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INJURIOUS FALLS IN OLDER ADULTS:

EARLY IDENTIFICATION OF INDIVIDUALS AT RISK OF FALLS—FROM OBSERVATIONAL STUDIES TO IMPLEMENTATION

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Till mina älskade döttrar Hedvig, Edith och Ruth. Ni är hela min värld.

ABSTRACT

Falls among older adults is a rapidly growing research field with still remaining knowledge gaps that need to be addressed. Most available screening tools for falls have been developed for older adults in specific care settings and screening tools for injurious falls are particularly scarce. This thesis aims to contribute to the field of knowledge through: 1) development of the First-time Injurious Fall (FIF) screening tool to predict first-time injurious falls among older adults; 2) evaluation of the FIF tools` usability in different settings such as e-health; 3) exploration of older adults' experiences of being assessed with the FIF tool; 4) assessment of healthcare professionals' experiences of barriers and facilitators regarding the implementation of the FIF tool in clinical and public health settings.

The aims of this thesis were to examine the predictive capacity of the FIF-tool, and a modified FIF tool (in which one-leg standing is replaced by self-reported balance), and to explore and describe older adults' and healthcare professionals' experiences with the FIF tool to gain insight into the barriers and facilitators for implementing the FIF tool in primary healthcare and public health settings. To reach the aims for study I and II, we used data from the ongoing population-based, Swedish National Study on Aging and Care in Kungsholmen (SNAC-K), Skåne (SNAC-S) and Blekinge (SNAC-B). For study III and IV, we conducted qualitative interviews with patients and healthcare professionals from primary healthcare and public health settings.

The results from **study I** suggest that the FIF tool is a valid tool to use for prediction of first-time injurious falls in community-living older adults. The predictive values with Harrell`s C were 0.72 for women and 0.77 for men.

In **study II**, we concluded that the predictive values for first-time injurious falls did not differ between the FIF tool and the modified-FIF tool (where one-leg standing was replaced with a self-reported question about balance), 0.70 for women and 0.71 for men, and hazard ratios were similar for both tools.

Results from **study III** indicate that older adults consider screening for fall risk to be meaningful and important to prevent falls, even though a low risk result may create a false sense of security. The informants did not experience any difficulties using the FIF tool.

In **study IV**, healthcare professionals expressed that the FIF tool was easy to use and meaningful for preventing falls in primary healthcare and public health settings. However, the FIF tool needs to be clearer and requires organizational conditions to facilitate an implementation process. Most importantly, the instrument needed to be easily accessible so that a result could be documented in their patient record system and with support from the management become a new routine.

In conclusion, the results suggest that 1) the FIF tool has an acceptable predictive capacity for injurious falls over five years of follow-up, 2) both in its original and modified form, 3) older adults perceived that it was unproblematic to be screened with the FIF tool and, 4) healthcare professionals expressed that the FIF tool worked well in clinical practice but that there was room for some improvements, particularly with regard to ensuring easy accessibility.

Keywords: injurious falls, screening tool, primary prevention, external validity, primary healthcare, public health, interviews.

SAMMANFATTNING

Forskningsområdet kring skadliga fallolyckor bland äldre personer är välstuderat. Det finns dock vissa kunskapsluckor som återstår att adresseras. Syftet med denna avhandling är att bidra med kunskap inom detta område genom: 1) forskning om FIF-verktygets förmåga att förutsäga skadliga fall bland äldre, 2) kunskap om FIF-verktygets användbarhet i olika miljöer, till exempel e-hälsa, 3) äldres erfarenheter av att bedömas med FIF-verktyget, 4) hälso- och sjukvårdspersonalens upplevelse kring hinder och underlättande faktorer för implementering av FIF-verktyget i kliniska miljöer och folkhälsoarbete.

Syftet med denna avhandling är att fylla dessa kunskapsluckor genom följande mål: att undersöka både FIF-verktygets och ett modifierat FIF-verktygs (där enbensståendet blivit ersatt med en självrapporterad fråga om upplevd balansförmåga), förmåga att predicera skadliga fallolyckor, att beskriva äldre och hälso- och sjukvårdspersonalens upplevelser av FIF-verktyget för att få en inblick i hinder och förutsättningar för implementering av FIF-verktyget i primärvårds- och folkhälsosammanhang. För att nå målen för studie I och II använde vi data från den pågående befolkningsstudien, the Swedish National Study on Aging and Care i Blekinge (SNAC-B), Skåne (SNAC-S) och Kungsholmen (SNAC-K). För studie III och IV genomförde vi kvalitativa intervjuer med patienter i primärvården och hälso- och sjukvårdspersonal inom primärvård och folkhälsa.

Resultaten från **studie I** tyder på att FIF-verktyget är ett verktyg som kan förutsäga förstagångsskadade fall hos hemmaboende äldre. FIF-verktyget har en godtagbar extern validitet. De prediktiva värdena med Harrell`s C var 0,72 för kvinnor och 0,77 för män.

I **studie II** drog vi slutsatsen att de prediktiva värdena för skadliga fallolyckor för individer som faller första gången inte skiljde sig åt mellan FIF-verktyget och det modifierade-FIF-verktyget, 0.70 för kvinnor och 0.71 för män, där hazard ratios var likartade för båda verktygen.

Våra resultat från **studie III** visar att äldre anser att screening för fallrisk är meningsfullt och viktigt för att förebygga fall, även om ett resultat med låg risk kan skapa en falsk känsla av trygghet. Informanterna upplevde inga svårigheter med att använda FIF-verktyget.

Med **studie IV** ansåg hälso- och sjukvårdspersonal att FIF-verktyget var lätt att använda och upplevdes meningsfullt för att förebygga skadliga fallolyckor i primärvården och inom folkhälsoarbete. Dock behövde FIF-verktyget tydligare instruktioner och kräver organisatoriska förutsättningar för att underlätta en implementeringsprocess. Viktigast av allt var att instrumentet behöver vara lättillgängligt så att ett resultat kan dokumenteras i ett journalsystem och få stöd från ledningen för att kunna bli en ny fungerande rutin.

Sammanfattningsvis tyder resultaten från denna avhandling på att: 1) FIF-verktyget är ett giltigt verktyg som visade goda prediktiva värden för att förutsäga skadliga fall hos hemmaboende äldre, 2) både i originalform och som modifierad version, 3) äldre vuxna upplevde att det fungerade bra att bedömas med FIF-verktyget och 4) hälso- och sjukvårdspersonal ansåg att FIF-verktyget fungerade bra i praktiken, men det fanns ett visst behov av tydliggörande av FIF-verktyget.

Nyckelord: skadliga fallolyckor, screeninginstrument, primär-prevention, extern validering, primärvård, folkhälsoarbete, intervjuer.

LIST OF SCIENTIFIC PAPERS

This thesis is based on the following original papers. Each paper will be referred to by its Roman numerals (Study I-IV):

I. **Frisendahl N**, Ek S, Rosendahl E, Boström A-M, Fagerström C, Elmståhl S, Welmer A-K. Predictive performance of the FIF screening tool in two cohorts of community-living older adults. *J Am Med Dir Assoc.* 2020;S1525-8610(20)30367-4.*

II. **Frisendahl N**, Ek S, Rosendahl E, Franzén E, Boström A-M, Welmer A-K. Can the 1-Leg Standing Test Be Replaced by Self-reported Balance in the First-Time Injurious Fall Screening Tool? *J Geriatr Phys Ther*. 2022 Aug 10.**

III. **Frisendahl N**, Karlsson P, Ek S, Franzén E, Boström A-M, Welmer A-K. Older adult´s experiences of being screened for fall risk in a clinical setting: A focus group study. *Under review.*

IV. **Frisendahl N**, Karlsson P, Sandlund C, Ek S, Franzén E, Boström A-M, Welmer A-K. Healthcare professionals` views of barriers and facilitators for implementing a fall risk screening tool in clinical and public health settings. *Manuscript.*

CONTENTS

LIST OF ABBREVIATIONS

FIF tool	First-time injurious fall screening tool
PARIHS	The Promoting Action on Research Implementation in Health Services
i-PARIHS	The intergrated Promoting Action on Research Implementation in Health Services
IADL	Instrumental Activities of Daily Living
SNAC	Swedish National Study on Aging and Care
SNAC-K	Swedish National Study on Aging and Care in Kungsholmen
SNAC-B	Swedish National Study on Aging and Care in Blekinge
SNAC-S	Swedish National Study on Aging and Care in Skåne
HR	Hazard ratio
SD	Standard deviation
CIs	Confidence intervals
AUC	Area Under the Receiver Operator Characteristic (ROC) curve
LASA	Longitudinal Aging Study Amsterdam
FRAT-up	Web based Fall Risk Assessment Tool
STEADI	Stopping Elderly, Accidents, Deaths, & Injuries
WHO	World Health Organization

DEFINITIONS OF CENTRAL CONCEPTS

Older adults – 60 years and older

Injurious falls – hospitalization for or receipt of inpatient or outpatient care because of falls

The Youden index cut-off – where the balance between sensitivity and specificity is optimal

Primary prevention – aims to identify older adults at a high risk of falling but who has not suffered from any previous falls

Secondary prevention – aims to reduce the risk of further falling amongst those who have already suffered a previous fall

Screening – checking for disease when there are no symptoms

Harrell`s C statistics – is a goodness of fit measure for models which produce risk scores

1 INTRODUCTION

I have had one previous encounter with an injurious fall. This was when I was 20 years old and my grandmother passed away during the aftermath of an injurious fall in which she had suffered a brain hemorrhage. The accident was traumatizing and deeply saddening, and the loss of my grandmother caused me a great deal of pain. This experience helped me decide that I wanted to work with something meaningful, to work with something that could help other people. A few years later I graduated as a physiotherapist, and have since then had an extra focus on the older generation. I hope that, in the future, the older generation will be prioritized, since I know from my clinical work that there is a gap between the research and the reality of primary healthcare. I hope that my work as a PhD student, I have contributed in the process of minimizing the gap above with this thesis.

According to The World Health Organization (1), the number of people over 60 years is growing faster than any other age group worldwide. This age group was estimated to be 688 million in 2006 and is expected to grow to almost two billion by 2050. Falls are a common, serious and preventable problem experienced by one third of community-living adults older than 65 years each year. Falls and fall-related injuries are a major public health concern associated with subsequent morbidity, disability, hospitalization, institutionalization, and mortality (1).

Over the past 30 years, total deaths, and disability-adjusted life years due to falls have increased in Europe, presenting an alarming trend (1). About every other fall result in a minor injury and 3-4% of falls lead to fractures (2). Falls contribute to 5-10% of all emergency department visits among older adults, and contribute to longstanding pain, disability, and earlier death (3). The number of people being hospitalized or seeking primary care because of a fall is expected to increase in the near future, due to the aging of the population, resulting in considerable costs for society (1, 3). Injurious falls will burden the healthcare system substantially and lead to rising healthcare costs. The cost of falls and associated injuries has been estimated to account for 1.5% of healthcare costs in the European countries, including both direct (fall-related) costs and indirect costs (loss of mobility, confidence, and functional independence) (4). Given the impact of falls on individuals' health and economic costs, identifying and implementing effective strategies for the prevention of falls is of utmost public health relevance.

