three studies [35, 39, 50]. Participants are asked to hold their arms in front of them in an angle of 90 degrees, stretch forward as far as possible and to go back to the beginning position. The distance between beginning position and stretched position is measured which indicates high or low fall risk. This test takes less than 5 minutes to complete. The AUC was reported in two studies [35, 39] and varied from 0.51 to 0.60. Murphy et al. [50] mentioned a sensitivity and specificity of 73% and 88% respectively.

Fall History

Five studies explored the accuracy of Fall History (FH) [51-55], which takes only a few minutes to assess. In these five studies, FH had different definitions. The most used definition was at least one fall in the previous year. The AUC was investigated by Tiedemann et al. [55] and Nitz et al. [54] which varied from 0.64 to 0.71. Sensitivity and specificity were explored in four studies and varied from 39% to 69% and from 63% to 82%, respectively.

Quality Appraisal

The methodological quality was assessed of all articles and is presented in Table 1. Three articles were classified as high quality, 21 articles as moderate quality and three articles as low quality.

Discussion

The aim of this study was to identify the most suitable fall risk assessment tools (s) for the primary care setting (i.e. requires limited time, no expensive equipment and no additional space) with good predictive performance to assess fall risk among independently living older people. This systematic review identified six fall risk assessment tools for the primary care setting. The vast majority of the included studies identified the fall risk among older people over a period of 12 months (mean 15 months; range 6 month – 9 years), see Additional file 2. None of the six fall risk assessment tools appear to be adequate in discriminating between people with and without a high fall risk, when taking the thresholds of Šimundić [26] for good diagnostic accuracy (AUC>0.7) into account. These findings did not alter when only taking the moderate and high quality articles into account. Four studies did report an AUC > 0.7 for the TUG test [32, 41], Gait Speed test [44] and FH[55], indicating good diagnostic accuracy [26]. However, most articles reported AUC's ranging from 0.5 to 0.7, indicating insufficient diagnostic accuracy for all included tools. Furthermore, sensitivity and specificity of the same tool varied substantially across studies, refraining us from making a convincing conclusion.

The results of this review are also acknowledged by others. For example, even though the TUG test is widely used to assess fall risk, other studies also showed the lack of predictive ability of the TUG test regarding falls [56, 57]. Furthermore, the study of Gates et al. [58] stated "*At present, recommending any screening test for routine clinical use is not possible. Despite the number of studies that have been conducted, no strong evidence exists that any screening test is useful for identifying fallers.*" With the current systematic review, thirteen years after the review of Gates et al. [58], we have to conclude the same. Conclusive evidence to identify a fall risk assessment tools with adequate predictive performance and accuracy is still lacking.

Since choice based on predictive performance ability is not possible, suitability for the primary care setting prevails as for now. Primary health care providers have limited time and lack resources for expensive equipment, room or training [15-20]. Considering this, the most suitable tool identified in this review appears to be FH as it takes only a few minutes to conduct and requires no training, expensive equipment or space (adjustments). The BBS and the Tinetti test would not be suitable as they take 15-20 minutes to complete and require training to conduct. The TUG and Gait Speed tests both are quick (< 5min.), but they require training and space to conduct (>4 metre). The FR test is quick (< 5min.) and does not require much space, however it requires more training compared to FH and the reported AUCs are also lower compared to FH.

Even though the diagnostic accuracy of FH is insufficient, it is the same or even better than that of most of the other five fall risk assessment tools, see Table 1. Barker et al. [59] also found that FH appears to be a suitable assessment tool when exploring the clinometric evaluation of four fall risk assessment tools. They stated that "*the predictive validity of all tools was found to be low, with no tool offering greater ability to identify residents who would fall than a simple screening question 'has the resident fallen in the past 12 months?"*. In addition, patient's fall history is used in many multifactorial assessment tools and algorithms and appears to be an important risk factor for fall risk (OR: NS-14.02) [47, 52, 54, 60-67]. Nevertheless, by using only patient's fall history as a fall risk assessment tool, first time fallers will not be discovered. This certainly is a huge disadvantage. However, older people might be less willing to start and complete fall prevention interventions when they did not experience a previous fall. They often do not associate themselves with having a high fall risk [68, 69]. Hence, the experience of a previous fall might influence motivation to start and complete a fall prevention intervention [70].

According to the study of Nordin et al. [71], assessment of fall risk with clinical judgement as well as FH among their population of frail older people was superior to performance-based measures. Meyer et al. [72] even stated that fall risk assessment tools should be avoided "*since it has no clinical consequences other than the waste of scarce nursing resources*". Due to the increasing work pressure [15-18] and lack of awareness [73, 74], health care professionals might not assess a patient's fall risk when it is based on clinical judgement alone as it is not part of a systematic assessment strategy. Systematically assessing for fall risk by using FH together with the health care professional's expertise might therefore be an adequate strategy.

Practice recommendations

In daily practice, GPs can ask their older patients during a consultation if they had a fall during the past 12 months. Even if the patient says 'no', the GP might still notice a high fall risk based on clinical judgement (e.g. walking or sitting difficulties due to strength and balance problems, dizziness, use of benzodiazepines, visual impairment, etc.). If the GP suspects high fall risk after this brief assessment, (s)he can investigate the underlying cause of the fall risk by conducting a multifactorial assessment so adequate care can be offered. Depending on the organization of the GP practice, the GP could also refer the patient to another health care provider, such as the practice nurse specialized in elderly care, who might have more time to investigate the underlying cause of the fall risk. By conducting a brief fall risk assessment that leads to a comprehensive multifactorial assessment to identify the underlying causes, followed up with multifactorial interventions that tackle the identified risk factors, a patient's fall rate can be reduced [75-77]. As pointed out in the American Geriatrics Society/British Geriatrics Society clinical practice guidelines, it is recommended to conduct a fall risk assessment annually [78].

Strengths and Limitations

The results from this review were difficult to combine. Different studies used different cut-off scores, modified versions of the same tests and presented different outcome measures. These differences between studies made it difficult to give a convincing conclusion of the results.

Since we have included at least three studies for each tool, conducting a meta-analysis for each tool seems feasible. However, we did not conduct a meta-analysis for two reasons. First, the diversity between studies that assessed the same tools was large, e.g. differences in cut-off scores, follow-up periods, study population (sex, age, in/exclusion criteria) and quality differences. This made a meta-analysis unsuitable for most tools. Second, the results from our study are already clear without conducting a meta-analysis, namely none of the six identified tools appear to be adequate in discriminating between people with and without a high fall risk, when taking the thresholds of Šimundić [26] for good diagnostic accuracy (AUC>0.7) into account. Another limitation is the possibility of publication bias of studies with worse outcomes, which might have led to an overestimation of the predictive performance of the included fall risk assessment tools. Nevertheless, these limitations support our conclusion that none of the included tools has sufficient predictive performance.

Further Research

The underlying cause of falls is often multi-factorial and complex. This makes it difficult, if not impossible to adequately identify people with high fall risk with only a physical test or a short questionnaire. None of the fall risk assessment tools identified in this review, which focus on fall history, balance and strength problems, are able to identify older people with high fall risk adequately. Therefore, other ways of assessing high fall risk among independently living older people in the primary care setting should be studied. To improve predictive performance of a fall risk assessment tool, it might help to develop a multi-factorial assessment tool that also takes a person's behaviour and environment into account.

Overall, the results from this systematic review show that the predictive performance of the six identified fall risk assessment tools is insufficient. Overall, FH appears to be the same or even better than the other five fall risk assessment tools. In addition, this tool is most suitable for the primary care setting as it is quick and does not require equipment, space or training. FH together with a health care professional's clinical judgement, might be a promising strategy for the primary care setting to identify older people with high fall risk. When older people with a high fall risk are identified, they can be offered adequate fall preventive care. This could reduce falls and fear of falling, which might lead to maintained or improved quality of life and prolonged autonomy of older people.

List of abbreviations

GP: General Practitioner

QUIPS: Quality in Prognosis Study

AUC: Area Under the Curve

ROC: Receiver Operating Characteristic

TUG: Timed-Up-and-Go

BBS: Berg Balance Scale

POMA-B: Performance Oriented Mobility Assessment-Balance

POMA-G: Performance Oriented Mobility Assessment-Gait

FR: Functional Reach

FH: Fall History

Declarations

Ethics approval and consent to participate

Ethics approval is not required for this literature review.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors have no conflicts of interests to declare.

Funding

This work was supported by ZonMw ,the Netherlands organization for health research and development [grant number 531001210]. The funder had no role in the creation of the research question, design of the study, data collection, analysis, interpretation, or in the writing of this manuscript.

Author Contributions

WM conducted the systematic review and wrote the manuscript. JK, CL and IG reviewed articles for inclusion, reviewed the quality check, and provided feedback on the manuscript. All authors read and approved the final manuscript.

