Review Article

Fall risk question-based tools for fall screening in community-dwelling older adults: a systematic review of the literature

Chrysoula Argyrou[1,2], Yannis Dionyssiotis[3], Antonios Galanos[1], John Vlamis[4], Ioannis K.Triantafyllopoulos[5], Ismene A. Dontas[1], Efstathios Chronopoulos[1]

[1] *Laboratory for Research of the Musculoskeletal System "Th. Garofalidis", Medical School, National and Kapodistrian University of Athens, General Hospital of Athens KAT, Greece;*
[2] *4th Orthopaedic Department, General Hospital of Athens KAT, Greece;*
[3] *Spinal Cord Injury and Rehabilitation Clinic, University of Patras, Greece;*
[4] *3rd University Orthopaedic Department, General Hospital of Athens KAT, Greece;*
[5] *5th Orthopaedic Department, HYGEIA Hospital, Athens, Greece*

Abstract

Fall screening tools aim to accurately identify the high fall risk individuals. To increase ease of administration and cost-effectiveness many studies focus on question-based tools. The purpose of this systematic review was to identify question-based tools for fall risk assessment in community-dwelling older adults over the age of 60 and the risk factors that are covered by these tools. The PRISMA guidelines were followed. A literature search was conducted in PubMed/MEDLINE, Web of Science and Google Scholar. Data quality assessment was performed with the Ottawa–Newcastle scale. The results identified 20 studies that used 22 question-based tools to assess fall risk. The number of questions per tool varied from 1 to 41 questions. Data quality varied greatly, with values 3-9 for cohort and 2-7 for cross-sectional studies. The most commonly reported fall risk factors were fall history, feeling of unsteadiness, fear of falling, muscle strength, gait limitation and incontinence. Healthcare providers should use the above tools with caution regarding the limitations of each tool. Further studies should be designed to address individuals with high fall risk, such as individuals with cognitive impairment, as they are under-represented or excluded from most of the existing studies.

Keywords: Community-dwelling older adults, Elderly, Fall risk, Fall risk screening, Questionnaires

Introduction

Falls have become a major public health issue nowadays. According to the Centers for Disease Control and Prevention (CDC), 1 in 3 older adults report a fall, 3 million older adults are treated for fall injuries every year and more than 300,000 older individuals are hospitalized for hip fractures[1-3]. Falls also represent a major socio-economic issue, as it is estimated that in the U.S. alone the medical fall-related economic burden for older adults is about 50 billion dollars for non-fatal fall injuries and 754 million dollars for fatal falls[4]. Similarly, data from the UK indicate that around 2.3 billion GBP per year are spent on fall-related injuries in individuals over 65 years of age[5].

Numerous fall risk factors for community-dwelling older adults have been identified and they generally fall into two broad categories: intrinsic factors that include factors like advanced age, fall history, balance and gait problems, vision

The authors have no conflict of interest.

Corresponding author: *Chrysoula Argyrou Nikis 2, 14561, Kifisia, Athens, Greece*

E-mail: *chrisa.a@hotmail.com*

Edited by: *Dawn Skelton*

Accepted *23 September 2023*

impairment, chronic disease and extrinsic factors that include mostly environmental factors like uneven surfaces, poor lighting, home hazards and footwear[6]. It is, also, well-established the fact that the accumulation of multiple risk factors increases the fall risk[7].

Fall screening tools for older adults living in the community aim to accurately identify the high fall risk individuals and subsequently apply appropriate intervention strategies to reduce the incidence of falls and the adverse sequelae that follow for both the individuals and the society. Current clinical practice guidelines on fall assessment worldwide recommend a combination of questionnaires and performance-based tools to address the multi-factorial nature of fall risk factors[5,8,9]. However, meticulous assessment with the use of many tools is time-consuming and requires trained personnel to administer and interpret the tests, which is not always feasible. To overcome this, many studies focus on the development of question-based tools that can be easily administered and make the screening process cost-effective. Such questionnaires are already embedded in current fall assessment algorithms, like the Stay Independent questionnaire administered by the Stopping Elderly Accidents, Deaths, and Injuries (STEADI) initiative of the CDC[10]. However, a gold standard questionnaire has yet to be established and current questionnaires vary greatly as to their length and risk factor selection for inclusion[11].

The purpose of this study was to perform a systematic review of current literature to identify question-based tools for fall risk assessment in community-dwelling older adults and the risk factors that are covered by these tools.

Methods

A literature search was conducted in Pubmed/MEDLINE, Web of Science and Google Scholar on September 1st 2022. An update search was performed on December 1st 2022. The PRISMA guidelines of 2020 for reporting systematic reviews were followed[12]. The PICO method was used as follows[13]; Population: community-dwelling older adults over 60 years of age, Intervention: question-based tools evaluating fall risk, Comparison: none, Outcome: fall risk identification. The present review was registered in PROSPERO (Registration ID: CRD42023389873).

As search keywords for Pubmed/MEDLINE the following terms were used: "Accidental Falls", and "Aged", and "Risk", and "Independent Living", and "Mass Screening" or "Surveys and Questionnaires". Keywords were adapted accordingly to the other databases. The references of the articles identified through the search were also addressed for relevant information.

The inclusion criteria were: a) prospective, retrospective and cross-sectional studies, b) studies that included only question-based tools to evaluate fall risk, c) age of the participants ≥60 years old, d) year of publication within the last ten years (2012-2022). The exclusion criteria were: a) study protocols, systematic/scoping/literature reviews and meta-analyses, b) non-English studies, c) studies without available full text.

Literature search and data extraction were performed by two independent reviewers (C.A. and Y.D.) based on the aforementioned criteria. In case of disagreement, a consensus was reached with the help of a third reviewer (E.C.). For data extraction, we decided to include as many parameters as possible regarding each study's design, psychometric properties and risk factors assessed. More specifically, a Microsoft Excel spreadsheet was created with study design data (type of study, tool name, number of questions, type of questions), the participants' characteristics (age, gender), psychometric properties of the tools (area under the curve - AUC, sensitivity, specificity, Cronbach's α coefficient, intraclass correlation coefficient - ICC, correlation with other tools) and the risk factors included in each tool.

Data quality assessment was performed with the Newcastle-Ottawa scale (NOS) for cohort studies and the adaptation for cross-sectional studies[14,15]. NOS is a widely used risk of bias assessment tool, validated and easy to perform. For the NOS administration, two reviewers (C.A. and Y.D.) independently assessed the risk of bias. In cases of disagreement, a consensus was reached with discussion and with the help of a third reviewer (E.C.).

Results

The literature search identified 1,531 studies. Of those, 264 were excluded as duplicates and 84 as studies published before 2012. The remaining 1,183 articles were screened and 953 were excluded based on their title and abstract. Of the remaining 230 studies, 3 were excluded as they were not written in English, 108 as they were reviews and meta-analyses and 103 as they included performance-based instruments. 10 studies were added as a result of citation searching and 6 were excluded as they were also based on performance tests. A total of 20 studies and 22 question-based tools were included in the review. Figure 1 is the PRISMA flow diagram of the review.