2 BACKGROUND

2.1 Injurious falls

Injurious falls can be classified in different ways, including "*bone fracture*"*," other serious injuries"*, and "*hospitalized fall"* (3). This doctoral project follows the definition of an injurious fall as hospitalization for or receipt of outpatient or inpatient care because of a fall (5). We only include low energy falls from the same level, with no other person involved. Injurious falls can lead to long-term consequences such as a lower activity level, institutionalization, a higher risk of dependency, and increased mortality (6-8). Several studies have shown a decrease in quality of life after a fall injury (8-10), and falls are one of the leading causes of disability for individuals over 75 years age (11).

2.2 Risk factors

Risk factors for falling can be categorized as biological (e.g. age, sex and diseases), environmental (e.g. inadequate lightning), behavioral (e.g. badly fitting footwear, multiple medications), and sociodemographic (e.g. low income and low education) (1). A number of risk factors for falls have been identified in epidemiological studies, including sociodemographic, psychological, medical, medication-related, physical, and somatosensory factors (12). Gait and balance impairments are among the domains that most consistently predicts future falls (13), the one-leg standing test has been shown to be independently associated with a higher risk of falls (14).

The most important risk factor for falls is a previous fall (4, 13-14). This suggests that we can reduce the overall number of falls in the population by preventing or delaying the first fall (13). Since the consequences and increased risk of experiencing more falls after a first injurious fall are considerably high (15), delaying or preventing first-time falls will have important effects on public health as well as on the daily lives of older adults.

Previous studies have shown that risk factors for falls are likely to co-exist in older adults and may have an interactive rather than an isolated impact on the risk of injurious falls (5, 16). There are some risk factors that may prove to be able to predict falls more strongly depending on the sex of the person (17-19). Older women are more likely to fall and have a greater risk of suffering an injurious fall than men. They also have a higher risk of fractures because of fragility due to a number of factors, such as: longer life expectancy, higher risk of impaired balance (20), a decrease of bone mass and an increase of bone loss as a result of menopause (21). Fear of falling, a measure of an older adult's perceptions about the falls they have experienced (15), is another consideration. Previous studies have shown heterogeneous results in predicting future falls in the community (15).

2.3 Identifying individuals at high risk of injurious falls

Most fall screening tools available are designed for older adults in a specific care setting, e.g. nursing homes. Several screening tools for fall risk are used among community-dwelling older adults and those tools include questionnaires used alone or in a combination with more time intensive functional assessments (22). These, however, have difficult distinguishing between those who have fallen and those who have not (23-24).

Earlier studies examining prediction of falls have focused on single physical function tests, such as one-leg standing or the chair stand test. However, these tests have been shown not to be sensitive enough to predict the majority of injurious falls (24-26). Furthermore, it has been shown that

there is insufficient detection of falls and evaluation of the detected falls, underscoring the need for more sensitive methods (27). Few available screening tools for falls have been validated in more than the development population (24), and screening tools developed to predict risk of injurious falls are especially scarce (25-27). There, currently, is a shortage of tools, aimed to identify community-living older adults, that is not developed without information about previous falls (28-31). This make it so that it is more difficult to identify older adults who have a high risk of falling but have not yet fallen and could benefit from a referral to undergo further preventive interventions and fall risk assessments (5, 16, 32).

Recent studies indicate that sex differences also need to be taken into consideration when designing fall-preventive strategies. As of now, the available screening tools for injurious fall risk do not consider the differences between males and females. Considering the low predictive values of the existing assessment tools, it might prove to be more effective to focus on detecting those with a high risk of injurious falls using reliable screening tools and follow up the initial screening with a person-centered assessment.

2.4 First-time Injurious Fall (FIF) screening tool

A screening tool called the First-time Injurious Fall (FIF) screening tool (**Figure 1**), was developed for the prediction of first-time injurious falls in community-living older men and women (19). The screening tool includes three self-reported questions (age, cohabitation status and Instrumental Activities of Daily Living (IADL) dependency) and one physical test (one-leg standing). The FIF tool is quickly and easily administered. It was created to be used in primary healthcare or public health settings to identify fall risk in older adults who would benefit from primary preventive interventions. When constructing the tool, first, previously established fall risk factors were identified from reviews and meta-analyses. Second, risk factors that had an association with injurious fall were analyzed and then selected based on the β coefficients from sex-specific multivariate Cox proportional hazards models. Third, on the basis of the final Cox models, scores were created for women and men, respectively. Finally, the scores were categorized based on the Youden index, and according to the magnitude of hazard ratios (HR), as low and high risk of falling.

First time Injurious Falls – the FIF screening tool

			Women	Men
How old are you?	60-69	□	0	0
	70-79	□	1	2
	80-89	□	2	3
	90+	□	4	4
Do you live with someone?	Yes	□	0	0
	No	□	1	1
Do you need help in any or several of the following:	Yes	□	2	1
	No	□	0	0
• managing finances • using telephone • grocery shopping • using public transportation • preparing meals • cleaning • doing laundry				
Physical test (eyes open - 2 attempts/leg - best attempt counts)				
One leg balance	<5 seconds	□	1	1
	≥5 seconds	□	0	0
	Total score =		___ /8	___ /7

Low fall risk 0-2 p	High fall risk 3+ p

Figure 1. The FIF tool.

2.5 Primary prevention and screening

2.5.1 Screening

Screening is often focused, with the aim of identifying people who are manifestly healthy but have an asymptomatic condition (in this case, fall risk) that has not yet been diagnosed or found (33-34). False-positive results could lead to some level of anxiety for screening patients (35). However, the benefits for screening include the reduction in costs associated with treatment from e.g. fracture and hospitalization. One important distinction between the FIF tool and a diagnostic tool is that the FIF tool screens for fall risk over time. Additionally, the design of diagnostic tests is to compare the screening with a reference (gold) standard test, an example for this is screening for cancer in comparison to a diagnosis of cancer (36). Current guidelines regarding fall risk prevention, targeting

community-living older adults, have three consecutive stages they recommend: screening as a mean to identify those at an increased risk of falling, ongoing, multifactorial, fall risk assessment meant for those at risk of falling; and, the implementation of interventions tailored to the individual (37). Fall prevention is a multifaceted task, and a meta-analysis identified exercise-based interventions as the most powerful means to prevent falls (38).

2.5.2 Primary versus secondary prevention

The current approach to preventive measures against falling is to primarily rely on so called secondary prevention, which aims at reduce the risk of further falling among those who have already suffered a previous fall and have been seeking care as a result. An alternative approach would be primary prevention which aims to identify older adults at a high risk of falling but who have not suffered from any previous falls and would benefit from receiving further assessment and preventive interventions regarding their risk of falling (39-40).

Prevention for a disease often focus on a condition that means the kind of internal process that increases the risk for future ill health, in this case: injurious falls (41). Prevention for a disease also means that we will postpone or stop the disease that will not kill us but still reduce our health (34). Another way to look at the FIF tools' ability to screen the older populations risk of falling is in the way of primary prevention (34). This type of prevention, as we tend to look at it, puts a focus on early detection (41). Primary prevention is often conceived as screening for a disease, or a fall, as to turn it into something positive by identifying it before it reaches a negative effect on the individuals such as an injurious fall (34). Primary prevention may include long-term regular exercise programs while secondary prevention may include environmental modifications and multifactorial interventions.

The current guidelines, from the World Falls Guidelines (15), states that an older adult without a history of falling, or only suffered a single, non-severe fall, with no problems with gait nor balance, is defined as at a low risk of fall. These who fall under this definition is should still be recommended primary prevention and offered an education regarding falls prevention as well as information about general health and/or fall preventive exercises, if interested. For those who have sought care for a previous fall, the risk of suffering another fall within one year is 70% (15).

2.5.3 Implementation, translation into clinical practice

It has been suggested that there is a gap between evidence-based knowledge and practice in fall screening and prevention (5-6). The effectiveness of evidence-based fall prevention is only as strong as the level of adherence to recommendations (42). The lack of implementation of high-quality evidence in health services is a concern that threatens the quality of fall prevention measures. Therefore, research should focus on decreasing the gap between evidence-based knowledge and practice in fall prevention to enhance the implementation process (43-44). Research findings are not as clear-cut as they can be perceived; - they must be collated, summarized, and synthesized together and presented in ways that make them informative and acceptable for implementation (45).

An important consideration in the implementation process is to investigate how the FIF tool is perceived by different healthcare professionals in clinical and public health settings (46). Having the older adults engaged in the implementation process is essential for the further prevention of injurious falls. It is vital that their beliefs, attitudes, how they priorities falls and how they had handled an injurious fall, are understood, to have a successful intervention (15). Healthcare professionals can serve a vital part in the primary preventions done after an older adult have suffered an injurious fall. Having a screening tool that is quickly and easily administered can further

facilitate the healthcare professional when prioritizing who needs to undergo a more thorough fall risk assessment.

Previous research on the implementation of fall prevention interventions rarely assesses the determinant factor, which is crucial when adapting research findings to different contexts. In addition, clear and transparent reporting of implementation strategies are scarce (47). Furthermore, evaluating the research process can provide information on the aspects of an intervention that work, which might be helpful when trying to optimize interventions and apply them appropriately across different groups and settings (48). Moreover, it is important for research to be based on patients' and healthcare professionals' priorities and preferences, to improve research quality, relevance, implementation, and cost-effectiveness of research (49).

2.6 Primary healthcare & public health

The Swedish healthcare system is split into public and private sectors. The primary healthcare services are mainly consisting of family physicians that offers medical examinations, treatment and care for most of the common illnesses and conditions. Additionally, health and medical care is also offered by other healthcare professionals, such as: physiotherapist, occupational therapist and specialized nurses (50). The prevention of falls and the consequences thereafter is a multifaceted task (38).

The involvement of several professions is needed to meet the needs of older adults who often have several concurrent health problems, to identify the most effective and feasible intervention to prevent falls in older adults. Indeed, physiotherapist`s have a crucial roll in the prevention work, they have an education in rehabilitation and to assess fall risk where exercise is an important part. This work should be handled by a qualified personal such as a physiotherapist (15).

The task of spreading scientifically based knowledge to encourage a good public health and the prevention of injury and disease, is done by the Public Health Agency of Sweden (51). The agency´s mission is to monitor the public health and the factors that may affect it. They also pay special attention on those groups of people with the highest risk of suffering from ill-health.

Theoretical framework

This doctoral thesis aimed to use the Promoting Action on Research Implementation in Health Services framework, or PARIHS for short (52). It was first published in 1998 and has, since then, gone through further development and improvement. This has led to a new, refined version named integrated or i-PARIHS framework, which is used for this thesis (53). The i-PARIHS framework was designed to facilitate evidence use at the practical level. The core constructs of the i-PARIHS framework are innovation, recipients, context, and facilitation.