Acknowledgements

Not applicable.

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Figure Legends

Figure 1. Search keywords

Figure 2. Flowchart literature search

Figure 3. Eligibility criteria

Figure 1. Search keywords

(Frail Elderly[Mesh] OR Aged[Mesh] OR Frail Elderly* OR Aged*)
AND
(Accidental Falls[Mesh] OR Accidental Falls*OR Falls*)
AND
(Risk Assessment[Mesh] OR Prognosis[Mesh] OR Diagnosis[Mesh] OR Risk Assessment* OR Prognosis* OR Diagnosis* OR Screening* OR Prediction*)
AND
(Specificity and Sensitivity[Mesh] OR Data Accuracy[Mesh] OR Sensitivity* OR Specificity* OR Accuracy* OR Validity*)

Figure 2. Flowchart Literature Review

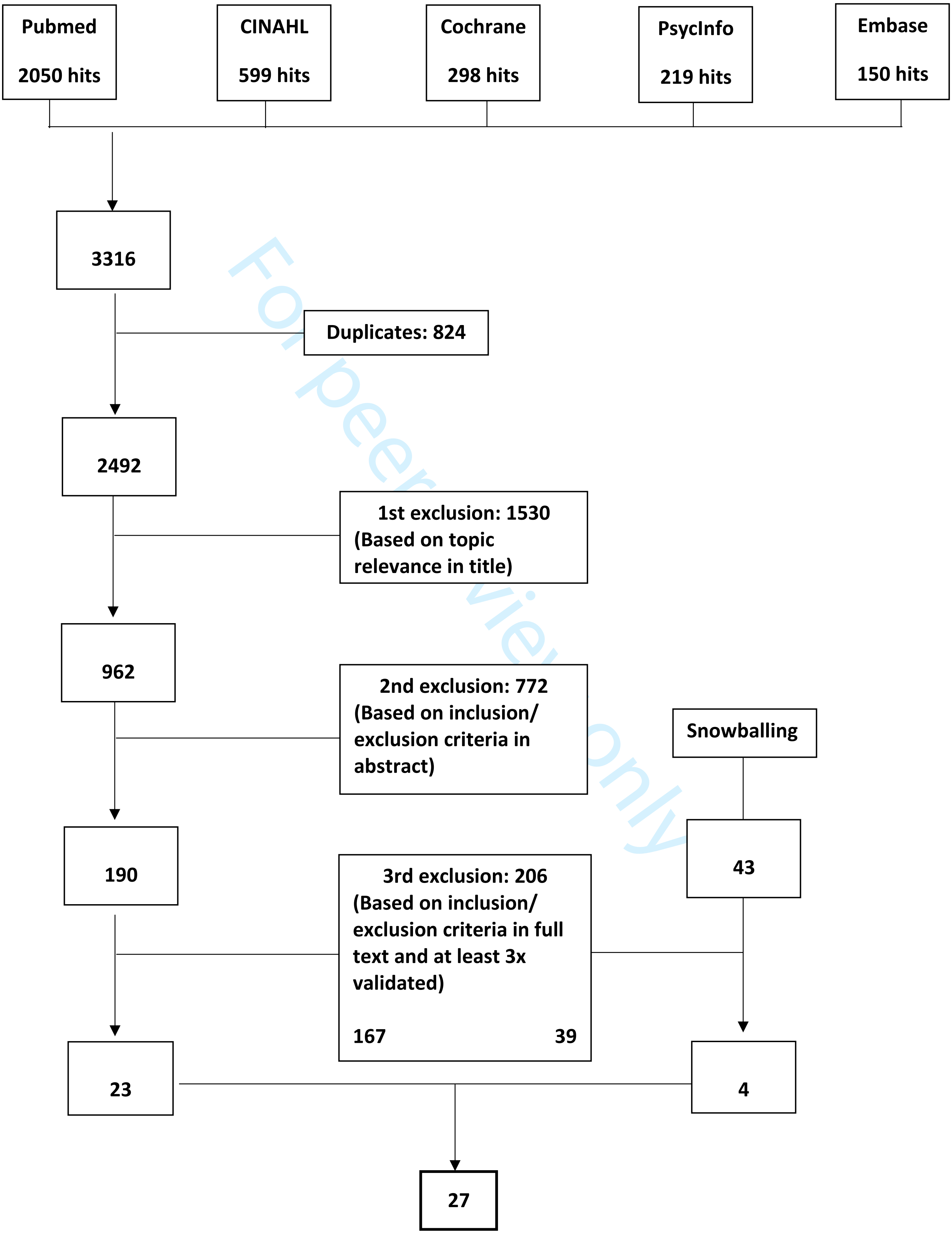

Figure 3. Eligibility criteria

Articles were included when they met the following inclusion criteria:

1. Prospective studies in which the primary or secondary purpose was to evaluate the performance of one or more fall risk assessment tools for predicting fallers.
2. The participants were older people living in the community or substantially independently
3. Full articles published in English, Dutch or German

Articles were excluded when they met one or more of the following exclusion criteria:

1. Fall risk assessment tools which require expensive computer software programs, other advanced expensive software or instruments not available in usual primary care units (e.g. sensors, electronical platforms, force plates).
2. Literature reviews and studies with no follow up of fall incidents.
3. No reported Area Under the Curve (AUC), sensitivity or specificity of the fall risk assessment tools.
4. Assessment tools specifically developed for or only tested on populations with a specific disease (e.g. cancer, diabetes, Parkinson etc.)
5. The participants were living in hospital or other institutionalised settings

Additional file 1

Recent queries in pubmed

Search,Query,Items found,Time

#1,"Search (((((""Aged""[Mesh]) OR ""Frail Elderly""[Mesh] OR Aged* OR Frail Elderly* OR Elderly*)) AND (""Accidental Falls""[Mesh] OR Accidental Falls* OR Falls*)) AND (((""Risk Assessment""[Mesh]) OR ""Diagnosis""[Mesh]) OR ""Prognosis""[Mesh] OR Risk Assessment* OR Diagnos* OR Prognos* OR Screen* OR Predict*)) AND (((""Sensitivity and Specificity""[Mesh]) OR ""Reproducibility of Results""[Mesh]) OR ""Data Accuracy""[Mesh] OR Sensitivity* OR Specificity* OR Accuracy* OR Reliab* OR Valid*) Filters: Full text	Publication date from 2000/01/01 to 2020/07/01	Field: Title/Abstract",1956,03:40:44	

Additional file 2.

Overview characteristics included articles

Author	N	Age (range, mean, SD)[1]	Gender	Exclusion	Inclusion	Follow up in months	Included instrument[2]
Alexandre et al., 2012 [29]	60	≥60 (60-82)	29 men/ 31 women	PD, history of transitory ischemic attack, stroke, cognitive impairment, wheelchair, fall in the previous 6 months	n.a.	12 months	TUG test
Bizovska et al., 2018 [48]	131	≥60 (mean 70.8, SD 6.7)	23 men/ 108 women	Any injury or surgery on the musculoskeletal system during the last two years before the baseline measurement	Aged ≥60; ii) no known neurological or musculoskeletal problem that may affect gait or balance abilities; iii) ability to stand and walk without any assistance and assisting device	12 months	POMA-B POMA-G
Bongers et al., 2015 [43]	352	≥70 (mean 76.2 (SD 4.3)	all women	too ill to be screened by GP, currently receiving treatment from geriatrician or received comprehensive geriatric assessment in past 3 months	n.a.	12 months	Gait speed test (4m)
Bongue et al., 2011 [30]	1759	≥65 (65-95, 70.7 (SD 4.6))	862 men/ 897 women	neurological disease, cognitive impairment, unable to understand French or follow simple commands	n.a.	12 months	TUG test
Chow et al., 2019 [42]	192	≥65 (mean: 74.4)	81 men/ 111 women	n.a.	aged ≥65, being discharged from the ED, English speaking, had capacity to give consent, and personally identified a risk factor for falling (if a patient reported that they had either fallen in the last year, worried about falling, or admitted that they felt unsteady when standing or walking)	6 months	TUG test
Coll-Planas et al., 2006 [51]	192 (268 with 76 drop-outs)	≥65 (89 >83 years, 103 ≤83 years)	34 men/ 158 women	living in nursing home	Community dwelling elderly aged ≥65	12 months	Fall history
Ersoy et al., 2009 [47]	125	≥50 (50-79, 61.4 (SD 7.9)	all women	unable to walk without assistance or aids	postmenopausal community dwelling women aged 50+	6 months	BBS