Study design results

The study design was cross-sectional in 8 studies[16-23], retrospective in 1[24], prospective in 10[25-34] (with a follow-up period from 3 months to 3 years) and both retro- and prospective in 1 study[35]. Overall, the majority of the participants of the included studies were females with a percentage ranging from 45% to 84%. The number of questions per tool varied from 1 to 41 questions, as well as the type of the answers with 9 tools answered as yes/no[18,19,21,24,32,33,35], 5 as 4-point scale[16,20,22,29], 2 as 11-point scale[28,31], 1 as dichotomous[23], 1 as multiple choice questions (MCQs)[25] and 6 as mixed answering systems[17,26,30,33,34]. Table 1 provides a detailed overview of the characteristics of the included studies.

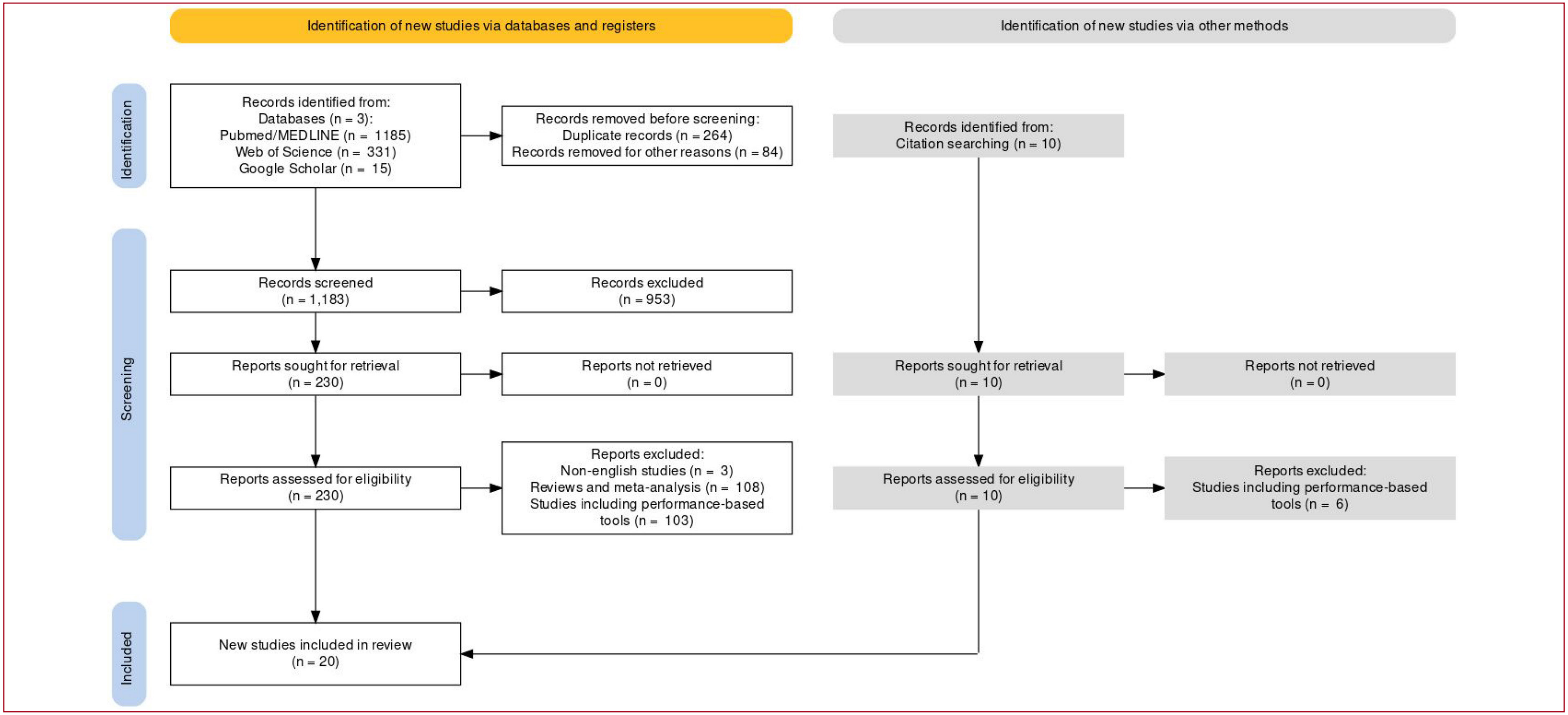

Figure 1. PRISMA flow diagram of the review.

Psychometric properties results

Validity measures (AUC, sensitivity, specificity) were reported in 10 studies[18,22,25-27,30,32-35], reliability measures (ICC and Cronbach's α) in 7[16,19-23,32] and correlation coefficient in 3[19,20,22]. One study reported only the content validity coefficient[17] and one only the incident rate ratio between fallers and non-fallers[31]. Table 2 presents the reliability and validity of the tools included in the review.

Fall risk factors

The fall risk factors assessed by the tools of the included studies were recorded and summarized in Table 3 and Figure 2. Figure 2 also depicts the overall percentage of each of the 34 risk factor's appearance in the tools. Risk factors that contributed with a percentage of more than 30% in the tools (fall history, balance disturbance/feeling of unsteadiness, fear of falling, muscle strength/physical function, gait limitation/

Table 1. Overview of question-based tools assessing fall risk included in the review.

Tool name	Study	Tool developer*	Tool name	No of questions	Type of answers	Participants	Type of study	Age	Gender of participants (% females)
Scripted Fall Risk Screening Tool (FRST)	Feilding et al, 2013[16]		Modified Fall Risk Screening Tool (FRST)	23	4-point scale	111	Cross-sectional	NA (age > 65 years)	NA
Modified Suzuki's fall assessment Questionnaire (FRAS)	Hirase et al, 2014[35]	Suzuki et al.[36]	Modified Suzuki's fall assessment Questionnaire (FRAS)	7	Yes/no	1871	Retrospective	76.5 ± 7 (65-95)	67.8%
						292	Prospective (3-months)	81.6 ±6.2 (66-92)	82.4%
Questionnaire from NHATS study	Gadkaree et al, 2015[25]		Questionnaire from NHATS study	5	MCQ	7609	Prospective (12-months)	65-69 = 27.9% 70-74 = 25% 75-79 = 19.1% 80-84 = 14.7% 85-89 = 9.1% 90+ = 4.3%	56.6%
Frailty Index (FI)	Kojima et al, 2015[26]	Mitnitski et al.[41]	Frailty Index (FI)	40	Dichotomous and 3-point scale	248	Prospective (24-weeks)	72.9 ± 6.1	63.7%
NA, Online Questionnaire	Obrist et al, 2016[27]		NA, Online Questionnaire	36	NA	134	Prospective (6-months)	69.3 ± 5.6 (NA)	45%
ABC	Cleary et at, 2017[28]	Powel and Meyers[42]	ABC	16	11-point scale	45	Prospective (6-months)	83.2 ± 6.3 (67-94)	68.9%
Self-reported unsteadiness	Donoghue et al, 2017[29]		Self-reported unsteadiness	3	4-point scale	1621	Prospective (2-years)	71.2 ± 5.2 (65-93)	51.6%
3-STEADI (3 key questions)	Eckstrom et al, 2017[24]		3-STEADI (3 key questions)	3	Yes/no	405	Retrospective	73.1	64.2%
NA	Rodriguez et al, 2017[30]		NA	2	Yes/no and 3-point scale	772	Prospective (12-months)	80.7 ± 0.1 (median ± SD)	62.5%
Online Assessment Instrument for Elderly Falls (IAQI)	Silveira et al, 2018[17]		Online Assessment Instrument for Elderly Falls (IAQI)	14	6 MCQs, 8 yes/no	24	Cross-sectional	NA (age > 60 years)	NA
FRRISque	Chini et al, 2019[18]		FRRISque	10	Yes/no	854	Cross-sectional	60-69 = 43.4% 70-79 = 39.7% 80-89 = 14.8% >90 = 2.1%	57.6%
Thai-modified STEADI	Loonlawong et al, 2019[19]	Rubenstein et al.[38]	Thai-modified STEADI	12 (original) and 18 (Thai-modified)	Yes/no	480	Cross-sectional	72.8 ± 6.64 (65–90)	52%
Chinese HomeFAST	Lai et al, 2020[32]	Mackenzie et al.[37]	Chinese HomeFAST	20	Yes/no	210	Prospective (6-months)	71.45 ± 6.38 (66-81)	50%