Innovation: The explicit focus on sourcing and utilizing available research evidence is a central construct in the i-PARIHS framework, and is done to inform the innovation. The evidence here is viewed as a type of "knowledge", this new knowledge serves as the substance which is needed to be incorporated to facilitate change and improvements. The innovations characteristics then creates a set of conditions, e.g. if the innovation is useful or clear, and this makes the innovation more or less likely to be acknowledged and applied (53).

In this thesis, I wanted to externally validate the FIF tool before the test periods in the clinical context to increase knowledge before the innovation. Also, to increase knowledge about the FIF

tool´s prerequisites to predict injurious falls in other settings and with other populations than the development one.

Recipients: The i-PARIHS framework suggests using recipients as a construct. This construct consists of participants influence and affected by implementations done at both the individual level and the collective team level. The, involved, participants views, beliefs and their established way of practice can, according to the i-PARIHS framework, affect, significantly, the ease of introducing a new change or innovation. This construct consists of a wide variety of recipients, including but not limited to, patients, clients, clinical staff and managers (53).

In this thesis, the recipients are the older adults and healthcare professionals. Information will be received from the interviews where they explore and describe how the FIF tool worked in clinical practice. The information from the interviews will give information about support and resist for this innovation.

Context: There is a distinction between the layers of context done in the i-PARIHS framework. The context is split into inner and outer context, where inner context contains the immediate local setting (i.e. the primary care) and the organization in which the unit or team is embedded. The outer context, however, reference the healthcare system in a wider sense. This is were the organization is based and it reflects the social, political and regulatory infrastructure as well as the policy that surrounds it (53).

For this thesis, inner context on the local level are focusing on the primary healthcare and public settings including the culture and past experiences of the healthcare professionals that work there. At the organizational level, culture and support from the management are important for the inner context and also the structure of the systems in the primary healthcare where the FIF tool has been testing. As for the outer context, this thesis' focus is on the policy drivers, priorities in the primary healthcare and the environmental stability.

Facilitations: The construct of facilitation is proposed to be what activates the implementation through the use of assessment and responds to the characteristics of the innovation construct and the contextual setting of the recipients within their construct. To achieve this a role is required (the facilitator) and an array of actions and strategies (the facilitation process) is set to further enable the implementation (53).

In this thesis, focus is to get information about the barriers and facilitators from the healthcare professionals to get knowledge about how to succeed in the implementation process with the FIF tool.

Additionally, for the qualitative studies, I have taken an **epistemological approach** where I assume that knowledge is subjective and constructed by social realities. The social reality is than constructed through phenomena created by those living in a specific social context (54). For this thesis, the idea was to get a rich understanding of the older adults' different perceptions of being screened with the FIF tool and how to use the FIF tool as a healthcare professional in primary healthcare and public health settings.

2.7 Rationale for the thesis

We know that falls, especially injurious falls, are a worldwide health issue. Most fall screening tools available are designed for older adults in a specific setting care setting, e.g. nursing homes.

These, however, have difficult discriminate between those who have fallen and those who have not (23-24).
Screening tools for injurious falls are particularly scarce, especially screening tools that can be used to identify fall risk in community-living older adults, without using information about previous falls. Knowledge is also lacking regarding attitudes of older adults and healthcare professionals toward the use of screening tools in clinical practice and how to facilitate an implementation process in primary healthcare and public health settings.

The FIF tool showed a good predictive ability in the development sample (19). With this in mind I have set a goal to use an available and applicable framework when starting the implementation process (53), see **Figure 2.** I aimed to externally validate the FIF tool in another sample than the development sample. Further on, I wished to extend the usability to a e-health setting and adapt the screening tool to the primary healthcare and the public health setting. I also wanted to increase our knowledge about how the FIF tool is perceived from the older adults' perspective as well as becoming aware of the FIF tools barriers and facilitators prior to future implementation into different healthcare settings.

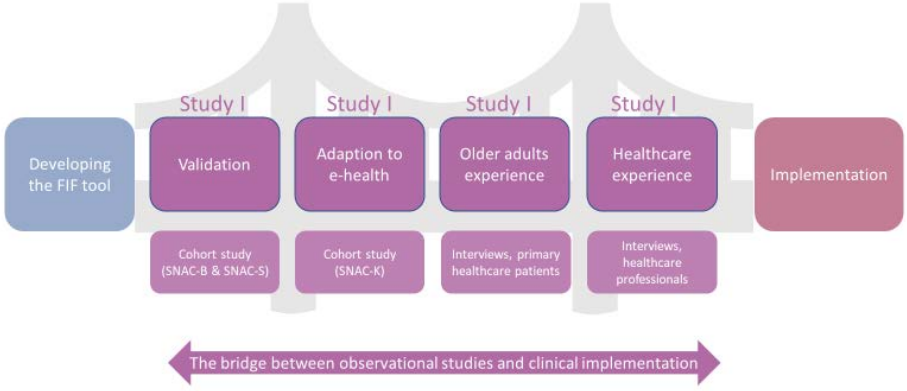


Figure 2. A model illustrating the (possible) role of the present thesis in bridging the knowledge gap between the development of the FIF (screening) tool and the implementation into clinical practice.

3 AIMS

3.1 Overall aim

The overall aim of this thesis was to enable detection of community-living older adults at high risk of first-time injurious falls, and explore barriers and facilitators for the implementation and knowledge translation of the FIF tool into clinical practice. The specific aims and research questions were as follows:

3.2 Specific aims

Study I aimed to examine the external validity of the FIF tool by examining its predictive performance in two cohorts of community-living older adults.

> Research question: To what extent can the FIF-tool discriminate between older adults who will experience a first-time injurious fall from those who will not?

Study II aimed to examine the predictive ability of the FIF tool and a modified FIF tool (in which one-leg standing is replaced by self-reported balance) for first-time injurious falls.

> Research question: Can we detect injurious falls with similar predictability using self-reported balance in place of an objective measure of balance?

Study III aimed to explore and describe older adults' experiences of being screened for risk of an injurious fall using the FIF tool.

> Research question: What are patients' attitudes towards being assessed with the FIF tool?

Study IV aimed to explore and describe healthcare professionals' experiences in using the FIF tool in order to gain insights into the barriers and facilitators for implementing the FIF tool in primary healthcare and public health settings.

> Research question: Which possible barriers and facilitators for implementation of the FIF tool do the healthcare professional experience during a trial period?

4 MATERIALS AND METHODS

4.1 Study design

This thesis used both quantitative and qualitative approaches to increase the level of knowledge about the predictive ability of the FIF tool and the m-FIF tool among different populations and settings, and to achieve information from both older adults and healthcare professionals to better understand the barriers and facilitators for the implementation of the FIF tool into clinical practice. **Study I** and **study II** are cohort studies based on population-based data and use statistical methods to analyze the predictive ability for the FIF tool and the m-FIF tool. **Study III** and **study IV** are interview studies, that use qualitative methods to explore and describe older adults and healthcare professionals' experiences, for an overview see **Table 1.**

Table 1. Summary of the design and methods used in the four individual studies.

	Design	**Population (n=numbers of individuals)**	**Methods**
Study I	Cohort study	SNAC-Blekinge (n=494) and SNAC-Skåne (n=2272)	Descriptive statistics. Survival analysis using Cox regression. Harrell`s C and the Youden index cut-off.
Study II	Cohort study	SNAC-Kungsholmen (n=1194)	Descriptive statistics. Survival analysis using Cox regression. Harrell`s C and the Youden index cut-off.
Study III	Clinical study, qualitative design	Patients attending primary healthcare in Stockholm (n=17)	Focus group interviews. Qualitative content analysis.
Study IV	Clinical study, qualitative design	Healthcare professionals from primary healthcare in Stockholm and public health setting (n=20)	Focus group and individual interviews. Reflexive thematic analysis.

4.2 Study I & II

4.2.1 Setting and participants

In **study I** we used data from the Swedish National Study on Aging and Care (55), in Blekinge (SNAC-B) and, Skåne (SNAC-S) and in **study II** we used data from (SNAC-K) in Kungsholmen. All SNAC centers use similar study protocols for recruitment and data collection. A stratified sampling procedure was employed; the population in each site was stratified by age (60, 66, 72, 78, 81, 84, 87, 90, and 93 years), and then random samples were selected from each age group. Follow-up is performed every 6 years for younger cohorts (60-78 years) and every 3 years for older cohorts (78 years) (56).

In **SNAC-B**, a total of 873 participants from a mid-sized town in Blekinge, southern Sweden were invited to participate in the baseline examination. Examination took place at a research center, and,

to reduce selection bias, home visits were also offered for more frail individuals who were unable to attend in person. A total of 698 persons participated in the baseline examination in 2013- 2015, giving a response rate of 79.9%. Because this study aimed to identify community-living older adults at risk of a first-time injurious fall, we excluded those who lived in an institution (n=2), had missing data on accommodation (n=125), and had experienced an injurious fall within 3 years of the baseline examination (n=44). Of the remaining 527 participants, 33 participants were excluded because of missing data on Instrumental Activities in Daily Life IADL (n=1), one-leg standing (n=31), and cohabitation status (n =1). The final analytical sample consisted of 494 individuals. Of those, 269 (54%) were women (mean age 75 years, Standard Deviation [SD] 7.8) and 225 (46%) were men (mean age 74 years, SD 8.0).

In **SNAC-S**, a total of 5370 participants from 5 municipalities, including both urban and rural areas in southern Sweden, were invited by letter to participate in the study (57). Of those, 2931 persons participated in the baseline examination (2001-2004), giving a response rate of 60%. We excluded those who lived in an institution (n=36), had missing data on accommodation (n=82), and had experienced an injurious fall within 3 years before the baseline examination (n=163). Of the remaining 2650 participants, 378 participants were excluded because of missing data on instrumental activities of daily living (IADL) (n=57), test of one-leg standing (n=320), and cohabitation status (n=1). The final analytical sample consisted of 2272 individuals. Of those, 1205 (53%) were women (mean age 71 years, SD 9.6) and 1067 (47%) were men (mean age 70 years, SD 9.2).

In **SNAC-K**, a total of 3363 individuals (73.3% of all eligible individuals) participated in the baseline examination between year 2001 and 2004. This study used baseline data from the fourth wave of follow-up between 2010 and 2012, when a question about self-reported balance problems was included in the cohort study. In total, 1520 individuals from 5 age groups (60, 81, 84, 87, 90+), were examined during this period. Since this study aimed to identify community-living older adults at risk of a first-time injurious fall, we excluded those who lived in an institution (n=54), had missing data on accommodation (n=1) or had experienced an injurious fall within 3 years of the examination date (n= 197). Of the remaining 1268 participants, 74 participants were excluded due to missing data on (IADL) (n= 22), test of one-leg standing (n=35) or self-reported balance problems (n=17). The final analytical sample consisted of 1194 individuals. Of those, 740 (62%) were women (mean age 73.6 years, SD 13.1) and 454 (38%) were men (mean age 70.6 years, SD 12.2). The injurious fall rate per 1000 person-years was 54.9 (95% CI: 47.22-63.78) for women and 36.3 (95% CI: 28.84-45.78) for men.