Faber et al., 2006 [49]	72 (total 245)	84.9 (SD 6.0) (of total 245)	14 men/ 58 women	in ability to walk 6m with(out) aids, capacity to understand instructions, medical contraindications to participate, cognitive impairment	n.a.	10 months	POMA-B POMA-G
Gerdhem et al., 2005 [52]	984	75 (75.01-75.99)	all women	n.a.	community dwelling women aged 75 in Malmö	12 months	Fall history
Hofheinz et al., 2016 [31]	120	≥60 (60-87, 72.2 (SD 6.8)	26 men/ 94 women	cognitive limitations, neurological or musculoskeletal diagnose	able to walk 10m with(out) aid, able to understand instructions, able to carry glass in one hand	12 months	TUG test
Kang et al., 2017 [33]	541	≥60 (67.4 (SD 5.6))	234 men/ 307 women	Inability to perform the basic activities of daily living and thus could not complete performance-based assessments; visual impairments; current use of drugs (psychotropic drugs, cardiovascular drugs, hypoglycemic agents, non-steroidal anti-infammatory drugs, analgesics, dopaminergic drugs, PD's drugs or more than four kinds of complex drugs).	Aged ≥60 years and joined the China's national free physical examination programs	12 months	TUG test Gait speed test (4m)
Kang et al., 2018 [32]	619	≥60 (60-86, 67.4 (SD 5.6))	262 men/ 357 women	Severe functional impairment, current use of sedative drugs, antiepileptic drugs ans so on, refusal to participate in the follow-up of this study	Aged ≥60, who joined the free physical examination program	12 months	TUG test
Kojima et al., 2015 [34]	259	≥65 (72.6 (SD 5.9)	95 men/ 164 women	≥3 falls in past year, unstable medical conditions, already exercising 150min/week	aged ≥65 able to walk independently and participate in group exercise	6 months (24 weeks)	TUG test
Lin et al., 2004 [35]	1200	≥65 (73.4 (SD=NR)	709 men/ 491 women	NR	NR	12 months	TUG test FR test
Lindeman et al., 2008 [53]	65	≥65 (67.7 (SD 6.0))	33 men/ 32 women	use of walking aid, self-reported neurological disorders, or spinal or lower extremity joint pain interacting with stepping performance, inability to come to the research department without help, cognitive impairment	community dwelling elderly aged ≥65	12 months	Fall history

Melzer et al., 2010 [36]	98	≥65 (65-91, 78.4 (SD 5.7))	26 men/ 72 women	serious visual impairment; inability to ambulate independently; cognitive impairment; severe focal muscle weakness or paralysis; severe peripheral or compression/entrapment neuropathies; symptomatic orthostatic hypotension, respiratory, cardiovascular, musculoskeletal or neurological disorders that might have interfered with participation in the exercise program; cancer, metastatic or under active treatment; and use of medication known to impair balance or strength.	n.a.	12 months	TUG test BBS
Muir et al., 2008 [46]	187	≥47 (47-90, 79.4 (SD 5.83))	122 men/ 65 women	n.a.	community dwelling veterans of WWII and the Korean War residing in 3 regions of southwestern Ontario	12 months	BBS
Murphy et al., 2003 [50]	50	≥60 (72.3 (SD 8.6))	13 men/ 37 women	no exclusion based on disease	community dwelling elderly aged ≥60	14 months	FR test
Nitz et al., 2013 [54]	449	≥40 (40-80, 59.3 (SD 10.6))	all women	n.a.	independently mobile and cognitively competent women from the electoral rool in North Brisbane Health district	108 months (9 year)	Fall history
Ollsen Möller et al., 2012 [37]	153	≥65 (66-94, 81.5 (SD 6.3))	51 men/ 102 women	n.a.	Age ≥65, living in the municipality where the study was conducted; needing help with at least two activities of daily living (ADL); admitted to hospital at least twice or with at least four contracts with outpatient or primary healthcare during the previous 12 months; being able to communicate verbally and have not cognitive impairments (i.e. ≥25 MMSE)	12 months	TUG test

Pai et al., 2010 [38]	13	≥65 (65-85, 72 (SD 5))	9 men/ 4 women	musculoskeletal, neurological, cognitive or other systemic disorders, osteopenic or osteoprotic, cognitive impairment, symptomatic postural hypotension	ambulatory community dwelling elderly	29-32 months	TUG test
Russell et al., 2008 [39]	344	≥60 (75.9 (SD 8.5)	106 men/ 238 women	n.a.	community dwelling elderly aged ≥60 presented to an ED as a result of a fall being directly discharged home following emergency care and able to walk independently	12 months	TUG test FR test
Tiedemann et al., 2010 [55]	362	≥74 (74-98, 80.25 (SD=4.5))	128 men/ 234 women	blindness, minimal English language skills, and cognitive impairment	community dwelling elderly aged 63-95 resided in Sydney, Australia	12 months	Fall history
Trueblood et al., 2001 [40]	180	≥60 (60-96, 77.9 (SD 7.26))	37 men/ 143 women	cognitive deficits, underlying neurological problems	aged ≥60, able to stand for 5 min. without aid, able to walk 40 feet at one time without aid.	6 months	TUG test POMA-B POMA-G
Tsutsumimoto et al., 2013 [44]	59	≥65 (Non-fallers 84.0 (SD 1.1) 85.5 (SD 1.4))	11 men/ 48 women	very severe cardiac, pulmonary, musculoskeletal, or neuropathological disorders associated with inability to step safely, cognitive impairment	community-dwelling older people receiving long-term care services aged ≥65, able to walk independently, and having adequate hearing and vision	12 months	Gait speed test (4m)
Verghese et al., 2002 [45]	59	≥65 (Nonfallers 79.7 (SD 6.6) Fallers 79.4 (SD 5.7))	25 men/ 34 women	severe visual loss interfering with completion of neuropsychological tests, non-English or non-Spanish speaking, institutionalization, healthy enough to make a clinic visit	community dwelling elderly aged ≥65	12 months	Gait speed test (4m) POMA-B

Wrisley et al., 2010 [41]	35	60-90 (72..9 (SD 7.8))	17 men/ 18 women	cognitive impairment, history of osteoporosis, recent fractures, or lower-extremity surgery; history of progressive neuromuscular disorder; history of whiplash, neck injury, or current complaints of neck pain; history of unstable agina or uncontrolled cardiorespiratory problems; taking any medications that might affect balance; history of any fall in past 6 months and more than one fall in the last year; pain in any segment greater than 2/10 on a 10-point verbal analog scale; not returning the monthly fall calendar	community dwelling elderly aged 60-90 able to stand independently longer than 1 min.	6 months	TUG test

[1] range, mean, SD: only described when reported in included article
[2] TUG test: Timed Get Up and Go test
POMA- B: Performance Oriented Mobility Assessment –Balance
POMA-G: Performance Oriented Mobility Assessment –Gait
BBS: Berg Balance Scale
FR test: Functional Reach test

PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	Title, page 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.	Abstract, page 2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	Background, page 3
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	PICO: Background, page 3 S: Methods, Analysis/Figure 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.	N/A
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.	Methods, Figure 3
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	Methods, Study selection
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	Methods, Figure 1
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	Methods, Eligibility criteria and study selection
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	Methods, Eligibility

PRISMA 2009 Checklist

			criteria and study selection
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	Methods, Analysis
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	Methods, Quality appraisal
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	N/A
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.	N/A

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	N/A
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	N/A
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	Methods, Figure 2
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	Additional File 2
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	Results, Table 1
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	N/A
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	N/A
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	N/A
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	N/A
DISCUSSION			

PRISMA 2009 Checklist

Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	Discussion, page 8-10
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	Discussion, Limitations
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	Discussion, page 8-10
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	Declarations, Funding

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

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BMJ Open

A practical and validated tool to assess falls risk in the primary care setting: A systematic review

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2020-045431.R2
Article Type:	Original research
Date Submitted by the Author:	15-Jul-2021
Complete List of Authors:	Meekes, Wytske; Tilburg University Tranzo Scientific Centre for Care and Welfare, Korevaar, J; NIVEL Leemrijse, Chantal; NIVEL Van de Goor, Ien ; Tilburg University Tranzo Scientific Centre for Care and Welfare
Primary Subject Heading:	General practice / Family practice
Secondary Subject Heading:	Public health
Keywords:	GENERAL MEDICINE (see Internal Medicine), PRIMARY CARE, PREVENTIVE MEDICINE, PUBLIC HEALTH

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A practical and validated tool to assess falls risk in the primary care setting: A systematic review

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Abstract

Objective: Although several falls risk assessment tools are available, it is unclear which have been validated and which would be most suitable for primary care practices. This systematic review aims to identify the most suitable falls risk assessment tool for the primary-care setting (i.e. requires limited time, no expensive equipment and no additional space) and that has good predictive performance in the assessment of falls risk amongst older people living independently.

Design: A systematic review based on prospective studies.