Table 1. *(Cont. from previous page).*

Tool name	Study	Tool developer*	Tool name	No of questions	Type of answers	Participants	Type of study	Age	Gender of participants (% females)
Persian Fall Risk Screening Tool (FRST)	Tabatabaei et al, 2020[20]	Feilding et al, 2013[16]	Persian Fall Risk Screening Tool (FRST)	23	4-point scale	537	Cross-sectional	67.18 ± 6.93	57.1%
MFES (modified falls efficacy scale)	Yang et al, 2020[31]	Hill et al.[44]	MFES (modified falls efficacy scale)	14	11-point scale	47	Prospective (12-months)	78.9 ± 5.5 (70-93)	74.5%
Brazil HomeFAST	Ferreira et al, 2021[21]	Mackenzie et al.[37]	Brazil HomeFAST	20	Yes/no	50	Cross-sectional	73.2 ± 5.8	84%
LRMS	Argyrou et al, 202222		LRMS	11	4-point scale	173	Cross-sectional	72.3 ± 6.3 (60–91)	69.4%
3-STEADI (3 key questions)	Burns et al, 2022[33]	Eckstrom et al, 2017[24]	3-STEADI (3 key questions)	3	Yes/no	1563	Prospective (12-months)	65-74 = 68.2% 75-84 = 26.5% >85 = 5.3%	52.5%
Stay Independent		Rubenstein et al.[39]	Stay Independent	12	Yes/no				
AGS/BGS		AGS/BGS Panel[39]	AGS/BGS	3	Yes/no and number of falls				
Short FES-I		Kempen et al.[40]	Short FES-I	7	4-point scale				
Fell in the past year			Fell in the past year	1	Yes/no				
Fallen in the past 12 months			Fallen in the past 12 months	1	number of falls				
Machine learning	Ikeda et al, 2022[34]		Machine learning	14	Yes/no and MCQs	61883	Prospective (3-years)	72.8 ± 5.5 (non-fallers) 75.4 ± 6.1 (fallers)	53.72%
FRSAS (Fall Risk Self Assessment Scale)	Wang et al, 2022[23]		FRSAS (Fall Risk Self Assessment Scale)	41	Dichotomous	222	Cross-sectional	73.84 ± 7.46 (65-90)	63.06%

*Age presented as mean ± SD (range), unless stated otherwise. * in cases that the developer of the original tool is different from the authors of the study.*

use of walking device and frequent urination/incontinence) are depicted separately in Figure 3. The studies that were included in the review are presented in the tables chronologically based on their publication year and alphabetically for studies published within the same year.

Risk of bias assessment

The risk of bias assessment indicated that the included studies varied greatly, with values 3-9 for cohort and 2-7 for cross-sectional studies, as shown in Table 4. Overall, 10 out of 20 studies were characterized as high risk of bias, 4 as medium risk and 5 as low risk of bias.

Adaptations of previously reported instruments

Fielding et al.[16] in 2013 tested the reliability of the scripted Fall Risk Screening Tool (FRST) in a cross-sectional study of 111 participants. In 2020, Tabatabaei et al.[20] translated and evaluated the Persian version of the FRST and found it to have a significant correlation of the Timed-Up and Go (TUG) test.

Table 2. Validity and reliability of the questionnaires included in the review.

Tool name	Study	AUC	Sensitivity	Specificity	Cronbach's α	ICC	Correlation with other tools (r)	Other parameters
Scripted Fall Risk Screening Tool (FRST)	Feilding et al, 2013[16]				0.869	0.830 (inter-rater)		
Modified Suzuki's fall assessment Questionnaire (FRAS)	Hirase et al, 2014[35]	0.73 (0.62,0.83) for the 7 factors	84%	68%				
Questionnaire from NHATS study	Gadkaree et al, 2015[25]	Any fall 0.69 (95% CI = [0.67, 0.71]) Recurrent falls 0.77 (95% CI = [0.74, 0.79])						
Frailty Index (FI)	Kojima et al, 2015[26]	0.62 (95 % CI[0.53, 0.71])	31.6%	85.9%				OR = 3.04, (95 % CI = [1.53,6.02])
NA, Online Questionnaire	Obrist et al, 2016[27]	0.67 (95% CI = [0.54, 0.81]						
ABC	Cleary et at, 2017[28]				0.973*	0.879* (95% CI = [0.779, 0.934]) (test-retest)		OR = 0.95
Self-reported unsteadiness	Donoghue et al, 2017[29]							IRR = 1.53 (0.93, 2.49)
3-STEADI (3 key questions) vs Stay Independent	Eckstrom et al, 2017[24]	**0.981 (SE=0.021)	100%**	83.3%**	0.746** (Stay Independent)			95% of high-risk (with 12-Item Stay Independent) were identified with 3-STEADI
NA	Rodriguez et al, 2017[30]	0.74 (95% CI = [0.66, 0.82])	70%	72%				
Online Assessment Instrument for Elderly Falls (IAQI)	Silveira et al, 2018[17]							CVC = 0.76 (clarity), CVC = 0.82 (content)
FRRISque	Chini et al, 2019[18]		91.3%	73.4%				
Thai-modified STEADI	Loonlawong et al, 2019[19]				0.78 (12 and 18-Item)	0.95 (12-Item) 0.91 (18-Item)	r = 0.330 (TUG), r = -0.499 (BBS) – 12-Item r = 0.358 (TUG), r = -0.484 (BBS) – 18-Item	
Chinese HomeFAST	Lai et al, 2020[32]		83%	96%	0.94	0.89 (95% C.I. = [0.84, 0.93]) (inter-rater) 0.88 (95% C.I. = [0.90, 0.94]) (test-retest)		
Persian Fall Risk Screening Tool (FRST)	Tabatabaei et al, 2020[20]				0.73		r = 0.122 (TUG)	CVI = 0.87