For both **study I** and **study II**, the excluded participants did not differ substantially from the analytical sample in terms of the proportion of women, but were on average older and had a lower education level compared with the analytical sample ($P < .05$).

4.2.2 Data collection

Nurses and physicians collected data through structured interviews, clinical examinations, and physical function tests. All SNAC-centers are linked to the National Patient Register and to the Swedish Cause of Death Registry.

The development of the **FIF tool** has been described in detail elsewhere (19). Briefly, it was constructed by combining previously established risk factors from reviews and meta-analyses. The tool was formulated based on the β coefficients from sex-specific multivariate Cox proportional

hazards models. The FIF tool has a maximum score of 8 points for woman and 7 points for men. To enhance usefulness in a community setting, two suggestions of categorization were made:

1. Based on hazard ratios (HRs) and significant association to an injurious fall. The scores were categorized into low, medium, and high risk. Low risk was assigned to scores 0 in women and 0 to 2 in men, medium risk was assigned to scores between 1 and 3 in women and 3 and 4 in men, and a high risk was assigned to values 4+ and 5+ in women and men, respectively.

2. Based on the Youden index, a cut-off at 3 or higher for high risk (where the balance between sensitivity and specificity is optimal), categorized into low and high risk (58). The variables included in the final FIF tool are age, cohabitation status, IADL, and balance (one-leg standing) (19).

The age of the participants at the baseline examination was categorized into 4 groups: 60 to 69, 70 to 79, 80 to 89, and +90 years. Cohabitation status was classified into "living alone" for those who were unmarried, divorced, or widowed and "cohabitating" for those who lived with a spouse or partner. Functional dependency was defined as being dependent in one or more of the IADL items: managing finances, using the telephone, grocery shopping, using transportation, preparing meals, cleaning, and doing laundry. One-leg standing was measured as the time in seconds that the participants could stand on one leg with their eyes open (up to 60 seconds). The participants had to have no shoes on, their arms hanging along their sides and they each chose which leg to stand on first. The test was attempted two times per leg, and the best overall score was used. The one-leg standing test is a reliable and validated measurement for balance (59-60). A one-leg standing time of less than 5 seconds was chosen as the cut-off for balance impairment, as indicated by Vellas et al (25).

For **study II**, the *modified* FIF tool (m-FIF tool), where the one-leg-standing test is replaced by a question about self-reported balance problems, in accordance with Ganz, et al and the Stopping Elderly, Accidents, Deaths, & Injuries (STEADI) recommendations (13, 61-62). The question in this study was derived from the nurse interview "Would you say that you have problem with your balance? (in the past 12 months)" (yes/no).

4.2.3 Injurious falls

The definition of an injurious fall was a receipt for inpatient or outpatient care because of a fall. This information has been retrieved from the National Patient Register (63). Outcome status was determined by linking each participant's personal identification number (PIN) to the registers. Because of the PIN linkage, loss of follow-up data is minimal (63). The Swedish healthcare registers have been shown to be highly reliable (64). We used discharged diagnosis from the date of the baseline examination until the end of the follow-up period (up to five years). We included external cause codes (W00, W01, W05-W10, W17-W19) from the International Classification of Diseases, 10th Revision. The codes represent low energy falls from the same level, with no other person involved. Information about the vital status of the participants has been obtained from the Swedish Cause of Death Register. Data on previous falls included injurious falls within three years of the baseline examination.

4.2.4 Data analysis

For both studies, the differences in baseline characteristics between men and women were compared using the Chi^2 test. For **study I** and **study II**, Cox proportional hazards models were used to estimate HRs and 95% Confidence Intervals (CIs) of injurious falls as a function of the FIF tool. The

Cox proportional hazards model is commonly used to predict hazard ratio, which is the risk or probability of occurrence of an event of interest (65). In **study II** we also included the m-FIF tool, one-leg standing and self-reported balance problems, stratified by sex. Participants were censored at the date of the first injurious fall, death, or the end of the follow-up period (up to five years). The mean follow-up time for SNAC-S was 4.86 years (standard deviation [SD]: 0.65 years), for SNAC-B 4.10 years; (SD: 1.30 years) and for SNAC-K 4.25 years (SD: 1.38 years). The proportionality assumption was tested.

We applied Harrell's C-statistics in both studies, to evaluate the predictive ability of the scores, stratified by sex. We used Harrell's C-statistic because it is a goodness of fit measure and a suitable predictive statistical method to be used to evaluate risk models for survival data, where data may be censored (66). For **study II**, we also included the m-FIF tool, one-leg standing and self-reported balance problems. For the Harrell's C-statistics, a value within 0.7-0.8 is considered acceptable and a value above 0.8 is considered excellent (67). In both **study I** and **study II**, we used the Youden cut-off test to analyze the sensitivity and specificity of the scores and to distinguish low and high risk for an injurious fall. Cox proportional hazards models were repeated to generate survival plots according to the Youden cut-off.

Statistical analyses were performed using STATA version 15 (Stata Corp., College Station, TX).

4.3 Study III & IV

4.3.1 Setting and participants

In **study III**, participants were recruited from two primary healthcare rehabilitation clinics in two different locations within the Stockholm region. For **study IV,** participants were recruited through three primary healthcare rehabilitations clinics, two primary healthcare centers and one public health project in Sweden. All participants in **study IV** were working as a healthcare professional in primary healthcare or in a public health project. In **study III**, all participants who had a booked appointment with their healthcare professional and met the inclusion criteria (60 years of age or older, and able to speak and speak and understand Swedish) received a letter from the healthcare professional with information about the study. A purposive sampling was applied for both studies (68), based on the different healthcare settings and participants. All participants who were willing to be included in the study were screened with the FIF tool by their healthcare professional at the primary healthcare rehabilitation clinic or at home. They were then contacted by phone by the main author and asked if they wanted to participate in a focus group interview. For **study IV**, all participants received information and a letter from the main author with information about the study and that they may be asked to participate in a focus group interview or individual interview. All participants willing to be included in the study were scheduled for an interview at their workplace or digitally. The participants who were actively involved in clinical work were asked to use the FIF tool on suitable patients during at least one month. They were informed about the FIF tool by an oral/digital presentation and/or written instructions.

For **study III,** a total of 17 older adults (11 women and six men) agreed to participate in a focus group interview. 11 participants declined to participate due to illness (n=1), un-availability (n=7), or not wanting to participate in the study (n=3). The mean age of the 17 who participated was 78 years, with a range from 61 to 93. In **study IV**, a total of 20 healthcare professionals (nine physiotherapists, three occupational therapists, three managers, two nurses, two health educators, and one dietician),

including 13 women and seven men agreed to participate in the study. For more details about the participants in the studies, see **Table 2** and **Table 3**.

Table 2. Descriptions of participants in study III

Sex	Age	Cause of contact	FIF score 0-2p low,3+p high	Time between visit and interview
Male	84	Rehab for quadriceps rupture	3 points	29 days
Female	64	Rehab for lower fracture	3 points	34 days
Female	69	Rehab for ankle fracture	1 point	50 days
Male	90	Back pain	5 points	62 days
Female	61	Assessment of physical lADL needs	2 points	63 days
Female	64	Shoulder pain	1 points	81 days
Male	75	Exercise group	5 points	26 days
Male	83	Exercise group	3 points	26 days
Male	91	Exercise group	7 points	0 days
Female	72	Arthrosis	4 points	7 days
Female	83	Arthrosis	4 points	21 days
Female	93	Arthrosis	7 points	21 days
Female	73	Neck pain	5 points	14 days
Female	88	Vertebral compression	6 points	20 days
Female	78	Impaired balance	5 points	20 days
Female	84	Heart failure	2 points	28 days
Male	63	Cardiac rehabilitation	0 point	21 days

Table 3. Descriptions of participants in study IV

Sex	Age	Profession	Workplace
Female	35	Physiotherapist	Public health project
Female	28	Health educator	Public health project
Male	32	Health educator	Public health project
Male	33	Occupational therapist	Primary healthcare
Female	50	Physiotherapist	Primary healthcare
Male	35	Physiotherapist	Primary healthcare
Male	37	Physiotherapist	Primary healthcare
Male	42	Physiotherapist	Primary healthcare
Female	28	Physiotherapist	Primary healthcare
Female	35	Physiotherapist	Primary healthcare
Male	49	Manager	Primary healthcare
Female	46	Dietician	Primary healthcare
Female	48	Registered nurse	Primary healthcare
Female	42	Registered nurse	Primary healthcare
Female	32	Occupational therapist	Primary healthcare
Female	47	Manager	Primary healthcare
Female	44	Manager	Primary healthcare
Female	47	Occupational therapist	Primary healthcare
Female	24	Physiotherapist	Primary healthcare
Female	54	Physiotherapist	Primary healthcare

4.3.2 Data collection

In **study III,** the data were collected through five focus group interviews conducted from November 2021 to June 2022 at the two primary healthcare rehabilitation clinics. The number of participants at the interview sessions varied from two to six. All participants had previously visited the rehabilitation clinic, so the locations were familiar to the informants. For **study IV,** the data was collected through four focus group interviews and seven individual interviews conducted from June 2022 to January 2023. The number of participants at the various interview sessions varied from one to four depending on the type of interview. Two of the focus group interviews took place at primary healthcare rehabilitation clinics. All other interviews were held digitally.

For both studies six focus group interviews each were conducted by the first and the second author with one serving as moderator and the other as an observer. The observer took notes about things that could not be captured on the recordings, such as the interaction between the respondents. The additional interviews had only the first author as a moderator, without any observer.

In both **study III** and **study IV**, the interviews were conducted based on a semi-structured interview guide (69). The interview guide contained several questions regarding thoughts about their experiences of being screened with the FIF tool and what the participants thought about screening for risk of an injurious fall, in **study III** and for **study IV**, the interview guides contained several open-ended questions regarding the healthcare professionals' experiences from using the FIF tool in primary healthcare and public health, and barriers and facilitators for implementing the FIF tool. In order to create an interview atmosphere that fostered a sense of trust, the moderator and observer introduced themselves before the interview started, presenting their professional background and their role in the study. The opening question for **study III** was "Can you describe what you associate with screening?". Follow-up questions were then asked to delve deeper into the answers until the questions were explored. The interviews varied in duration between 18 and 42 minutes. For **study IV**, the opening question was "What are your thoughts about injurious falls?" Follow-up questions were then asked to delve deeper into the answers until the questions were exhausted and the interviews varied between 20 and 52 minutes.

4.3.3 Data analysis

For both **study III** and **study IV**, a discussion was held between the moderator and the observer about their first impressions of what was perceived during the interviews, before continuing with the transcription as a first step in the analysis process. In **study III**, the recordings of the five focus group interviews were transcribed verbatim by the first author. Inductive qualitative content analysis was used as the method of text analysis (70-71). In **study IV**, reflexive thematic analysis was used as the method of text analysis for all interviews (72). With a reflexive approach to the thematic analysis it was possible to go back to the text, changing codes and themes during the analysis process (73).

Both methods were chosen in order to achieve a broad picture of the participants' experience. The definition of a category is a concept that it is descriptive regarding its context, whilst a theme describes the category's context in a more thorough way (abstract and implicit), and thus requires a level of interpretation (74).