Methods: An extensive search was conducted in the following databases: PubMed, EMBASE, CINAHL, Cochrane and PsycINFO. Tools were excluded if they required expensive and/or advanced software that is not usually available in primary-care units and if they had not been validated in at least three different studies. Of 2,492 articles published between January 2000 and July 2020, 27 were included.

Results: Six falls-risk assessment tools were identified: Timed Up and Go test, Gait Speed test, Berg Balance Scale, Performance Oriented Mobility Assessment, Functional Reach test and falls history. Most articles reported AUC values ranging from 0.5 to 0.7 for these tools. Sensitivity and specificity varied substantially across studies (e.g. TUG, sens.:10-83.3%, spec.:28.4-96.6%).

Conclusions: Given that none of the falls risk assessment tools had sufficient predictive performance (AUC<0.7), other ways of assessing high falls risk amongst independently living older people in primary care should be investigated. For now, the most suitable way to assess falls risk in the primary care setting appears to involve asking patients about their falls history. Compared to the other five tools, the falls history requires the least amount of time, no expensive equipment, no training, and no spatial adjustments. The clinical judgement of healthcare professionals continues to be most important, as it enables the identification of high falls risk even for patients with no falls history.

Key words: Falls prevention, Falls risk assessment tools, Predictive Performance, Primary Care, Review

Strengths and Limitations of this study

- This review is built on extensive literature regarding falls risk assessment tools that are suitable for the primary care setting and representations of their predictive performance.
- We endeavoured to reduce bias by only including falls risk assessment tools that have been validated at least three times in different studies and by assessing the risk of bias.
- Given that different studies used different cut-off scores, addressed modified versions of the same tools and presented different outcome measures, it was difficult to combine the results and reach a convincing conclusion.

Introduction

Worldwide, falls are the second leading cause of accidental or unintentional injury deaths [1]. On average, one of every three people aged 65 years or older falls at least once a year [2], and an estimated 646,000 people die each year due to the consequences of falls [1]. These numbers are increasing as society ages [3]. The consequences of falls can range from scratches or bruises to hip fractures, brain injuries or even death [4, 5]. Falls can have a major, long-lasting negative impact on the quality of life and self-management of older people [4-6]. The treatment and rehabilitation of falls incidences are correlated with high costs in the healthcare sector [5, 7]. Therefore, the provision of falls prevention is important for older people.

Society is ageing, and older people are living independently at home for longer [3]. The first point of contact for health problems is the general practitioner (GP). The approaches adopted by GPs vary, with some providing no falls prevention care at all, while others are quite active with regard to falls prevention. Given that only 20% of all older patients inform their GPs about their falls, GPs are unaware of the occurrence of 80% of the falls amongst their patients [8, 9], and they are thus likely not to know which of their patients are at risk of falls. This situation results in a delay or lack of treatment for falls risk amongst older people, despite the availability of potentially effective falls prevention interventions [10-14].

The early identification of high falls risk amongst older people is a prerequisite to providing adequate care in time to reduce the risk of falls. Many tools are available for assessing falls risk, including the Timed Up and Go (TUG) test, the Tinetti Balance, the Berg Balance Scale (BBS) and the American Geriatrics Society/British Geriatrics Society guidelines for clinical practice. In a previous review, Gates et al. (2008) summarise the accuracy of tools for predicting the risk of falling amongst older adults living in communities. They conclude that there is insufficient evidence to show that any instrument was adequate for predicting falls and they neither report nor consider implications for practice. It thus remains unclear which falls risk assessment tools have good predictive performance and might be suitable for practice.

The high workload associated with primary care places constraints on the time of practitioners [15, 16]. They also have limited resources for expensive equipment (e.g. platforms, sensors), and their practices generally have little space [17-20]. A suitable falls risk assessment tool for primary care settings should therefore require limited time, no expensive equipment and no space adjustments. This systematic review aims to identify falls risk assessment tools that are the most suitable for primary care (i.e. quick [<5 min], no expensive equipment or specific resources required) and that have demonstrated good predictive performance in assessing the risk of falls amongst older people living independently. In this study, an assessment tool is understood as a tool that defines the nature of a specific problem: whether a patient does or does not have a high risk of falls [21]. No additional assessment is required to identify high or low falls risk. Additional assessment is needed only to explore which intervention is needed to reduce a patient's risk of falls.

Methods

Study selection

A systematic literature search was conducted in the following databases: PubMed, EMBASE, CINAHL, Cochrane and PsycINFO, using the search keywords presented in Figure 1 (see Additional File 1). Mesh terms were used when possible. Additional articles were included after snowballing. The flowchart for the literature search is displayed in Figure 2.

Figure 1. Search keywords

Figure 2. Flowchart for the literature search

Eligibility criteria and study selection

The proportion of older people is increasing, and the current population of older people is ageing differently than was the case 20 years ago (e.g. people are becoming older and are more vulnerable to chronic diseases) [22, 23]. Given the importance of validating suitable falls risk assessment tools in the current population of older people, the review included articles published between January 2000 and July 2020 that met the criteria for inclusion (as presented in Figure 3).

This review includes only prospective studies, thus making it possible to summarise the predictive performance of falls risk assessment tools [24]. In addition, our final analysis includes only tools that have been assessed in at least three different studies. This was done in order to ensure the validity of the tools that were included, as studies are likely to differ (e.g. in terms of the age, sex or frailty of the selected population).

The first round of exclusion based on title was performed by WM. All articles from the second round of exclusion based on abstract were reviewed by WM. In addition, JK, CL and IG each reviewed 67 articles from a sample of 200 articles from the second round of exclusion. Given the high level of agreement between the reviewers, only the sample of 200 articles was reviewed independently by two reviewers to identify differences in scoring. For the third round of exclusion, WM reviewed all full texts, with JK, CL and IG each reviewing one third of all full texts. Differences between reviewers were discussed until consensus was reached. In total, 26 articles were included in this study.

Quality appraisal

The quality of the included studies was assessed independently by two reviewers (WM, together with JK, CL or IG) using the Quality in Prognosis Studies (QUIPS) tool [25, 26]. Articles were classified as being of low quality (*), referring to high potential bias; moderate quality (**), referring to moderate potential bias; or high quality (***), referring to low potential bias. The reviewers resolved differences through discussion until consensus was reached.

Figure 3. Eligibility criteria

Analysis

This review investigates the predictive performance of prognostic tests for predicting the likelihood of experiencing a fall. The predictive performance of a prognostic test is often described similarly to that of diagnostic tests, based on diagnostic accuracy [24]. In this review, diagnostic accuracy refers to the ability to discriminate accurately between fallers and non-fallers according to various measures, including sensitivity, specificity and area under the curve (AUC) [27]. To this end, data regarding sensitivity, specificity and AUC were extracted from the articles and described.

Sensitivity refers to the ability to classify individuals correctly as being at risk of falls, and specificity refers to the ability to classify individuals correctly as not being at risk of falls [28]. A diagnostic test has good predictive value if sensitivity and specificity are >70% [29]. The AUC is the area under the receiver operating characteristic (ROC) curve, which represents the accuracy of the test. The ROC curve can be used to select the best cut-off score for most optimal sensitivity and specificity, with greater AUC reflecting a better test. The accuracy of a diagnostic test is considered good or excellent if the AUC is >0.7 [27]. We ranked the outcomes, taking into account the cut-off values for good sensitivity, specificity and AUC [27, 29].

When analysing the results, we also considered criteria regarding the suitability of falls risks assessment tools for the primary care setting. The time available to primary healthcare providers is limited, due to their high workload [15, 16, 19, 20]. They also have limited resources for expensive equipment (e.g. platforms, sensors), and their practices generally have little space [17, 18]. When analysing the results, we therefore considered the following criteria for a suitable tool: limited time, no expensive equipment and no spatial adjustments.

Patient and public involvement

Before conducting the systematic review, an informal focus group was conducted with primary care professionals (4 GPs, 2 practice nurses and 3 district nurses)—the end-users—to identify their needs and wishes regarding falls risk assessment tools. We used the results of this informal focus group, together with previous literature, to define the suitability criteria used in this study. This ensured that the perspective of primary care professionals was taken into account when analysing the results of the review. No patients were directly involved in this systematic review.

Results

The 27 articles included in this review identify a total of six falls risk assessment tools. Each of these tools is described below and presented in Table 1. Further details about the included articles are provided in Additional File 2.

Timed Up and Go test

The Timed Up and Go (TUG) test takes only a few minutes to complete, and it was described in 14 studies [30-43]. In this test, participants are asked to stand up from a chair, walk three metres, turn, walk three metres back and sit down again. The time taken to perform this task indicates high or low falls risk. The cut-off scores reported in the articles varied from 10.9 to 13 seconds. The AUC is described in 11 studies, ranging from 0.46 to 0.89. In eight studies, sensitivity ranges from 10% to 83.3%, and specificity ranges from 28.4% to 96.6%.