Table 2. *(Cont. from previous page).*

Tool name	Study	AUC	Sensitivity	Specificity	Cronbach's α	ICC	Correlation with other tools (r)	Other parameters
MFES (modified falls efficacy scale)	Yang et al, 2020[31]				0.95***	0.93 (test-retest)***		IRR = 0.96
Brazil HomeFAST	Ferreira et al, 2021[21]					0.83 (95% CI = [0.70,0.90]) (inter-rater) 0.85 (95% CI = [0.74,0.91]) (intra-rater)		
LRMS	Argyrou et al, 2022[22]	0.930 (95% CI= [0.88, 0.98])	93%	91%	0.807	0.991 (test-retest)	r = 0.831 (TUG), r = −0.820 FES-I, r = −0.812 (Tinetti balance), r = −0.789 (Tinetti gait), r = −0.562 (GDS-15)	
3-STEADI (3 key questions)	Burns et al, 2022[33]		68.7%	57.9%				OR = 3 (95% CI = [2.3, 4.1])
Stay Independent			55.7%	75.9%				OR = 3.9 (95% CI = [2.9, 5.3])
AGS/BGS			60.1%	66.4%				OR = 3 (95% CI = [2.2, 4])
Short FES-I			22.5%	89.4%				OR = 2.5 (95% CI = [1.6, 3.8])
Fell in the past year			40.3%	86.2%				OR = 4.2 (95% CI = [3.1, 5.8])
Fallen in the past 12months			45.3%	83.4%				OR = 4.2 (95% CI = [3, 5.7])
Machine learning	Ikeda et al, 2022[34]	0.88 (SD=0.02)						
FRSAS (Fall Risk Self Assessment Scale)	Wang et al, 2022[23]				0.757	0.967 (test-retest)		

*AUC = area under the receiver operating characteristic curve, ICC = intraclass correlation coefficient, α = Cronbach's alpha coefficient, r = Spearman's correlation coefficient, CI = confidence interval, IRR = incident rate ratio, OR = odds ratio, CVC = content validity coefficient, CVI = content validity index. *from Cleary et al.[43]; **from Rubenstein et al.[38]; ***from Hill et al.[44]*

Hirase et al.[35] in 2014 used a modified Japanese fall risk assessment tool developed by Suzuki et al. in 2000[36]. The authors identified 7 of the 15 questions of the original Suzuki questionnaire that were related to physical function in a retrospective study, based on the correlation of the questions with the TUG and the chair standing test, and then monitored the occurrence of a fall over a 3-month follow-up. They reported an AUC of 0.73 (95% CI= [0.62-0.83]), sensitivity of 84% and specificity of 68% in fall detection.

Lai et al.[32] and Ferreira et al.[21], validated the use of the HomeFAST tool for community-dwelling older adults in China and Brazil respectively. The HomeFAST is a self-reporting screening tool which was originally reported by Mackenzie et al.[37] to assess home hazards in fall risk.

Fall risk tools from large national longitudinal studies

In 2015, Gadkaree et al.[25] used data from the National Health and Aging Trends Study (NHATS) to compare a simple question-based model with performance-based tests in fall prediction. The study was comprised of 7609 participants followed up for a period of 1-year. They concluded that a simple model comprising of questions on age, race, gender, fall history and self-reported balance issues can predict

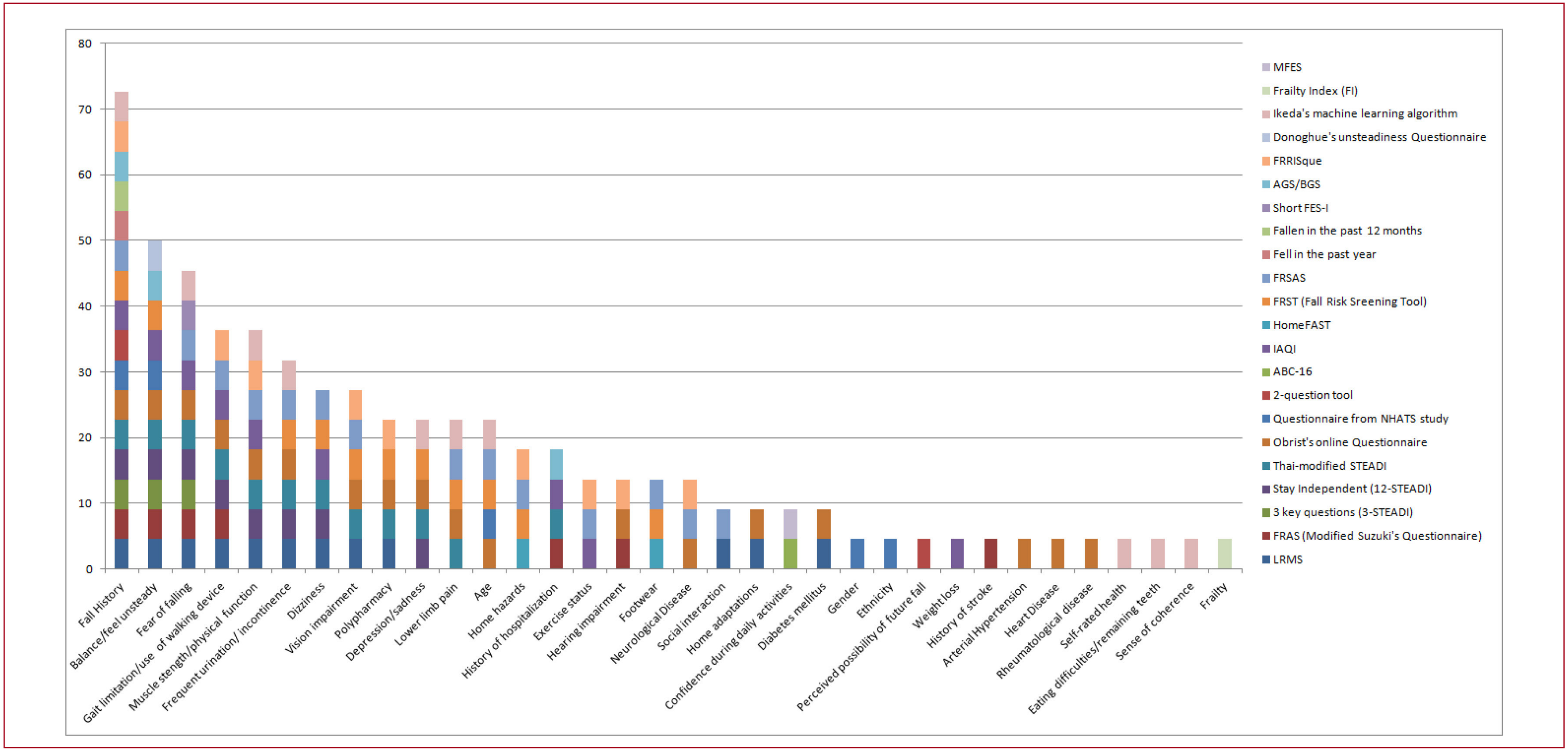

Figure 2. Fall risk factors and overall percentage of each factor assessed by the tools of the included studies.

falls (AUC=0.69, 95% C.I.=[0.67, 0.71]) and fall recurrence (AUC=0.77, 95% CI=[0.74, 0.79]).