Initially, all the transcribed texts were read by the main and second author so they could familiarize themselves with the material. Analysis of the text then followed an inductive qualitative content

analysis process (70-71) for **study III,** or the reflexive thematic analysis (72), for **study IV**. To ensure trustworthiness, more than one member of the research team took part in the analysis.

In **study III**, the first author performed the first analytical steps, in which meaning-bearing units with similar content were extracted from the text and classified, condensed, coded, and categorized. The second author then independently read and familiarized themselves with two randomly selected interviews to validate the preliminary analysis performed by the first author. Both authors refined and relabeled the categories by discussing and comparing the emerging results and interpretations with the content of the original interviews until consensus was reached. The last author acted as a peer reviewer in the later part of the analytical process and assessed whether part of the findings reflected the content of the interviews. Finally, an overall theme covering all five categories was developed.

For **study IV**, the first author also performed the first analytical steps, meaning-bearing units with similar content were extracted from the text, coded and thematized. The second author then independently read and familiarized himself with two randomly selected interviews to validate the preliminary analysis performed by the first author. Also, they both refined and relabeled the subthemes and themes by discussing and comparing the emerging results and interpretations with the content of the original interviews until consensus was reached. The last author acted as a peer reviewer in the analytical procedure and assessed whether part of the findings reflected the content of the interviews. Finally, three themes with underlying subthemes were developed.

4.4 Ethical considerations

The Regional Ethical Review Board in Lund, Sweden gave ethical approval for **study I** (Reg. no. LU 744-00, LU 128-00, LU 604-00), and the Regional Ethical Review Board in Stockholm, Sweden gave ethical approval for **study II** (Reg. no. 01-114, Ö 26-2007, 2010/2:4). The research protocol has been approved by the Regional Ethical Review Board in Sweden, and written consent was obtained from all participants for **study I** and **study II.** All participants gave their informed written consent. If a person could not answer, a proxy (often a close family member) was also asked. All participants were informed about the purpose and content of the study. The participants were also made aware that they could chose to drop out at any point, without giving a reason.

Ethical approval was obtained from the Ethical Review Board in Stockholm (Reg. no. 2020–00134) for **study III**. Ethical approval was obtained from the Ethical Review Authority (Reg. no. 2020-00134, 2021-04733, and 2022-02258-02) for **study IV.** All participants who agreed to participate in the focus group interview or individual interview received both oral and written information about the purpose of the study. All participants also signed an informed consent form. They were informed that their participation was voluntary and that they could withdraw at any time. The study was conducted in accordance with the Declaration of Helsinki (75).

For **study III** and **study IV**, all data has been pseudonymized and no personal data could be linked to the participants (76). All participants were given a code number. The number is used to make sure that no personal data are available for unauthorized. Furthermore, all research data are stored in a safety box and is only available for the researchers within the research group.

The testing of the FIF tool includes a test of balance (one-leg standing), which challenges the balance ability of the participants when the participant tries to stand on one leg for 30 seconds. During this step, there is a potential risk of the participants losing balance and falling. With this in mind, the

healthcare professionals were trained to perform the balance test in a safe way where, such that in front of the participants there was an object available to support and grip and behind the participants there was a bench or chair to sit on. Nurses and physicians working with the data collection in **study I** and **study II** also evaluate if they think it is safe to conduct the physical tests before starting. If the test leader felt that it was unsafe the test was not performed.

In **study III,** for healthcare professionals, it is also important to bear in mind when presenting the results of the FIF tool that the patient may have difficulty in identifying as a person at risk of injurious falls. It is therefore important that the healthcare professional only provides recommendation about fall prevention measures and emphasizes that this is only a screening for the risk of a future injurious fall within 5 years and that the results only show a potential risk and not something that will definitely happen. The participants of **study I** and **study II** where put through a thorough medical examination. Because of this a possible issue that could arrive was the possibility of the physician discovering an, previously, unknown medical condition or disease. If these conditions or diseases were to be discovered the participants would be sent a letter where the staff would recommend them to see their family physician.

During the focus group interview, it was necessary to consider that the participants may not feel comfortable with the other group participants or the fact that the interviews were recorded. There could also be a power imbalance within the group (77). The sensitivity is partly due to the balance test, which some people could perform better than others.

The location of the interview is an important consideration for creating a safe and open atmosphere. Therefore, the interviews with the older adults were conducted at a clinic where the older adults felt familiar with the environment.

5 RESULTS

5.1 Study I

The final analytical sample consisted of 2766 individuals. Of those, 1474 (53%) were women, and 1292 (47%) were men. From SNAC-B, 269 (54%) were women (mean age 75 years, SD 7.8) and 225 (46%) were men (mean age 74 years, SD 8.0). From SNAC-S, 1205 (53%) were women [mean age 71 years, standard deviation (SD) 9.6] and 1067 (47%) were men (mean age 70 years, SD 9.2).

In both SNAC-S and SNAC-B, it was more common for the women of the study, when compared to the men, to be living alone, to be older and have a lower educational level. In SNAC-S the women were more prone to have impaired balance than the men. The injurious fall rate per 1000 person-years was 19.7 (95% CI: 17.4-22.2) for the total sample. The injuries fall rate per 1000 person-years for SNAC-B was 26.7 (95% CI: 19.8-36.0) and for SNAC-S was 18.7 (95% CI: 16.4-21.3)

Table 4 shows the HRs and 95% CIs for first injurious falls in women and men up to 5 years after baseline in relation to the three categories of the FIF score, total sample. The HRs of an injurious fall were 1.55 (95%, CI: 0.83-2.82) and 5.23 (95%, CI: 2.63-10.38), for women and men in the medium risk group, and 6.22 (95%, CI: 3.35-11.54) and 13.60 (95%, CI: 6.71-27.58) for women and men in the high-risk group, compared to those in the low risk group.

Table 4. Hazard ratios and 95% confidence intervals (CIs) for first injurious fall in women and men up to five years after baseline in relation to categories of FIF score.

	n	cases	Score cut-off	Hazard ratio (CI)	p-value
Women(n=1.474)					
Low risk	316	12	0	ref	
Medium risk	847	49	1-3	1.55 (0.83-2.92)	0.171
High risk	311	62	≥4	6.22 (3.35-11.54)	**<0.001**
Men (n=1.292)					
Low risk	861	13	0-2	ref	
Medium risk	315	22	3-4	5.23 (2.63-10.38)	**<0.001**
High risk	116	19	≥5	13.60 (6.71-27.58)	**<0.001**

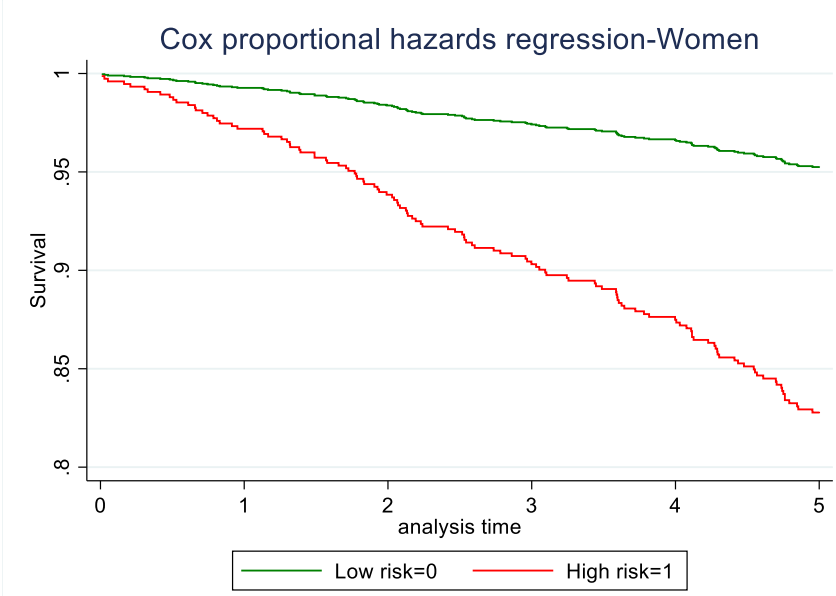
In comparison, **Table 5** shows the HRs and 95% CIs for first injurious falls in women and men up to 5 years after baseline in relation to the optimal Youden cut-off of the FIF score in the total sample.

The HRs of an injurious fall in the high risk group for women and men were 3.88 (95%, CI: 2.68-5.61) and 7.30 (95%, CI: 3.91-13.64), compared to those in the low risk group.

Table 5. Hazard ratios and 95% confidence intervals (CIs) for first injurious fall in women and men up to five years after baseline in relation to the optimal Youden Cut-off of FIF score.

	n	cases	Score cut-off	Hazard ratio (CI)	p-value
Women(n=1.474)					
Low risk	978	44	0-2	ref	
High risk	496	79	≥3	3.88 (2.68-5.61)	**<0.001**
Men (n=1.292)					
Low risk	861	13	0-2	ref	
High risk	431	41	≥3	7.30 (3.91-13.64)	**<0.001**

The survival plots for the Youden cut-off are presented in **Figure 3.** The predictive capacity of the scores in the total sample, measured with Harrell's C-statistic, were 0.72 for women and 0.77 for men.



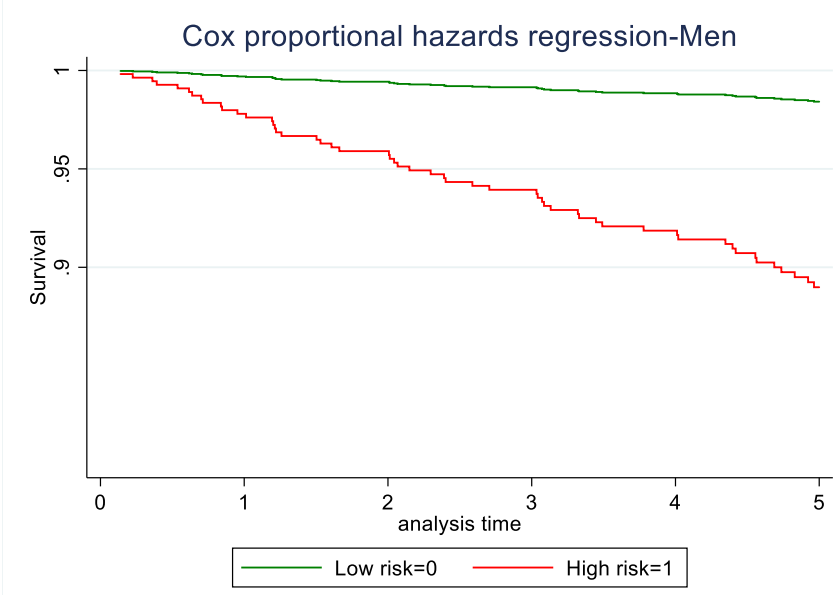


Figure 3. Survival plots showing time to an injurious fall with the optimal Youden cut-off of FIF score, for women and men, total sample.