Gait Speed test

The Gait Speed test, based on a distance of four metres, takes only a few minutes to complete, and it is evaluated in four studies [34, 44-46]. In this test, participants are asked to walk four metres at their usual pace. The time taken to complete the task is recorded, and gait speed is calculated (m/s). An AUC value of 0.5 is reported by Bongers et al. [44], and a value of 0.77 is reported by Tsutsumimoto et al. [45]. In an investigation of AUC for different follow-up periods and for any or recurrent falls, Kang et al. [34] report values ranging from 0.54 to 0.68. Sensitivity and specificity were reported in two studies [45, 46], ranging from 38.4% to 100% and from 23.9% to 84.7%, respectively, depending on the cut-off scores.

Berg Balance Scale

The Berg Balance Scale (BBS) evaluates a participant's balance based on 14 items scored along a five-point Likert scale and takes 15–20 minutes to complete. The score for each item ranges from 0 to 4 points, with

Table 1. Falls risk assessment tools included in this review

Tools	Authors and year	Suitability	N	Cut-off score[1]	AUC (95%CI)	Sens	Spec	Quality[2]
Timed Up and Go test	Alexandre et al., 2012 [23]	Time: <5min.	60	12.47 s	0.68 (0.54-0.83)	0.737	0.658	**
	Bongue et al., 2011 [24]		1759	10.9 s	0.54 (0.52-0.57)			**
	Hofheinz et al., 2016 [25]	Space: ±4 m.	120		0.58			**
	Kang et al. 2018 [26]		541	any falls	0.607 (0.549-0.665)			**
		Tools: Stopwatch, chair, tape-measure		any falls	0.642 (0.584-0.700)			
				recurrent falls	0.688 (0.602-0.773)			
				10.15s, recurrent falls	0.733 (0.645-0.821)	0.675	0.563	
	Kang et al., 2017 [27]	Training required: Yes	619	>10.2 s	0.603 (0.545-0.661)			**
	Kojima et al., 2015 [28]		259	12.6 s	0.58	0.305	0.895	**
	Lin et al., 2004 [29]		1200		0.61			**
	Melzer et al., 2010 [30]		98		0.57			***
	Ollsen Möller et al., 2012 [31]		153	≥12-13s at 6 months follow up		0.67	0.50	*
				≥12-13s at 12 months follow up		0.78	0.37	
	Pai et al., 2010 [32]		13		0.46	0.50 (0.09-0.91)	0.56 (0.40-0.96)	**
	Russel et al., 2008 [33]		344		0.63 (0.57-0.69)			**
	Trueblood et al., 2001 [34]		180			0.1	0.95	**
	Wrisley et al., 2010 [35]		35	12.34 s	0.89	0.833	0.966	***
	Chow et al., 2019 [36]		192	12 s	0.54	0.706 (0.562-825)	0.284 (0.211-0.366)	**
Gait speed test (4m)	Kang et al., 2017 [27]	Time: <5 min.	541	any falls	0.563 (0.504-0.622)			**
				any falls	0.586 (0.526-0.647)			
		Space: ± 5 m.		recurrent falls	0.542 (0.445-0.639)			
				recurrent falls	0.680 (0.593-0.768)			
	Bongers et al., 2015 [37]	Tools: Stopwatch, tape-measure	352		0.5			**
	Tsutsumimoto et al., 2013 [38]		59	0.67m/s	0.77 (0.62-0.92)	0.82	0.71	**
	Verghese et al., 2002 [39]	Training required: Yes	59	≥12 s		1	0.239	***
				≥14 s		0.769	0.565	
				≥18 s		0.384	0.847	
Berg Balance Scale	Melzer et al., 2010 [30]	Time: 15-20 min.	98	≤52	0.47			***
	Muir et al., 2008 [40]	Space: ± 1-2 m.	187	≤53 (multiple falls)	0.68	0.69 (0.50-0.83)	0.57 (0.47-0.66)	**
				≤54 (any fall)	0.59	0.61 (0.50-0.72)	0.53 (0.43-0.63)	

		Tools: Stopwatch, 2 chairs, tape-measure, step bench Training required: Yes		≤45 (multiple falls)		0.42 (0.26-0.61)	0.87 (0.79-0.92)	
				≤45 (any falls)		0.25 (0.16-0.36)	0.87 (0.79-0.92)	
	Ersoy et al., 2009 [41]		125	≤48		0.686	0.756	*
Performance Oriented Mobility Assessment - Balance	Trueblood et al., 2001 [34]	Time: ± 10 min. Space: ± 1-2 m. Tools: chair without handrails Training required: Yes	180	10		0.24	0.91	**
	Verghese et al., 2002 [39]		59	≤8		0.076	0.913	***
				≤9		0.23	0.804	
				≤10		0.615	0.695	
	Bizovska et al., 2018 [42]		131	(multiple fallers)	0.659	0.89	0,47	**
	Faber et al., 2006 [43]		72	10		0.640 (0.445-0.798)	0.661 (0.530-0.771)	**
Performance Oriented Mobility Assessment -Gait	Trueblood et al., 2001 [34]	Time:±10 min. Space: ± 1-2 m. Tools: obstacle-free corridor or space Training required: Yes	180	9		0.21	0.95	**
	Bizovska et al., 2018 [42]		131		NR because NS			**
	Faber et al., 2006 [43]		72	9		0.64 (0.445-0.798)	0.625 (0.494-0.74)	**
Functional Reach test	Lin et al., 2004 [29]	Time: <5 min. Space: ± 1-2 m. Tools: Tape-measure Training required: Yes	1200		0.509			**
	Russel et al., 2008 [33]		344		0.60 (0.54-0.66)			**
	Murphy et al., 2003 [44]		50	8in.		0.73	0.88	*
Falls History	Coll-Planes et al., 2006 [45]		192	≥1 fall(s) in previous year		0.595	0.645	**
	Gerdhem et al., 2005 [46]		984	1 fall in previous year		0.39	0.82	**
				≥2 falls in previous year compared to ≤ 1 fall		0.46	0.8	
	Lindemann et al., 2008 [47]		65	≥1 fall(s) in previous year		0.63	0.77	**
	Nitz et al., 2013 [48]		449	History of multiple falls	0.64			**
	Tiedemann et al., 2010 [49]		362	≥1 fall(s) in previous year	0.71	0.69 (0.57-0.78)	0.63 (0.57-0.69)	**

[1] s: seconds / m: meters / in: inch [2]Quality assessed with QUIPS tool: * High bias, ** Moderate Bias, *** Low Bias

179 an overall maximum score of 56 points. Balance is evaluated by asking participants to perform a variety of sitting, transferring and standing positions. In an assessment of which cut-off scores on the BBS best predict the risk of falling, Muir et al. [47] distinguish between single and multiple falls. They report an AUC of 0.68 for multiple falls with a cut-off score ≤53, and an AUC of 0.59 for a single fall with a cut-off score ≤54. A lower value of 0.47 is reported by Melzer et al. [37]. Sensitivity and specificity are reported in studies by Muir et al. [47] (25%–69%) and by Ersoy et al. [48] (53%–87%).

185 *The Tinetti tests*

186 The Tinetti tests are widely used tests for assessing the risk of falling, but there are many variations. One is the Performance Oriented Mobility Assessment (POMA) Total, which consists of two components to assess balance (POMA-B) and gait (POMA-G) and takes about 20 minutes to complete. For the POMA-B test, which is assessed in four studies [41, 46, 49, 50], participants are asked to perform nine different movements to assess balance. Depending on the cut-off scores, sensitivity ranges from 23% to 89%, with specificity ranging from 47% to 91.3%. An AUC of 0.66 is reported by Bizovska et al. [49], but no cut-off scores are specified, and the comparison concerns multiple falls, thus excluding single falls. In the POMA-G, participants are asked to perform six different movements to assess gait. It is recommended to conduct this test in a corridor. The only study to specify the space used for the test is by Bizovska et al. [49]: a well-lit corridor with a length of 30 metres. Faber et al. [50] and Trueblood et al. [41] report sensitivities ranging from 21% to 64% and specificities ranging from 63% to 95%. Bizovska et al. [49] do not report any specific results, as they found no significant differences between fallers and non-fallers in relation to the POMA-G.

198 *The Functional Reach test*

199 The Functional Reach (FR) test is validated in three studies [36, 40, 51]. In this test, participants are asked to hold their arms in front of them in an angle of 90 degrees, stretch forward as far as possible and return to the starting position. The distance between the starting position and the stretched position is used as an indicator of the risk of falling. This test takes less than five minutes to complete. The AUC is reported in two studies [36, 40], varying from 0.51 to 0.60. Murphy et al. [51] mention a sensitivity of 73% and a specificity of 88%.