Balance impairment was the objective of the study by Donoghue et al.[29]. They assessed self-reported unsteadiness with a 4-point scale and a 2-year follow-up and they concluded that unsteadiness is an independent risk factor for recurrent falls, fear of falls and activity restriction. Their study was conducted as a part of the Irish Longitudinal Study on Ageing (TILDA).

The CDC has implemented the STEADI guidelines for the identification and management of fall risk[8]. Part of the STEADI protocol is the 12-item questionnaire (Stay Independent) that was previously validated by Rubenstein et al. in 2011[38]. Eckstrom et al.[24] compared the Stay Independent questionnaire with a shortened version, the 3-key questions and reported a 95% agreement between the 2 tools

Table 3. Risk factors of question-based tools assessing fall risk.

	LRMS	FRAS (Modified Suzuki's Questionnaire)	3 key questions (3-STEADI)	Stay Independent (12-STEADI)	Thai-modified STEADI	Obrist's online Questionnaire	Questionnaire from NHATS study	2-question tool	ABC-16	IAQI	HomeFAST	Scripted FRST	FRSAS	Fell in the past year	Fallen in the past 12 months	Short FES-I	AGS/BGS	FRRISque	Donoghue's unsteadiness Questionnaire	Ikeda's machine learning algorithm	Frailty Index (FI)	MFES
Fall History	X	X	X	X	X	X	X	X		X		X	X	X	X		X	X		X		
Balance/feel unsteady	X	X	X	X	X	X	X			X		X					X		X			
Fear of falling	X	X	X	X	X	X				X			X			X				X		
Gait limitation/use of walking device	X	X		X	X	X				X			X					X				
Muscle stength/physical function	X			X	X	X				X			X					X		X		
Frequent urination/ incontinence	X			X	X	X						X	X							X		
Dizziness	X			X	X					X		X	X									
Vision impairment	X				X	X						X	X					X				
Polypharmacy	X				X	X						X						X				
Depression/sadness				X	X	X						X								X		
Lower limb pain					X	X						X	X							X		
Age						X	X					X	X							X		
Home hazards											X	X	X					X				
History of hospitalization		X			X					X							X					
Exercise status										X			X					X				
Hearing impairment		X				X												X				
Footwear											X	X	X									
Neurological Disease						X							X					X				
Social interaction	X												X									
Home adaptations	X					X																
Confidence during daily activities									X													X
Diabetes mellitus	X					X																
Gender							X															
Ethnicity							X															
Perceived possibility of future fall								X														
Weight loss										X												
History of stroke		X																				
Arterial Hypertension						X																
Heart Disease						X																
Rheumatological disease						X																
Self-rated health																				X		
Eating difficulties/remaining teeth																				X		
Sense of coherence																				X		
Frailty																					X	

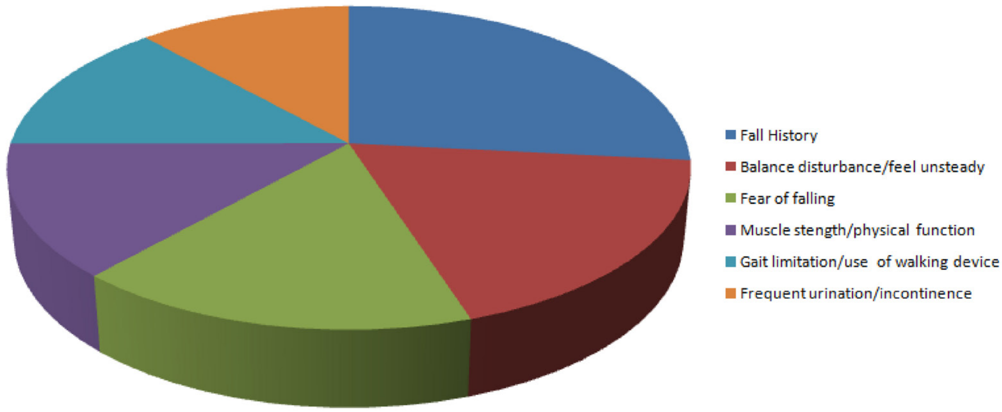

Figure 3. Risk factors that contributed overall to a percentage more that 30% by the identified tools.

Table 4. Risk of bias assessment with the Ottawa–Newcastle scale.

Study	Selection				Comparability	Outcome			Overall	Risk of Bias
	S1	S2	S3	S4	C	O1	O2	O3		
Cohort studies¥										
Hirase et al., 2014[35]	0	*	*	*	0	*	0	*	5	High
Gadkaree et al., 2015[25]	*	*	*	*	**	*	*	*	9	Low
Kojima et al., 2015[26]	0	*	*	*	**	*	*	*	8	Low
Obrist et al., 2016[27]	0	*	0	*	0	0	*	0	3	High
Cleary et al., 2017[28]	0	*	0	*	0	0	*	*	4	High
Donoghue et al., 2017[29]	*	*	0	*	**	0	*	*	7	Medium
Eckstrom et al., 2017[24]	0	*	*	0	0	*	0	*	4	High
Rodriguez et al., 2017[30]	*	*	*	*	**	0	*	*	8	Low
Lai et al., 2020[32]	*	*	0	*	0	0	*	*	5	High
Yang et al., 2020[31]	0	*	0	*	**	0	*	*	6	Medium
Burns et al., 2022[33]	*	*	*	*	**	0	*	*	8	Low
Ikeda et al, 2022[34]	0	*	0	*	0	0	*	*	4	High
Cross-sectional studies¥¥										
Fielding et al., 2013[16]	0	*	*	*	0	**	*	-	6	Medium
Silveira et al., 2018[17]	0	*	*	0	0	0	0	-	2	High
Chini et al., 2019[18]	*	*	*	*	0	*	*	-	6	Medium
Loonlawong et al., 2019[19]	0	*	*	*	0	*	*	-	5	High
Ferreira et al., 2021[21]	0	*	*	**	*	*	*	-	7	Low
Argyrou et al., 2022[22]	0	*	*	*	0	*	*	-	5	High
Wang et al., 2022[23]	0	*	*	*	0	*	*	-	5	High

¥ For cohort studies: S1: representativeness of the exposed cohort; S2: selection of the non exposed cohort; S3: ascertainment of exposure; S4: demonstration that outcome of interest was not present at start of the study; O1: assessment of outcome; O2: was follow-up long enough for outcomes to occur; O3: adequacy of follow-up of cohorts. ¥¥ For cross-sectional studies: S1: representativeness of the sample; S2: sample size, S3: non-respondents, S4: ascertainment of exposure; O1: assessment of outcome; O2: statistical test

in identifying high-risk individuals. An adaptation of the Stay Independent in the Thailand population was published by Loonlawong et al. in 2019[19]. Both the original and the adapted version of the questionnaire were found to have acceptable validity and reliability measures.