According to the Youden index cut-off, with a value of three, for women the sensitivity was 0.64, the specificity 0.69, and the percentage of correct classification 69%. For men, the sensitivity was 0.76, the specificity 0.69, and the percentage of correct classification were 0.69, see **Table 6**.

Table 6. Sensitivity, specificity and percentage of correctly classified first injurious falls up to five years after baseline for each value of the FIF score, in women and men.

FIF Score	Sensitivity (%)	Specificity (%)	Correctly classified (%)
Women			
0	100	0.00	8.34
1	90.24	22.50	28.15
2	82.11	47.59	50.47
3	**64.23**	**69.13**	**68.72**
4	50.41	81.57	78.97
5	41.46	89.05	85.07
6	22.76	94.60	88.60
7	9.76	97.78	90.43
8	7.32	98.74	91.11
Men			
0	100	0.00	4.18
1	90.74	30.45	32.97
2	79.63	55.41	56.42
3	**75.93**	**68.50**	**68.81**
4	59.26	83.12	82.12
5	35.19	92.16	89.78
6	16.67	97.50	94.12
7	9.26	99.92	96.13

5.2 Study II

Of the 1194 participants, 740 (62%) were women (mean age 73.6 years, SD 13.1) and 454 (38%) were men (mean age 70.6 years, SD 12.2). The injurious fall rate per 1000 person-years was 54.9 (95% CI: 47.22-63.78) for women and 36.3 (95% CI: 28.84-45.78) for men. A total of 166 individuals died during the time period (99 women and 67 men). It was more common for the women of the study, when compared to the men, to be living alone, to be older and have a lower educational level, it was also more common, for them, to need more help in IADL.

In **Figure 4**, for the FIF tool, the HRs of an injurious fall for women and men, respectively, in the high risk group were 6.69 (95%, CI: 4.40-10.17) and 6.45 (95%, CI: 3.69-11.27) compared to those in the

low risk group. For the m-FIF tool, the HRs were 7.29 (4.77-11.16) for women and 6.44 (3.69-11.24) for men, compared to those in the low risk group. The HRs of an injurious fall for women and men with impaired one-leg standing were 5.53 (95%, CI: 3.86-7.91) and 4.90 (95%, CI: 2.96-8.10) compared to those with unimpaired one-leg standing. The HRs of an injurious fall for women and men with self-reported balance problems were 3.34 (95%, CI: (2.40-4.66) and 2.22 (95%, CI: 1.40-3.52) compared to those without self-reported balance problems.

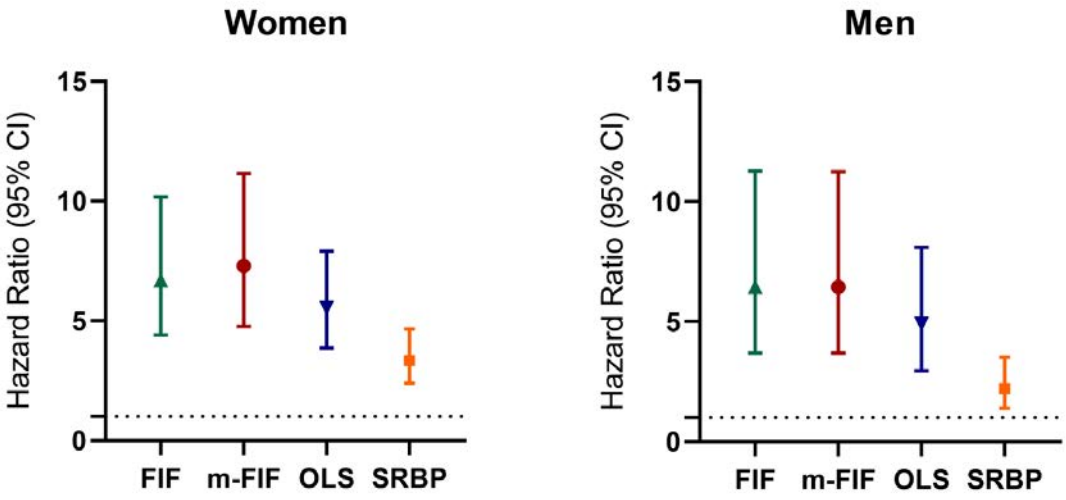


Figure 4. Hazard ratios and 95% confidence intervals (CIs) for first-time injurious fall in women and men up to 5 years after baseline in association with to the FIF tool, the m-FIF tool, one-leg standing (OLS) and self-reported balance problems (SRBP).

The predictive ability for women and men according to Harrell's C statistic was 0.70 and 0.71 for the FIF tool and the m-FIF tool. The predictive ability was 0.70 and 0.69 for one-leg standing, and 0.65 and 0.60 for self-reported balance problems, see **Table 7.**

Table 7. Predictive capacity of injurious falls during five years of follow-up according to Harrell´s C statistic for the FIF tool, the m-FIF tool, one-leg standing test and self-reported balance problems.

	Women, n=740			Men, n=454		
FIF tool	n	cases	Harrell´s C	n	cases	Harrell´s C
Low risk	354	26	0.70	261	16	0.71
High risk	386	144		193	56	
m-FIF tool						
Low risk	359	25	0.70	260	16	0.71
High risk	381	145		194	56	
One-leg standing						
Normal	408	39	0.70	278	22	0.69
Impaired	332	131		176	50	
Self-reported balance problems						
No	387	49	0.65	300	37	0.60
Yes	353	121		154	35	

5.3 Study III

The final analysis resulted in five categories *"Thoughts on screening and prevention",* "*Complexity of the risk of falls and its consequences", "Practical aspects of using the FIF tool", "Reflections on the results of the screening", and "Ideas about the development and use of the FIF tool".* All categories were integrated into one overarching theme *"Screening for fall risk is meaningful even though preventing falls is complex*", see **Figure 5**.

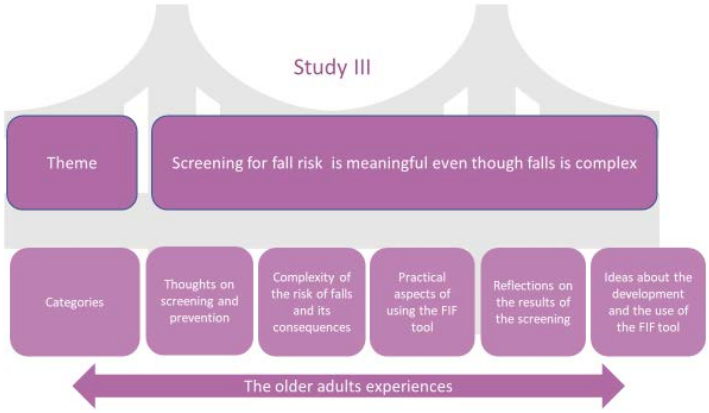


Figure 5. Theme and categories for study III.

Screening for fall risk is meaningful even though preventing falls is complex

The informants described screening for fall risk as meaningful and important since it may enable prevention of falls. Most informants experienced a positive feeling of having received a screening result on their risk of injurious falls. The informants also described that they perceived falls as highly complex. They were aware of factors and situations that could increase the risk of falls and had thoughts of preventive measures that may prevent falls. They described that a low risk result may create a sense of false security. Furthermore, they did not experience any difficulties using the FIF tool and they had suggestions about the development and use of the tool.

The overall theme was based on five different categories:

Thoughts on screening and prevention

The informants described that screening was important for preventing falls and that prevention at an early stage was important for preventing injurious falls. The informants also described how a screening result that does not indicate an increased risk of falls could create a false sense of security.

"I agree with you that you shouldn't, you should always think that there is always a fixed risk of falls, whether it's high or low. So, I can fall anyway." (Interview 4)

"When you're older, your balance is worse and you often have poorer bone structure. So, practicing balance and exercise would probably reduce the risk of falls." (Interview 5)

Complexity of the risk of falls and its consequences

The informants expressed that despite injurious falls being difficult to avoid, physical aids and various strategies could reduce their worries about falling and reduce the risk of falls. The informants described their worries about falling, and how balance training created various strategies for them to manage their worries. The informants also described how they perceived falls as highly complex. One of the reasons for this complexity, according to the informants, was the surrounding

environment, both indoors and outdoors, which was a strong contributing factor to falls being difficult to prevent. It also emerged from the same category that older adults are used to be independent, and that it may therefore be beneficial to have a screening instrument that provides an objective result. The informants expressed the importance of being involved in deciding on the actions if the screening test showed an increased risk of falls.

"I have a walker at home but I can't use it much. There are small spaces, and there are thresholds and so on. It's hard to get in, and it's difficult. Going into the toilet. It doesn't work." (Interview 3)

"Coming up with pointers, and doing this and that at home and removing carpets isn't going to do anything. People my age, and all of us in general, we have our set ideas and thoughts and habits. That's kind of how it is." (Interview 5)

Practical aspects of using the FIF tool

The informants perceived that the questions in the FIF tool as being easy to answer. None of the questions included in the screening instrument felt uncomfortable or sensitive to answer. The balance test was the easiest thing to remember and was perceived as being the most important part of the FIF tool.

"Yes, I was just thinking about the fact that I didn't need help, but I was lucky enough to have a sister who lived nearby who came up and helped me. Otherwise, I would have had to hire home care services or something to get help at home. You can't just jump on one leg and do everything." (Interview 1)

"It was easy for me. Yes, I didn't think standing on one leg was difficult at all." (Interview 5)

Reflections on the results of the screening

The informants experienced a positive feeling of having received a result about their balance ability and a risk assessment for future injurious falls. It emerged from the informants that it felt meaningful to hear about a result, but that it was important to get support from their healthcare provider if they had a high risk of falls.

"But if you think you're doing this, and then you get a high fall risk score. Subsequently, if you then find that out, there's a high risk that you will fall. Maybe not now for the first six months, but later on. Then you have to get some tips or tools on how to avoid it yourself." (Interview 4)

Ideas about the development and use of the FIF tool

The informants described a desire for screening to be more individualized and take place on several occasions. One idea regarding the field of application for the FIF tool was that the informants described how the FIF tool could facilitate assessment for physiotherapists and be used at the annual health check with a doctor, and that the patient could then be referred to the appropriate healthcare provider.

"No, but that you have to do it several times. Several different tests. I think that would also be good. Now you test twice, and then it's over. Maybe you weren't really in good shape then." (Interview 5)

"Yes, at a doctor's appointment, for example. When you go to the doctor for an annual check-up, then they do that, a quick little test to start prevention." (Interview 1)

5.4 Study IV

The analysis revealed three themes with five related sub-themes (see **Figure 6**): “Applicability in practice”, “How to get everyone on board”, and **“**Future opportunities” with five related subthemes “Quick and Easy”, “Valuable”, “Need of improvements”, “Organizational conditions”, and “Areas for application”.