Falls History

Five studies explore the accuracy of falls history (FH) [52-56], which takes only a few minutes to assess. These five studies apply different definitions of FH, with the most common being at least one fall in the previous year. Tiedemann et al. [56] and Nitz et al. [55] report AUC values ranging from 0.64 to 0.71. Sensitivity and specificity are explored in four studies, with sensitivity ranging from 39% to 69% and specificity ranging from 63% to 82%.

Quality Appraisal

The methodological quality of all articles was assessed (see Table 1). Three articles were classified as high quality, 21 articles as moderate quality and three articles as low quality.

Discussion

Discussion

This study aimed to identify falls risk assessment tools that are suitable for the primary care setting (i.e. they require limited time, no expensive equipment and no additional space) and that have good predictive performance in assessing the risk of falling amongst older people who are living independently. This systematic review identifies six falls risk assessment tools for the primary care setting. The vast majority of the included studies identify the falls risk amongst older people over a period of 12 months (mean: 15 months; minimum: 6 months; maximum: 9 years; see Additional File 2). None of these tools appears to be adequate in discriminating between people who are and are not at high risk of falling, taking into account the thresholds for good diagnostic accuracy (AUC>0.7), as proposed by Šimundić [27]. These findings do not change when considering only the articles of moderate and high quality. Four studies report AUC values >0.7 for the TUG test [33, 42], Gait Speed test [45] and FH[56], thereby indicating good diagnostic accuracy [27]. In most of the articles, however, the AUC values range from 0.5 to 0.7, thus indicating insufficient diagnostic accuracy for all of the tools addressed. Furthermore, the sensitivity and specificity of the same tool varied substantially across studies. We are therefore unable to draw convincing conclusions.

The results of this review are corroborated by other studies. For example, even though the TUG test is widely used to assess falls risk, other studies have also reported a lack of predictive ability for this test with regard to falls [57, 58]. Furthermore, as stated by Gates et al. [59], 'At present, recommending any screening test for routine clinical use is not possible. Despite the number of studies that have been conducted, no strong evidence exists that any screening test is useful for identifying fallers'. [58, p1113-1114]. The current systematic review, conducted 13 years later, leads to the same conclusion. The lack of conclusive evidence to identify falls risk assessment tools with adequate predictive performance and accuracy persists to date. It is therefore impossible to select an assessment tool based on predictive performance. Our review nevertheless adds valuable information to the existing body of literature concerning the tool that is currently most suitable for use by primary care providers to identify patients who are at high risk of falls.

Primary health care providers have limited time and lack resources for expensive equipment, space and training [15-20]. In light of these constraints, the results of this study suggest that the most suitable tool is FH, as it takes only a few minutes to conduct and requires no training, expensive equipment or spatial adjustments. The BBS and the Tinetti tests would not be suitable, as they take 15–20 minutes to complete and require training to conduct. The TUG and Gait Speed tests are both quick (< 5min.), but they require training and space (>4 metres) to conduct. Although the FR test is quick (< 5min.) and does not require much space, it requires more training than FH and the AUC values reported are lower than those for FH.

Despite the fact that it is insufficient, the diagnostic accuracy of FH is the same or even better than that of most of the other five falls risk assessment tools (see Table 1). Based on the clinometric evaluation of four falls risk assessment tools, Barker et al. [60] also identify FH as a suitable assessment tool, stating that 'the predictive validity of all tools was found to be low, with no tool offering greater ability to identify residents who would fall than a simple screening question "has the resident fallen in the past 12 months?' [59, p919]. Patient FH is also used in many multifactorial assessment tools and algorithms, and it appears to be an important factor in the risk of falling (OR: NS-14.02) [48, 53, 55, 61-68]. The use of FH nevertheless eliminates the possibility of identifying first-time fallers. Although this is clearly a major disadvantage, older people might be less willing to start and complete falls prevention interventions if they have not previously experienced a fall. They often do not consider themselves at high risk of falling [69, 70]. The experience of a previous fall might therefore enhance motivation to start and complete a falls prevention intervention [71].

According to a study by Nordin et al. [72], the assessment of falls risk through the combination of clinical judgement and FH amongst a population of frail older people was superior to performance-based measures. Meyer et al. [73] even assert that the use of falls risk assessment tools should be avoided, 'since it has no clinical consequences other than the waste of scarce nursing resources' [72, p421]. Due to increasing work pressure [15-18] and lack of awareness [74, 75], healthcare professionals might not assess a patient's risk of falling based solely on clinical judgement, as it is not part of any systematic assessment strategy. The systematic assessment of falls risk by combining FH and the expertise of healthcare professionals might therefore be an adequate strategy.

Practice recommendations

In daily practice, GPs can ask their older patients during consultation if they have had a fall during the past 12 months. Even if a patient has not had a fall, the GP might still identify a high falls risk based on clinical judgement (e.g. walking or sitting difficulties due to strength and balance problems, dizziness, use of benzodiazepines, visual impairment). If a high falls risk is suspected after such a brief assessment, the GP could investigate the underlying cause of the falls risk by conducting a multifactorial assessment so that adequate care can be provided. It should be noted that, in this study, FH is defined as an assessment tool and not as a screening tool. A falls risk assessment tool defines the nature of the problem, and thus whether a patient is or is not at high risk of falling [21]. No additional assessment is required to identify high or low falls risk. Additional assessment (e.g. multifactorial assessment) is needed only to determine which intervention is needed in order to reduce a patient's high falls risk. Screening tools are intended to evaluate the possible presence of specific problems. A screening tool would require additional assessment in order to verify that a patient has a high falls risk [21].

Depending on the organisation of the GP practice, the GP could also refer the patient to another healthcare provider (e.g. a practice nurse specialised in geriatric care), who might have more time to investigate the underlying cause of the falls risk. A patient's falls risk could be reduced by conducting a brief falls risk assessment that leads to a comprehensive multifactorial assessment to identify the underlying causes, followed by multifactorial interventions that address any risk factors that have been identified [76-78]. The clinical practice guidelines of the American Geriatrics Society/British Geriatrics Society recommend conducting falls risk assessments annually [79].

Strengths and Limitations

This review was not registered at PROSPERO, the international prospective register of systematic reviews. This could have caused duplication of review topics. Nonetheless, no ongoing reviews were found in the PROSPERO register that specifically focus on suitability of falls risk assessment tools for the primary care setting.

In this review, the initial screening of titles and abstracts was performed by one researcher (WM). For the second round of selection, a sample of 200 articles was reviewed independently by a second researcher (JK, CL or IG), based on abstract (>95% consensus). Even though this is an acceptable procedure according to the Cochrane Handbook for Systematic Reviews of Interventions, each screening step should ideally be performed by at least two people working independently [80]. Our results might therefore be subject to bias due to our method of study selection.

The results of this review were difficult to combine. Different studies used different cut-off scores, addressed modified versions of the same tests and presented different outcome measures. These differences between studies made it difficult to arrive at a convincing conclusion based on the results.

Given that we have included at least three studies for each tool, it would seem feasible to conduct a meta-analysis for each tool. We did not do this, however, for two reasons. First, the diversity between studies assessing the same tools was quite high. For example, there were substantial differences in cut-off scores, follow-up periods and study populations (e.g. in terms of sex, age), as well as in the criteria for inclusion and exclusion and the quality of the studies. These differences rendered a meta-analysis unsuitable for most tools. Second, the results of our study are clear without conducting a meta-analysis: none of the six tools identified in the review appears to be adequate in discriminating between people who are and are not at high risk of falling, taking into account the thresholds for good diagnostic accuracy (AUC>0.7), as proposed by Šimundić [27]. Another limitation is related to the possibility of publication bias against studies with worse outcomes, which might have led to an overestimation of the predictive performance of the falls risk assessment tools that were included. All of these limitations support our conclusion that none of the tools addressed has sufficient predictive performance.

Further Research

The underlying cause of falls is often multi-factorial and complex. This makes it difficult, if not impossible to adequately identify people who are at high risk of falling using only a physical test or brief questionnaire. None of the falls risk assessment tools identified in this review, all of which focus on falls history, balance, gait and/or strength problems, is capable of adequately identifying older people with high falls risk. It is therefore important to investigate other ways of assessing high falls risk in the primary care setting amongst older people who are living independently. The predictive performance of falls risk assessment tools could potentially be enhanced by developing a multi-factorial assessment tool that also takes into account a person’s behaviour and environment.