Studies of new fall risk assessment tools

A short questionnaire that consisted of 2 questions was developed by Rodriguez et al.[30] in 2017 and concluded that fall history combined with self-perceived fall risk resulted in a very good fall prediction, with sensitivity and specificity of 70% and 72% respectively.

In 2019, a cross-sectional study by Chini et al.[18] was conducted to validate the Fall Risk Tracking Tool (FRRISque) in Brazil. The final version of their questionnaire consisted of 10 questions out of 44 initial questions, as assessed by multivariate regression analysis. Their results were satisfactory with a sensitivity of 91.3% and a specificity of 73.4%, but no reliability measures were evaluated.

In 2022, a Greek cross-sectional study by Argyrou et al.[22] was performed to validate the newly developed LRMS questionnaire, assessing several risk factors with 11 questions. The authors reported high sensitivity and specificity with values of 93% and 91% respectively and high correlation with the TUG, the Falls Efficacy Scale International (FES-I), the Tinetti gait and balance scale and the Geriatric Depression Scale (GDS-15).

Another cross-sectional study for validation of a newly constructed self-reported questionnaire was reported in 2022 by Wang et al.[23] in the Chinese population. The purpose of the study was to assess the validity and reliability of the FRSAS (Fall Risk Self Assessment Scale), a 41-item questionnaire. The authors reported satisfactory internal consistency and test-retest reliability and they plan on conducting future larger sample size studies to test different types of population.

A large sample size study by Burns et al.[33] was published in 2022 to compare the performance of 6 different fall screening measures. These included the 3-key questions, the Stay Independent questionnaire, the questionnaire from the American Geriatrics Society/British Geriatrics Society (AGS/BGS)[39], the Short FES-I[40] and 2 single screening questions regarding the occurrence and number of falls in the previous year. The results showed high variability in the sensitivity (ranging from 22.5% to 68.7%) and specificity (from 57.9% to 89.4%) of the included instruments.

Ikeda et al.[34] used a machine-learning approach and selected 14 fall predictors among 142 candidate features. This was a 3-year prospective study in Japan with a sample of 61883 individuals. Sense of coherence, a measure of resilience to life stressors, was identified as a fall risk factor.

Tools originally designed to assess factors other than overall fall risk

Kojima et al.[26] (2015) used the frailty index (FI) as a measure of a 6-month fall prediction in British community-dwelling older adults. FI is a tool that is used to identify frail individuals and is constructed by the accumulation of deficits[41]. The authors used 40 deficits to construct the FI and their results indicated low sensitivity (31.6%) and high specificity (85.9%) in fall detection.

In the study by Cleary et al.[28], the authors used the Activities-specific Balance Confidence (ABC) scale, previously developed by Powell and Meyers in 1995[42], to predict fall risk. The original purpose of the tool was to assess confidence regarding loss of balance in the elderly and had demonstrated high Cronbach's α (0.973) and ICC (0.879) from a previous study by Cleary et al.[43] Their study reported that ABC could be used to predict fall risk in community-dwelling individuals over 65 years of age (odds ratio=0.95).

Yang et al.[31] (2020) evaluated the use of the modified Falls Efficacy Scale (MFES) for fall prediction, initially published by Hill et al. in 1996[44]. The MFES was designed as an extension to the Falls Efficacy Scale (FES) by Tinetti et al.[45] to incorporate the fear of falling during outdoor activities. In this small sample size study of 47 participants, the authors concluded that older individuals with low MFES were more prone to fall in one year with an incidence rate ratio of 0.96.

Tools from preliminary studies

This review also identified 2 preliminary studies that reported newly developed questionnaires to assess the understandability of the questions for future further testing. In 2016, Obrist et al.[27] developed an online questionnaire of 36 questions regarding fall risk, assessing multiple fall risk factors. The primary outcome of this preliminary study was the understandability of the questionnaire in order to perform future amendments.

A preliminary study by Silveira et al.[17] (2018), developed a fall risk questionnaire and used the content validity coefficient to evaluate the clarity, relevance and comprehension by a group of experts and a group of elderly individuals. However, the literature search did not reveal follow-up studies assessing these tools.

Discussion

The identified instruments aim to assess fall risk in community-dwelling older adults. Several factors affect the use of the presented tools in clinical practice and the use of each instrument should be selected with caution. It is important to note that there is great heterogeneity among the objectives of the included studies. As shown in the results section, the various studies included adaptations of previously reported tools, validation studies of newly developed tools, studies that were part of large national longitudinal studies on ageing (NHATS, TILDA), studies that used tools that were originally designed to assess frailty (FI), fear of falls (MFES) and balance confidence (ABC scale), as well as preliminary studies regarding tools that could be used in future validation studies to detect fall risk. Although the above tools successfully identified at-risk individuals, it is possible that tools that are developed with the scope of assessing fall risk as a primary intention, are more inclusive of the diverse potential risk factors. This is further highlighted by the fact that the most commonly reported fall risk factors identified in the present study are diverse and include fall history, balance disturbance/feeling of unsteadiness, fear of falling, muscle strength/physical function, gait limitation/use of walking device and frequent urination/incontinence.

Some of the identified tools focus more on the intrinsic or extrinsic fall risk factors. For example, the FES-I, MFES, FI and the ABC scale are tools that address fear of falling, frailty and balance confidence, which all address intrinsic fall risk factors. The questionnaires used by Hirase et al.[35], the 3-STEADI and the 2-question tool by Rodriguez et al.[30] also focus on physical function and balance. On the other hand, current literature suggests that the majority of falls have been reported to occur at home[46]. Therefore, tools like the HomeFAST focus on the extrinsic factors addressing home hazards. However, it is well-established that fall risk is multifactorial and that the accumulation of fall risk factors increases the overall risk[7]. To this end, many of the newly developed tools have incorporated both intrinsic and extrinsic factors in their design. These tools include the Stay Independent, the FRST, the LRMS, the FRSAS, the machine learning questionnaire by Ikeda et al.[34], as well as the 2 preliminary questionnaires by Obrist et al.[27] and Silveira et al.[17]. We believe that for active community-dwelling older adults it is more suitable to use multifactorial questionnaires to be more comprehensive of the underlying fall risk factors and subsequently design personalized interventions tailored to the needs of each individual. On the other hand, in the elderly unable to leave home, it is of great importance to assess home hazards, as falls are more likely to occur in this setting.