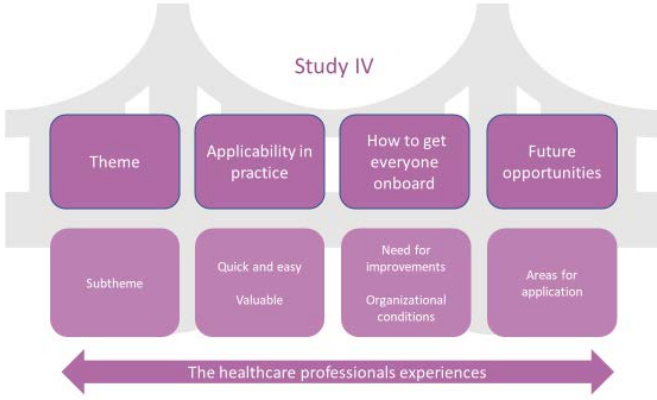


Figure 7. Theme and subthemes for study IV.

Applicability in practice

The informants described that the FIF tool was an **easy** tool to use that worked well and **quick** in clinical practice and in public health work. The performance of the tool was overall perceived clear and relevant for its purpose. They also highlighted the benefits of early detection and identification with screening. They describe screening as **valuable** such as giving support in an early stage of a disease to mitigate the risk of an injurious fall.

"Ah I can only agree. It was very easy to take, so it was quick to do. Nothing weird, just straight questions. Easy for the patients to answer. You didn't have to explain the questions. And it was quick. And just like you said, it felt like the patients found it very smooth as well." (Focus group interview 3)

"We've been able to choose whether they go to the falls prevention or promotion stage and there it's actually been golden to use and easy for us to be able to separate." (Focus group interview 1)

How to get everyone onboard

The informants described that there was **need for improvements** regarding the specific performance of the balance test, meaning it could be interpreted differently depending on experience or profession. The informants also explained that a new screening instrument requires **organizational conditions** to facilitate an implementation process. Most importantly the instrument needed to be easily accessible, that way, a result could be documented in their patient records and, with the support from the management, become a new routine. All this to facilitate for the limited time in everyday clinical practice. The informants described that there may be those with difficulty dealing

with changes when implementing a new screening tool. It needs to be a motivation from the managements' side at the workplace explaining why to change to another instrument.

"And then there was the one about if you've fallen three years ago and then someone who had good balance had slipped on a patch of ice or something and broken something and been in hospital because they've slipped. So, it's also a little bit of an interpretation question whether it's because of impaired balance or just one because of the ice patch." (Focus group interview 2)

"Yes, but it is certainly good to have such a transition period. It can be. So that you can get this last group of people who are still standing on the platform and have not joined this train. Who is at the front of the locomotive, who is in the middle and who is still on the platform" (Individual interview 7)

Future opportunities

The informants described different **areas of applications** of use for the FIF tool, where the general consensus was that it could work in many contexts and especially in primary healthcare. It did not feel as relevant to use the FIF tool in home rehabilitation since the primary purpose in home rehabilitation was to assess fall risk, even so, the patients they meet are often times too frail or have an already known risk of falling. Therefore, a screening tool was not as important in that context.

"I think that in home rehabilitation it might be automatic, where it is part of the first visit to check the living environment and to check what risks there are. Whereas here when we see patients in clinic, we are very focused on what the patient is here for and have very little time to deal with that particular problem. So, if you have a tool like this that screens quite quickly, it's quite useful to use more. Because I think we're generally a bit poor at using it unless they're looking specifically for that problem." (Focus group interview 3)

6 DISCUSSION

6.1 Main findings

The overall aim of this thesis was to enable detection of community-living older adults at high risk of first-time injurious falls, and to explore barriers and facilitators for the implementation and knowledge translation of the FIF tool into clinical practice. The findings of the current thesis will be discussed in light of the i-PARIHS framework (53), see **Figure 8**. The **observable results** show that both the FIF tool and the m-FIF tool have an acceptable predictive capacity for injurious falls over a follow-up period of five years. Older adults perceived that it was unproblematic to be screened with the FIF tool, and healthcare professionals expressed that the FIF tool worked well in clinical practice. The **usability** for the FIF tool was good. For the implementation process, there was some need for improvements of the FIF tool regarding the specific performance of the balance test, meaning that it could be interpreted differently depending on experience or profession. These circumstances affect both the **clarity** and **trialability** for the FIF tool. To facilitate the integration of the FIF tool in to clinical practice the instrument needs to be made easily accessible for healthcare professionals to facilitate the **degree of fit with existing practice and values.** Healthcare professionals need to be able to easily document the results of the FIF tool, and as such it is necessary for them to have the proper terms and groundwork done in the medical record system. However, for **relative advantage,** the FIF tool and its implementation need to be supported by the management to make the transition into a new routine easier.

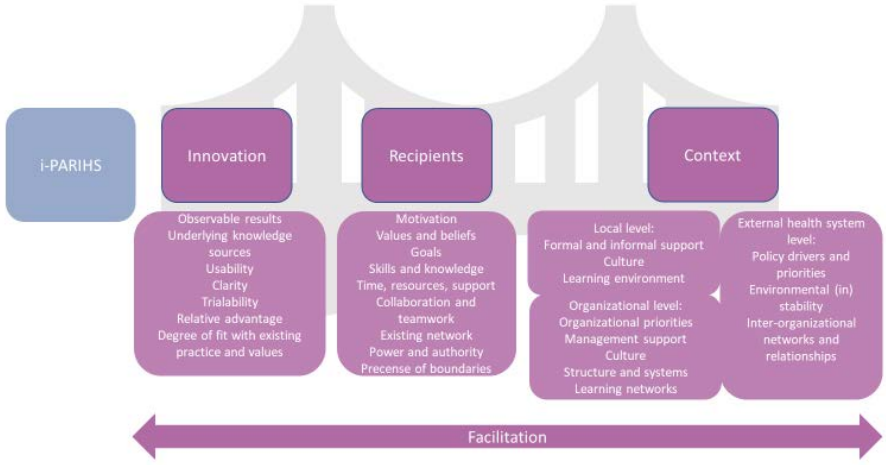


Figure 7. Overview of the included characteristic from the i-PARIHS framework

6.1.2 Innovation

The explicit focus on sourcing and utilizing available research evidence is a central construct in the i-PARIHS framework, and is done to inform the innovation. The evidence here is viewed as a type of "knowledge", this new knowledge serves as the substance which is needed to be incorporated to facilitate change and improvements. The innovations characteristic then creates a set of conditions,

e.g. if the innovation is useful or clear, and this makes the innovation more or less likely to be acknowledged and applied (53). For this thesis, the starting point was to increase knowledge about the FIF tool's predictive capacity in other settings than the development one (19). According to the **underlying knowledge sources, study I** showed **observable results** where the FIF tool had an acceptable external validity with the predictive values of 0.72 for women and 0.77 for men. Since these predictive values can be considered quite high compared to other validated tools (78-80), the results suggest that it is possible to predict first-time injurious falls with relatively high precision. For example, the Brief Performance-Based Fall Risk Assessment Tool, had an Area Under the Receiver Operator Characteristic (ROC) curve (AUC) of 0.72 (78), and the Fall Risk Assessment Tool (FRAT-up), had an AUC of 0.65 (79). Similarly, another study validating the LASA Fall Risk Profile had a value of AUC 0.65 for the current sample and 0.71 for the development sample (80). It is important to remember that these tools are assessment tools rather than screening tools. Despite this difference, the FIF tool had comparable or even better sensitivity and specificity than the fall risk assessment tools. This increased the **relative advantage** for the FIF tool. Harrell's C is a type of C-statistic (71), which is comparable to the AUC. The Harrell's C-statistic was 0.75 and 0.77 for women and men respectively for the FIF tool, in the development study (19), were we expected the values to be a bit higher.

The results from the Youden cut-off were far more robust across cohorts than the three categories (low risk 0p, medium risk 1-3p and high risk 4+p), since it was 2.5 in both cohorts and also in the development study (19). In **study I,** the predictive values with the Youden cut-off had a sensitivity of 0.64 for women and 0.76 for men and a specificity of 0.69 for both sexes. In Tiedemann et al.'s Brief Performance-Based Fall Risk Assessment Tool, values for sensitivity and specificity were between 0.26-0.70 and 0.52-0.89, respectively (78). Similarly, the LASA fall risk profile for recurrent falling reported a sensitivity of 56.6% and a specificity of 71.4% (81), and another study with a predictive model for recurrent fallers, reported a sensitivity of 0.59 and specificity of 0.87 (81). These studies included previous falls, which is the most prominent determinant of subsequent falls.

The predictive values for the FIF tool found in **study II** were lower than those found in the previous studies (19, 82). Since there was a lack of participants at the age of 70, one possible explanation for the results, if they had been included, is that there would have been more individuals scoring in the middle range that would have been directed into either the low- or high risk group. The results from **study II** also indicated that the one-leg standing by itself is a good predictor of first-time injurious falls with predictive values of 0.70 and 0.69 for women and men, respectively. Indeed, the one-leg standing test is considered to be a good indicator of balance ability (83), and a sensitive test for older adults when trying to distinguish fallers from non-fallers (84). Self-reported balance ability showed slightly lower predictive values and HRs than the one-leg standing test.

To conclude, the **observable results** from **study I** and **study II,** indicate that both the FIF tool and the m-FIF tool can predict first-time injurious falls with a relatively high precision, even in different populations and settings. The **underlying knowledge sources** inform that the m-FIF tool can be suitable to use in eHealth settings, which may expand its **usability** into more contexts. Lastly, the results from the FIF tool increase the **relative advantage** since there are no other multifactorial screening tools to predict for first-time injurious falls that consider sex differences. Previous studies have shown that even though most risk factors for falls are shared between women and men, some factors seem to be more or less important for either sex (17-18). Taking sex differences

into account is important to enable a person-centered approach and to predict future falls even more accurately.

6.1.3 Recipients

This construct consists of participants influence and affected by implementations done at both the individual level and the collective team level. The, involved, participants views, beliefs, and their established way of practice can, according to the i-PARIHS framework, affect, significantly, the ease of introducing a new change or innovation. This construct consists of a wide variety of recipients, including but not limited to, patients, clients, clinical staff and managers (53). The results from **study III** show that older adults consider screening for falls to be meaningful and important to prevent falls, which shows their **values and beliefs** in a positive way for the FIF tool. On the other hand, there was some **presence of boundaries** since it also emerged that some older adults felt it was irrelevant to be screened with the FIF tool because they did not identify themselves as a person with a fall risk. Furthermore, the older adults highlighted that a low risk result may create a false sense of security, which should be kept in mind when communicating the screening tests results. It was found from another study, that individuals with a low physiological fall risk but who still worried about falling had an increased risk of falls (85). It is therefore likely that the benefits of screening still outweigh the risks that any false sense of security might involve.

According to **power and authority,** older adults are used to be independent, and must be allowed to create changes to prevent falls without someone else deciding and giving advice. Therefore, they described that it would be beneficial to have a screening tool that provides an objective result. In a study with participants with Parkinson's disease, it was observed that individual influence is related to one's own self-efficacy and self-competence (86).

Older adults described that screening for fall risk could give them an idea of their own abilities and an assessment of what was needed to prevent falls. **Goals and motivation** are important characteristics for the innovation, and older adults perceived the balance test to be the most important aspect of the screening instrument, as it provided information about their own abilities.