Taken together, the results of this systematic review indicate that the predictive performance of the six falls risk assessment tools identified in the studies reviewed is insufficient. Overall, FH appears to be the same or even better than the other five tools. In addition, this tool is most suitable for the primary care setting, as it is quick and does not require equipment, space or training. The combination of FH and the clinical judgement of a healthcare professional could be a promising strategy in the primary care setting for identifying older people who are at high risk of falling, such that they can be provided with adequate falls prevention care. This could reduce both falls and fear of falling, thereby maintaining or improving quality of life and prolonging autonomy for older people.

List of abbreviations

GP: General Practitioner

QUIPS: Quality in Prognosis Study

AUC: Area Under the Curve

ROC: Receiver Operating Characteristic

TUG: Timed Up and Go

BBS: Berg Balance Scale

POMA-B: Performance Oriented Mobility Assessment-Balance

POMA-G: Performance Oriented Mobility Assessment-Gait

FR: Functional Reach

FH: Falls History

Declarations

Ethics approval and consent to participate

No ethics approval was required for this literature review.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors have no conflicts of interests to declare.

Funding

This work was supported by ZonMw, the Netherlands Organisation for Health Research and Development [Grant Number 531001210]. The funder had no role in the creation of the research question, the design of the study, the collection, analysis or interpretation of data, or the writing of this manuscript.

Author Contributions

WM conducted the systematic review and wrote the manuscript. JK, CL and IG reviewed articles for inclusion, reviewed the quality check and provided feedback on the manuscript. All authors read and approved the final manuscript.

Acknowledgements

Not applicable.

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Figure Legends

Figure 1. Search keywords

Figure 2. Flowchart for the literature search

Figure 3. Eligibility criteria

Figure 1. Search keywords

(Frail Elderly[Mesh] OR Aged[Mesh] OR Frail Elderly* OR Aged*)
AND
(Accidental Falls[Mesh] OR Accidental Falls*OR Falls*)
AND
(Risk Assessment[Mesh] OR Prognosis[Mesh] OR Diagnosis[Mesh] OR Risk Assessment* OR Prognosis* OR Diagnosis* OR Screening* OR Prediction*)
AND
(Specificity and Sensitivity[Mesh] OR Data Accuracy[Mesh] OR Sensitivity* OR Specificity* OR Accuracy* OR Validity*)

Figure 2. Flowchart Literature Review

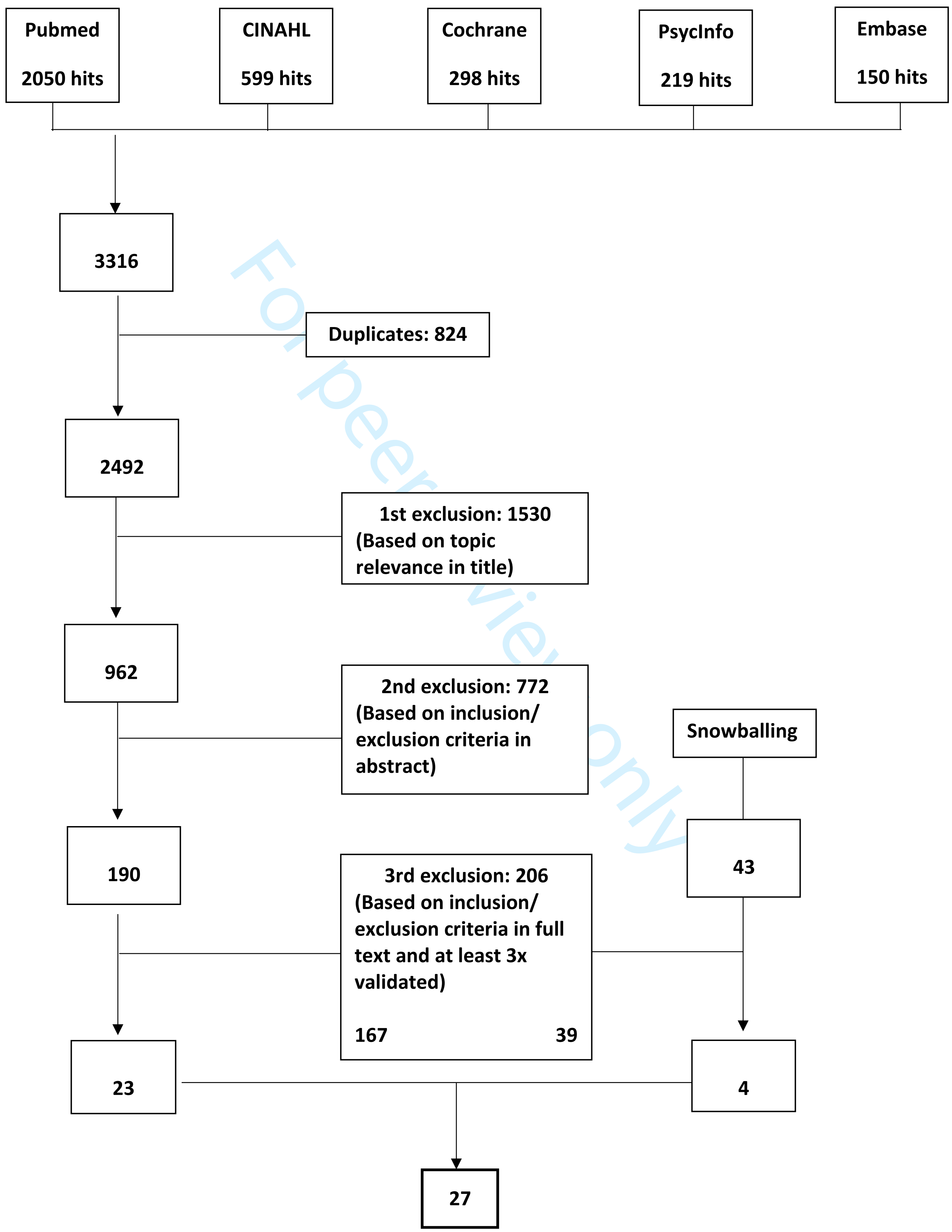

Figure 3. Eligibility criteria

Articles were included when they met the following inclusion criteria:

1. Prospective studies in which the primary or secondary purpose was to evaluate the performance of one or more fall risk assessment tools for predicting fallers.
2. The participants were older people living in the community or substantially independently
3. Full articles published in English, Dutch or German

Articles were excluded when they met one or more of the following exclusion criteria:

1. Fall risk assessment tools which require expensive computer software programs, other advanced expensive software or instruments not available in usual primary care units (e.g. sensors, electronical platforms, force plates).
2. Literature reviews and studies with no follow up of fall incidents.
3. No reported Area Under the Curve (AUC), sensitivity or specificity of the fall risk assessment tools.
4. Assessment tools specifically developed for or only tested on populations with a specific disease (e.g. cancer, diabetes, Parkinson etc.)
5. The participants were living in hospital or other institutionalised settings

Additional file 1

Recent queries in pubmed
Search,Query,Items found,Time

#1,"Search (((((""Aged""[Mesh]) OR ""Frail Elderly""[Mesh] OR Aged* OR Frail Elderly* OR Elderly*)) AND (""Accidental Falls""[Mesh] OR Accidental Falls* OR Falls*)) AND (((""Risk Assessment""[Mesh]) OR ""Diagnosis""[Mesh]) OR ""Prognosis""[Mesh] OR Risk Assessment* OR Diagnos* OR Prognos* OR Screen* OR Predict*)) AND (((""Sensitivity and Specificity""[Mesh]) OR ""Reproducibility of Results""[Mesh]) OR ""Data Accuracy""[Mesh] OR Sensitivity* OR Specificity* OR Accuracy* OR Reliab* OR Valid*) Filters: Full text	Publication date from 2000/01/01 to 2020/07/01	Field: Title/Abstract",1956,03:40:44

Additional file 2.