Also, the risk of bias assessment showed that the data quality of the included studies varied greatly, with 10 out of 20 studies being of high risk of bias, 4 of medium risk and only 5 characterized as having low risk of bias. The sample used in the majority of the studies was a convenience sample of people attending social events, outpatient clinics and communication via telephone calls and emails. Among the included studies Donoghue et al.[29] and Chini et al.[18] performed home-based interviews, while Rodriguez et al.[30] reported that the recruitment of the participants was performed through a mixed door-to-door approach and telephone calls. Home-based interviews and recruitment ensure a better representativeness of people unable to leave home, who are generally less likely to be recruited as study participants. However, they might be more prone to falls due to co-morbidities and physical restrictions which are both known fall risk factors[47].

Men were also under-represented by most of the included studies, as women are generally more likely to attend several social events and volunteer as study participants. Among the included studies, only the study by Gadkaree et al.[25] included gender as a risk factor. However, evidence suggests that females are more likely to sustain a fall compared to males[48]. What's more, according to the English Longitudinal Study of Ageing, gender-specific factors, like frailty and incontinence in women and depression and unsteadiness in men[49] should be taken into account when designing fall prevention interventions. This difference is not addressed by the tools identified in this study. Individuals with cognitive impairment were also excluded in most of the studies, further stressing the fact that another fall risk factor might be under-assessed. However, previous studies have emphasized the importance of cognitive impairment screening in fall risk assessment[50].

Regarding the psychometric properties of the included tools, most of the tools listed in this review mention either reliability or validity measures, while some of them are preliminary questionnaires designed for further study and lack extensive validation testing. The Stay Independent, the Chinese HomeFAST and the LRMS reported both reliability and validity measures. On the other hand, Ikeda et al.[34], Obrist et al.[27] and Gadkaree et al.[25] reported only the AUC, while Donoghue et al.[29] and Silveira et al.[17] reported the incident rate ratio and the content validity coefficient respectively. This heterogeneity highlights the fact that the psychometric properties of fall risk questionnaires are not easily tested due to the inherent multifactorial nature of the problem. Falls occur as a consequence of a constellation of underlying multiple factors and accurate quantification of every factor is a tenuous and challenging endeavor. This was previously also highlighted in a review article by Majkusova et al[51]. For example factors like "unsteadiness" or "dizziness" are inherently subjective; thus, evaluation of these factors varies greatly among different tools. The combination of difficulties regarding accurate testing of the psychometric properties along with the heterogeneity of fall risk factors might be the reason for the lack of a gold standard tool in the current literature.

The feasibility of the presented tools is also another aspect that should be taken into account. The response rate was reported to be low by the preliminary study of Obrist et al.[27] and rewording was needed for some questions. The ease of administration depends largely on the length of the tool and can affect the application of the tool. The length of the questionnaires varied from 1 to 41 questions, which is a wide range. Few-question tools (1-3 questions) were the one-question tools by Burns et al.[33], the 2-question tool by Rodriguez et al.[30] and the 3-question tools by Eckstrom et al.[24] (3-STEADI), by Donoghue et al.[29] and the AGS/BGS. While these tools are more time-efficient, with increased feasibility and provide an initial screening measure, they are not always helpful in identifying the risk factors that make each individual susceptible to falls. While an optimal questionnaire length has not been established in literature[52], we suggest that limiting the time of administration between

5 and 10 minutes provides all the necessary information while maximizing the response rate.

Conclusion

This systematic review identified 20 studies and 22 question-based tools to predict fall risk in community-dwelling individuals over 60 years of age. The most commonly reported fall risk factors were fall history, balance disturbance/feeling of unsteadiness, fear of falling, muscle strength/physical function, gait limitation/use of walking device and frequent urination/incontinence. Healthcare providers should use the above tools with caution regarding the limitations of each tool. Further studies should be designed to address individuals with high fall risk, such as individuals with cognitive impairment, as they are under-represented or excluded from most of the existing studies.

Disclaimer

Dr. Y. Dionyssiotis serves as Co-Editor-in-Chief in the JFSF. The manuscript underwent peer review process by independent experts.