Overview characteristics included articles

Author	N	Age (range, mean, SD)[1]	Gender	Exclusion	Inclusion	Follow up in months	Included instrument[2]
Alexandre et al., 2012 [29]	60	≥60 (60-82)	29 men/ 31 women	PD, history of transitory ischemic attack, stroke, cognitive impairment, wheelchair, fall in the previous 6 months	n.a.	12 months	TUG test
Bizovska et al., 2018 [48]	131	≥60 (mean 70.8, SD 6.7)	23 men/ 108 women	Any injury or surgery on the musculoskeletal system during the last two years before the baseline measurement	Aged ≥60; ii) no known neurological or musculoskeletal problem that may affect gait or balance abilities; iii) ability to stand and walk without any assistance and assisting device	12 months	POMA-B POMA-G
Bongers et al., 2015 [43]	352	≥70 (mean 76.2 (SD 4.3)	all women	too ill to be screened by GP, currently receiving treatment from geriatrician or received comprehensive geriatric assessment in past 3 months	n.a.	12 months	Gait speed test (4m)
Bongue et al., 2011 [30]	1759	≥65 (65-95, 70.7 (SD 4.6))	862 men/ 897 women	neurological disease, cognitive impairment, unable to understand French or follow simple commands	n.a.	12 months	TUG test
Chow et al., 2019 [42]	192	≥65 (mean: 74.4)	81 men/ 111 women	n.a.	aged ≥65, being discharged from the ED, English speaking, had capacity to give consent, and personally identified a risk factor for falling (if a patient reported that they had either fallen in the last year, worried about falling, or admitted that they felt unsteady when standing or walking)	6 months	TUG test
Coll-Planas et al., 2006 [51]	192 (268 with 76 drop-outs)	≥65 (89 >83 years, 103 ≤83 years)	34 men/ 158 women	living in nursing home	Community dwelling elderly aged ≥65	12 months	Fall history
Ersoy et al., 2009 [47]	125	≥50 (50-79, 61.4 (SD 7.9)	all women	unable to walk without assistance or aids	postmenopausal community dwelling women aged 50+	6 months	BBS

Faber et al., 2006 [49]	72 (total 245)	84.9 (SD 6.0) (of total 245)	14 men/ 58 women	in ability to walk 6m with(out) aids, capacity to understand instructions, medical contraindications to participate, cognitive impairment	n.a.	10 months	POMA-B POMA-G
Gerdhem et al., 2005 [52]	984	75 (75.01-75.99)	all women	n.a.	community dwelling women aged 75 in Malmö	12 months	Fall history
Hofheinz et al., 2016 [31]	120	≥60 (60-87, 72.2 (SD 6.8)	26 men/ 94 women	cognitive limitations, neurological or musculoskeletal diagnose	able to walk 10m with(out) aid, able to understand instructions, able to carry glass in one hand	12 months	TUG test
Kang et al., 2017 [33]	541	≥60 (67.4 (SD 5.6))	234 men/ 307 women	Inability to perform the basic activities of daily living and thus could not complete performance-based assessments; visual impairments; current use of drugs (psychotropic drugs, cardiovascular drugs, hypoglycemic agents, non-steroidal anti-infammatory drugs, analgesics, dopaminergic drugs, PD's drugs or more than four kinds of complex drugs).	Aged ≥60 years and joined the China's national free physical examination programs	12 months	TUG test Gait speed test (4m)
Kang et al., 2018 [32]	619	≥60 (60-86, 67.4 (SD 5.6))	262 men/ 357 women	Severe functional impairment, current use of sedative drugs, antiepileptic drugs ans so on, refusal to participate in the follow-up of this study	Aged ≥60, who joined the free physical examination program	12 months	TUG test
Kojima et al., 2015 [34]	259	≥65 (72.6 (SD 5.9)	95 men/ 164 women	≥3 falls in past year, unstable medical conditions, already exercising 150min/week	aged ≥65 able to walk independently and participate in group exercise	6 months (24 weeks)	TUG test
Lin et al., 2004 [35]	1200	≥65 (73.4 (SD=NR)	709 men/ 491 women	NR	NR	12 months	TUG test FR test
Lindeman et al., 2008 [53]	65	≥65 (67.7 (SD 6.0))	33 men/ 32 women	use of walking aid, self-reported neurological disorders, or spinal or lower extremity joint pain interacting with stepping performance, inability to come to the research department without help, cognitive impairment	community dwelling elderly aged ≥65	12 months	Fall history

Melzer et al., 2010 [36]	98	≥65 (65-91, 78.4 (SD 5.7))	26 men/ 72 women	serious visual impairment; inability to ambulate independently; cognitive impairment; severe focal muscle weakness or paralysis; severe peripheral or compression/entrapment neuropathies; symptomatic orthostatic hypotension, respiratory, cardiovascular, musculoskeletal or neurological disorders that might have interfered with participation in the exercise program; cancer, metastatic or under active treatment; and use of medication known to impair balance or strength.	n.a.	12 months	TUG test BBS
Muir et al., 2008 [46]	187	≥47 (47-90, 79.4 (SD 5.83))	122 men/ 65 women	n.a.	community dwelling veterans of WWII and the Korean War residing in 3 regions of southwestern Ontario	12 months	BBS
Murphy et al., 2003 [50]	50	≥60 (72.3 (SD 8.6))	13 men/ 37 women	no exclusion based on disease	community dwelling elderly aged ≥60	14 months	FR test
Nitz et al., 2013 [54]	449	≥40 (40-80, 59.3 (SD 10.6))	all women	n.a.	independently mobile and cognitively competent women from the electoral rool in North Brisbane Health district	108 months (9 year)	Fall history
Ollsen Möller et al., 2012 [37]	153	≥65 (66-94, 81.5 (SD 6.3))	51 men/ 102 women	n.a.	Age ≥65, living in the municipality where the study was conducted; needing help with at least two activities of daily living (ADL); admitted to hospital at least twice or with at least four contracts with outpatient or primary healthcare during the previous 12 months; being able to communicate verbally and have not cognitive impairments (i.e. ≥25 MMSE)	12 months	TUG test

Pai et al., 2010 [38]	13	≥65 (65-85, 72 (SD 5))	9 men/ 4 women	musculoskeletal, neurological, cognitive or other systemic disorders, osteopenic or osteoprotic, cognitive impairment, symptomatic postural hypotension	ambulatory community dwelling elderly	29-32 months	TUG test
Russell et al., 2008 [39]	344	≥60 (75.9 (SD 8.5)	106 men/ 238 women	n.a.	community dwelling elderly aged ≥60 presented to an ED as a result of a fall being directly discharged home following emergency care and able to walk independently	12 months	TUG test FR test
Tiedemann et al., 2010 [55]	362	≥74 (74-98, 80.25 (SD=4.5))	128 men/ 234 women	blindness, minimal English language skills, and cognitive impairment	community dwelling elderly aged 63-95 resided in Sydney, Australia	12 months	Fall history
Trueblood et al., 2001 [40]	180	≥60 (60-96, 77.9 (SD 7.26))	37 men/ 143 women	cognitive deficits, underlying neurological problems	aged ≥60, able to stand for 5 min. without aid, able to walk 40 feet at one time without aid.	6 months	TUG test POMA-B POMA-G
Tsutsumimoto et al., 2013 [44]	59	≥65 (Non-fallers 84.0 (SD 1.1) 85.5 (SD 1.4))	11 men/ 48 women	very severe cardiac, pulmonary, musculoskeletal, or neuropathological disorders associated with inability to step safely, cognitive impairment	community-dwelling older people receiving long-term care services aged ≥65, able to walk independently, and having adequate hearing and vision	12 months	Gait speed test (4m)
Verghese et al., 2002 [45]	59	≥65 (Nonfallers 79.7 (SD 6.6) Fallers 79.4 (SD 5.7))	25 men/ 34 women	severe visual loss interfering with completion of neuropsychological tests, non-English or non-Spanish speaking, institutionalization, healthy enough to make a clinic visit	community dwelling elderly aged ≥65	12 months	Gait speed test (4m) POMA-B

Wrisley et al., 2010 [41]	35	60-90 (72..9 (SD 7.8))	17 men/ 18 women	cognitive impairment, history of osteoporosis, recent fractures, or lower-extremity surgery; history of progressive neuromuscular disorder; history of whiplash, neck injury, or current complaints of neck pain; history of unstable agina or uncontrolled cardiorespiratory problems; taking any medications that might affect balance; history of any fall in past 6 months and more than one fall in the last year; pain in any segment greater than 2/10 on a 10-point verbal analog scale; not returning the monthly fall calendar	community dwelling elderly aged 60-90 able to stand independently longer than 1 min.	6 months	TUG test

[1] range, mean, SD: only described when reported in included article
[2] TUG test: Timed Get Up and Go test
POMA- B: Performance Oriented Mobility Assessment –Balance
POMA-G: Performance Oriented Mobility Assessment –Gait
BBS: Berg Balance Scale
FR test: Functional Reach test

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Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	Title, page 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.	Abstract, page 2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	Background, page 3
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	PICO: Background, page 3 S: Methods, Analysis/Figure 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.	N/A
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.	Methods, Figure 3
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	Methods, Study selection
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	Methods, Figure 1
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	Methods, Eligibility criteria and study selection
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	Methods, Eligibility

PRISMA 2009 Checklist

			criteria and study selection
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	Methods, Analysis
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	Methods, Quality appraisal
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	N/A
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.	N/A

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	N/A
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	N/A
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	Methods, Figure 2
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	Additional File 2
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	Results, Table 1
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	N/A
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	N/A
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	N/A
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	N/A
DISCUSSION			

PRISMA 2009 Checklist

Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	Discussion, page 8-10
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	Discussion, Limitations
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	Discussion, page 8-10
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	Declarations, Funding

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

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