References

1. Web–based Injury Statistics Query and Reporting System (WISQARS). In: Centers for Disease Control and Prevention NCfIPaC, editor. 2016.
2. Healthcare Cost and Utilization Project (HCUP). In: Agency for Healthcare Research and Quality R, MD, editor. 2012.
3. Bergen G, Stevens MR, Burns ER. Falls and Fall Injuries Among Adults Aged ≥65 Years - United States, 2014. MMWR Morb Mortal Wkly Rep 2016;65(37):993-8.
4. Florence CS, Bergen G, Atherly A, et al. Medical Costs of Fatal and Nonfatal Falls in Older Adults. J Am Geriatr Soc 2018;66(4):693-8.
5. National Institute for Health and Care Excellence: Guidelines. Falls: Assessment and Prevention of Falls in Older People. London: National Institute for Health and Care Excellence (NICE) Copyright © National Institute for Health and Care Excellence, 2013.; 2013.
6. Deandrea S, Lucenteforte E, Bravi F, et al. Risk factors for falls in community-dwelling older people: a systematic review and meta-analysis. Epidemiology 2010;21(5):658-68.
7. Campbell AJ, Robertson MC. Implementation of multifactorial interventions for fall and fracture prevention. Age Ageing 2006;35 Suppl 2:ii60-ii4.
8. Stevens JA, Phelan EA. Development of STEADI: a fall prevention resource for health care providers. Health Promot Pract 2013;14(5):706-14.
9. Guideline for the prevention of falls in older persons. American Geriatrics Society, British Geriatrics Society, and American Academy of Orthopaedic Surgeons Panel on Falls Prevention. J Am Geriatr Soc 2001;49(5):664-72.
10. Mark JA, Loomis J. The STEADI toolkit: Incorporating a fall prevention guideline into the primary care setting. Nurse Pract 2017;42(12):50-5.
11. Lusardi MM, Fritz S, Middleton A, et al. Determining Risk of Falls in Community Dwelling Older Adults: A Systematic Review and Meta-analysis Using Posttest Probability. J Geriatr Phys Ther 2017;40(1):1-36.
12. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. 2021;372:n71.
13. Roever L. PICO: Model for Clinical Questions. Evidence-Based Medicine. 2018.
14. Wells G, Shea B, O'Connell D, et al. The Newcastle–Ottawa Scale (NOS) for Assessing the Quality of Non-Randomized Studies in Meta-Analysis. 2000.
15. Herzog R, Álvarez-Pasquin MJ, Díaz C, et al. Are healthcare workers' intentions to vaccinate related to their knowledge, beliefs and attitudes? a systematic review. BMC Public Health 2013;13(1):154.
16. Fielding SJ, McKay M, Hyrkas K. Testing the reliability of the Fall Risk Screening Tool in an elderly ambulatory population. J Nurs Manag 2013;21(8):1008-15.
17. Silveira MB, Saldanha RP, Leite JCC, et al. Construction and validation of content of one instrument to assess falls in the elderly. Einstein (Sao Paulo) 2018;16(2):eA04154.
18. Chini LT, Pereira DS, Nunes AA. Validation of the Fall Risk Tracking Tool (FRRISque) in elderly community dwellers. Cien Saude Colet 2019;24(8):2845-58.
19. Loonlawong S, Limroongreungrat W, Jiamjarasrangsi W. The Stay Independent Brochure as a Screening Evaluation for Fall Risk in an Elderly Thai Population. Clin Interv Aging 2019;14:2155-62.
20. Tabatabaei HR, Ahmadipour H. Fall-Risk Assessment in the Elderly Using the Persian Version of Fall-Risk Screening Tool: A Population-Based Study. Int J Prev Med 2020;11:153.
21. Ferreira KSA, Gallo da Silva TT, Melo Filho J, et al. Reliability of HOME FAST BRAZIL-Self-Reported Version for Community-Dwelling Older Adults. Front Public Health 2021;9:713202.
22. Argyrou C, Dionyssiotis Y, Galanos A, et al. Development and validation of a fall risk Questionnaire in Greek community-dwelling individuals over 60 years old. J Frailty Sarcopenia Falls 2022;7(3):133-46.
23. Wang ZZ, Rong YT, Gu L, et al. Reliability and validity of the fall risk self-assessment scale for community-dwelling older people in China: a pilot study. BMC Geriatr 2022;22(1).
24. Eckstrom E, Parker EM, Lambert GH, et al. Implementing STEADI in Academic Primary Care to Address Older Adult Fall Risk. Innov Aging 2017;1(2):igx028.
25. Gadkaree SK, Sun DQ, Huang J, et al. Comparison of simple vs. performance-based fall prediction models: data from the National Health and Aging Trends Study. Gerontol Geriatr Med 2015;1.
26. Kojima G, Kendrick D, Skelton DA, et al. Frailty predicts short-term incidence of future falls among British community-dwelling older people: a prospective cohort study nested within a randomised controlled trial. BMC Geriatr 2015;15:155.
27. Obrist S. Development and evaluation of an online fall risk questionnaire: a pilot study: Verlag nicht ermittelbar; 2015.
28. Cleary K, Skornyakov E. Predicting falls in community dwelling older adults using the Activities-specific Balance Confidence Scale. Arch Gerontol Geriatr 2017;72:142-5.
29. Donoghue OA, Setti A, O'Leary N, et al. Self-Reported Unsteadiness Predicts Fear of Falling, Activity Restriction, Falls, and Disability. J Am Med Dir Assoc 2017;18(7):597-602.
30. Rodriguez-Molinero A, Galvez-Barron C, Narvaiza L, et al. A two-question tool to assess the risk of repeated falls in the elderly. PLoS One 2017;12(5).
31. Yang R, Pepper GA. Is fall self-efficacy an independent predictor of recurrent fall events in older adults? Evidence from a 1-year prospective study. Res Nurs Health 2020;43(6):602-9.
32. Lai FHY, Yan EWH, Mackenzie L, et al. Reliability, validity, and clinical utility of a self-reported screening tool in the prediction of fall incidence in older adults. Disabil Rehabil 2020;42(21):3098-105.
33. Burns ER, Lee R, Hodge SE, et al. Validation and comparison of fall screening tools for predicting future falls among older adults. Arch

Gerontol Geriatr 2022;101:104713.
34. Ikeda T, Cooray U, Hariyama M, et al. An Interpretable Machine Learning Approach to Predict Fall Risk Among Community-Dwelling Older Adults: a Three-Year Longitudinal Study. Journal of General Internal Medicine.
35. Hirase T, Inokuchi S, Matsusaka N, et al. A Modified Fall Risk Assessment Tool That Is Specific to Physical Function Predicts Falls in Community-Dwelling Elderly People. Journal of Geriatric Physical Therapy 2014;37(4):159-65.
36. Suzuki T. Questionnaire for falls assessment of elderly people and its application. Kosei Kagaku Kenkyusho 2000:142-63.
37. Mackenzie L. Evaluation of the clinical utility of the Home Falls and Accidents Screening Tool (HOME FAST). Disabil Rehabil 2017;39(15):1489-501.
38. Rubenstein LZ, Vivrette R, Harker JO, et al. Validating an evidence-based, self-rated fall risk questionnaire (FRQ) for older adults. J Safety Res 2011;42(6):493-9.
39. Panel on Prevention of Falls in Older Persons, American Geriatrics Society and British Geriatrics Society. Summary of the Updated American Geriatrics Society/British Geriatrics Society clinical practice guideline for prevention of falls in older persons. J Am Geriatr Soc 2011;59(1):148-57.
40. Kempen GI, Yardley L, van Haastregt JC, et al. The Short FES-I: a shortened version of the falls efficacy scale-international to assess fear of falling. Age Ageing 2008;37(1):45-50.
41. Mitnitski AB, Mogilner AJ, Rockwood K. Accumulation of deficits as a proxy measure of aging. ScientificWorldJournal. 2001;1:323-36.
42. Powell LE, Myers AM. The Activities-specific Balance Confidence (ABC) Scale. The Journals of Gerontology: Series A 1995;50A(1):M28-M34.
43. Cleary KK, Skornyakov E. Reliability and Internal Consistency of the Activities-Specific Balance Confidence Scale. Physical & Occupational Therapy In Geriatrics 2014;32(1):58-67.
44. Hill KD, Schwarz JA, Kalogeropoulos AJ, et al. Fear of falling revisited. Arch Phys Med Rehabil 1996;77(10):1025-9.
45. Tinetti ME, Richman D, Powell L. Falls efficacy as a measure of fear of falling. J Gerontol 1990;45(6):P239-43.
46. Ha VT, Nguyen TN, Nguyen TX, et al. Prevalence and Factors Associated with Falls among Older Outpatients. Int J Environ Res Public Health 2021;18(8).
47. Lee YY, Chen CL, Lee IC, et al. History of Falls, Dementia, Lower Education Levels, Mobility Limitations, and Aging Are Risk Factors for Falls among the Community-Dwelling Elderly: A Cohort Study. Int J Environ Res Public Health 2021;18(17).
48. Stevens JA, Sogolow ED. Gender differences for non-fatal unintentional fall related injuries among older adults. Inj Prev 2005; 11(2):115-9.
49. Gale CR, Cooper C, Aihie Sayer A. Prevalence and risk factors for falls in older men and women: The English Longitudinal Study of Ageing. Age Ageing 2016;45(6):789-94.
50. Blackwood J, Martin A. Screening for Cognitive Impairment as a Part of Falls Risk Assessment in Physical Therapist Practice 2017;40(4):197-203.
51. Majkusova K, Jarosova D. Validity of tools for assessing the risk of falls in patients. Central European Journal of Nursing and Midwifery 2017;8(3):697-705.
52. Kishore K, Jaswal V, Kulkarni V, et al. Practical Guidelines to Develop and Evaluate a Questionnaire. Indian Dermatol Online J 2021;12(2):266-75.