The informants in **study III** described how worries about falling could increase the risk of falls, and that it was therefore important to detect fall risk early on. The experience of worrying about falling should be important to bear in mind when working with fall prevention, which was consistent with a previous study in which older women with osteoporosis were interviewed (87). In the study, the informants described their worries about falling, and how balance training created various strategies for them to manage their worries. This is also consistent with another study indicating that perceived control was important for individuals with worries about falling (88).

From **study III,** the older adults perceived that only one round of testing was far too little to be able to make a fair assessment, as the daily pattern could vary from day to day. They described how it would be useful to have the opportunity to be screened on several occasions to see if the risk changed over time, making it possible to monitor and reduce the risk of falls in the long term. The older adults perceived that the screening instrument itself should be more individualized so that, for some, it would be possible to increase the degree of difficulty. However, the current guidelines for fall-risk prevention in community-living older adults recommended first screening to identify people at increased risk of falls; and if there was an increased risk, the healthcare professional should then continue with an in-depth examination and an individual assessment of the patient's needs (37).

In **study IV,** the healthcare professionals described the **usability** similarly as the older adults. They perceived that the FIF tool was an easy screening tool to use and that it worked well in clinical practice and in the public health work. The performance of the tool was overall perceived with **clarity** and relevant for its purpose. The importance for a tool to be quick and easy to manage was highlighted in another study evaluating a brief-self assessment tool for cognitive impairment in primary care (89).

The results from **study III**, emphasized the need for **time, resources and support** for older adults at high risk of injurious falls, and to actively involve the older adults in the planning of their care to increased their **knowledge and skills.**

6.1.4 Context

There is a distinction between the layers of context done in the i-PARIHS framework. The context is split into inner and outer context, where inner context contains the immediate local setting (i.e. the primary care) and the organization in which the unit or team is embedded. The outer context, however, reference the healthcare system in a wider sense. This is where the organization is based and it reflects the social, political and regulatory infrastructure as well as the policy that surrounds it (53).

6.1.4.1 Inner context

The inner context on the **local level** focuses on primary healthcare and public settings including the **culture** and **past experiences** of the healthcare professionals that work there (53). In **study IV,** the healthcare professionals experienced that the FIF tool worked well in a clinical context since it was perceived as clear and relevant, and a valuable screening tool with a high priority. They described the FIF tool as an instrument easy to apply, both in a primary healthcare and in a public health project which increased the **usability and clarity** for the innovation. It was described as a routine test, and that it was easy to carry out. The questions were perceived as being relevant, and not sensitive. However, there was some need for improvements to make the tool clearer and to mitigate misinterpretations. The healthcare professionals also described the need to have a wide dissemination of knowledge in order to implement a new instrument and to reach out widely, and extend the **existing networks.**

The FIF tool could also be useful on a larger group of older adults and used in public health work to provide the information on the need of health promotion interventions and extend the **usability** for the FIF tool. However, the healthcare professionals described **presence of boundaries,** that the primary purpose in home rehabilitation already was to assess fall risk and therefore a screening tool felt unnecessary. They describe that they often met frail older adults who already have a known fall risk and indicated that some older adults might have difficulty standing on one leg due to the use of a walker or wheelchair. In that case, the balance test could be time-consuming, and another screening tool could be more appropriate.

The healthcare professional enlightened that it was necessary to identify older adults through communal activities to reach those who were still healthy. Another possibility would be to use the FIF tool during the annual health check-up with the doctor or nurse at the healthcare center.

Healthcare professionals described the importance to create a living **culture** and **learning environment** of reminders and follow ups to facilitate a behavioral change in the clinical practice.

The healthcare professionals described the need to have a wide dissemination of knowledge in order to implement a new instrument and to reach out widely with **existing networks.** Healthcare professionals felt that the FIF tool was quicker to complete than expected which was perceived as an advantage due to **time, resources and support** in everyday work.

From **study III,** the informants described how they perceived falls as highly complex. One of the reasons for this complexity, according their **knowledge and skills**, was the surrounding environment, both indoors and outdoors, which was a strong contributing factor to prevent falls. This experience was similar to another qualitative study on balance training, in which women with osteoporosis described how environmental factors affected their fall-related worries (90). Previous studies also reinforced the older adults' perception that falls were complex, and fall prevention measures need to be individually tailored according to the older adults' status and the surrounding environment (91).

At the **organizational level**, workplace **culture** and **time, resources and support** from the management are important for the inner context. Managers or leaders have a central role in the i-PARIHS framework, in transforming cultures; therefore, they are vital in shaping context that is ready for change (53). The structure of the organizational systems in the primary healthcare where the FIF tool has been tested is an important factor in this context. Healthcare professionals described a need for **motivation and support** from the management's side, explaining why they should start using another tool. They expressed that a new routine must be driven by the **structure and system,** and emphasized the importance of **clarity** and **management support**. It became clear, from the healthcare professionals, that the ability to use the screening instrument required **organizational priorities.** For example, the FIF tool had to be easily documented in the patient records with keywords or question text and that it should be downloadable from the internet. They describe some ambiguity regarding items of the FIF tool and gave suggestions to facilitate and reduce the risk of misinterpretation of the instrument. A new routine needed to be established from the start so it could incorporate in a daily routine and facilitate **learning networks.**

6.1.4.2 Outer context

As for the outer context, this thesis focus is on the policy drivers, priorities in the primary healthcare and the environmental stability (53). The healthcare professionals believed that there may be those with difficulty dealing with changes when implementing a new screening tool. There also needs to be a **motivation** from the managements' side at the workplace explaining why to change to another instrument. The dissent to administratively imposed change was also a concern raised by healthcare professionals (92), and it could be seen as another mandate that placed additional demands on their clinical time. To support the **degree of fit with existing practice and values**, they recommend that healthcare professionals may be convinced by a short summary of the current clinical evidence as one element of implementing a change in clinical practice and also **time, resources and management support.**

Results from **study II,** indicate that the m-FIF tool may be suitable to use in eHealth settings, which may expand its **usability**. Another option could be to use the m-FIF tool in public health surveys, which are being administered digitally. A self-managed screening tool could be performed by the older adult herself/himself from home or in the waiting room before meeting the healthcare professional, at the primary healthcare rehabilitation clinic.

In addition, depending on the application area, **policy drivers and priorities,** the cut-off value for high fall risk can be raised or lowered, to increase either sensitivity or specificity. In a clinical setting, a low specificity may be beneficial to make sure that the invested time and money are efficiently spent for cost-effectiveness. However, high sensitivity may be useful for a public health fall prevention intervention, to include as many older adults as possible who are at an elevated risk and may need further assessments by a healthcare professional. In line with recommendations from STEADI (61-62), the FIF tool and the m-FIF tool could include questions about the fear of falling and if there have been any previous falls.

6.1.5 Facilitation

Facilitation is the construct that activates implementation through assessing and responding to characteristics of the innovation and the recipients within their contextual setting (53). In this thesis, focus was to get knowledge about the **underlying resources and observable results** from **study I** with the external validation of the FIF tool and **study II,** where we examined the possibility to extend the **usability** to other settings such as e-health settings. Another goal was to increase knowledge about the barriers and facilitators from the older adults and healthcare professionals to generate knowledge about the **trialability** and how to facilitate and succeed in the implementation process with the FIF tool.

In **study III and study IV,** both the older adults and the healthcare professionals expressed the **usability and clarity** of using the FIF tool in a positive way. The **trialability** for the innovation could be facilitated with a **structure and system,** including a **learning environment** with **management support, time, and resources.** However, this also indicated that the **trialability** could be more difficult in settings where these facilitators are not applicable.

6.2 Methodological considerations

6.2.1 Design

Study I and **study II** are both cohort studies, with populations-based data from SNAC-B, SNAC-S and SNAC-K. A good internal and external validity are both necessary for the quality of a quantitative study. Internal validity is the ability to measure what is intended to measure, external validity is defined as whether data can be applied to other populations (93). There are risks of bias that needs to be considered when research on cohorts is done. These risks are vital to keep in mind when aiming to have the best quality of research possible.

Study III and **study IV** were both using qualitative methods with two different analytic methods. Regarding the quality of qualitative studies, trustworthiness is essential. When assessing the trustworthiness, we used credibility, dependability, transferability and confirmability (71, 94). A study, aimed to enhance trust in its findings and interpretations, follows the concept of credibility. This concept also takes into consideration the decisions done, in the study, regarding the context, the participants and the gathering of the data. The concept of dependability deals with the studies instability. The instability refers to eventual data changes and the decisions made during the collection of data and the analytical process. The concept of transferability relates to whether the study's findings are capable of being transferred to other settings and groups, and to what extent. The concept differs from generalizability, however, in that there is the reader who judges whether the data collected is transferable or not. The concept of confirmability is to what consistency the

data and the findings of the study are understood. In the following discussion the contents of trustworthiness will be discussed (71, 94).

6.2.2 Internal validity

6.2.2.1 Systematic error (bias)

Recall bias. In **study I**, we have only chosen to study objectively measured falls leading to any type of healthcare visit. There are several strengths to this approach. First, we don't need to rely on the participants subjective perception of what a fall is, which could differ between individuals and subgroups (1). Second, people tend to forget and this is of course especially common among older adults (95). Lastly, by using objective measures of falls, we avoid recall bias that is commonly present in studies about self-reported falls where they use questionnaires. A report bias may inhibit the validity of self-reported balance in **study II**. This might be because older adults underestimate their physical capabilities, though this can differ by sex or individual differences (96).

Selection bias. In **study I** and **study II,** selection bias occurs when a sample selection is baselined, the inclusion of variables with missing data in the analysis and/or attrition during the follow-up. The participants of SNAC were selected at a random from Kungsholmen, Stockholm, and from rural and urban areas in Blekinge and Skåne, Sweden. A selection bias might have occurred during the selection as some individuals may be more inclined to participate than others might. What have been shown in SNAC is that the overall baseline for all age groups and sexes consist of a high participation rate (i.e. 60-80%). However, those who did decline from participating were older on average and had a lower educational level when compared to the analytical sample.

There is a potential selection bias for the outcome of injurious falls. The purpose of the FIF tool is to focus on the most severe falls, which effect individuals and society the most (1). One can hypothesize that there is a difference between subgroups regarding when to seek healthcare. Others may seek healthcare for a less severe injury whilst others do not. This in and of itself is, however, strictly a hypothesis, since we only know of falls severe enough the require medical attention. The downside of this method is that non-injurious falls or falls that never lead to seeking healthcare are not captured, which leads to an underestimation of the total number of falls in this population.

We chose to manage the selection bias by excluding participants living in nursing homes, due to them having a different healthcare seeking pattern, e.g. minor injuries can be treated directly at their accommodation. A sensitivity analysis was also conducted, including only severe injuries. Another way of viewing the selection done, having a focus on injurious falls rather than all falls, is that we have chosen to focus on those who will suffer the worst consequences of the fall. These types of fall are the ones that are the most important to be able to prevent.

Information bias. The information bias occurs when a measurement is done incorrectly or information is recorded incorrectly (97). Non-differential **misclassification** comes to be when different groups in a study is shown to have an equal probability of being misclassified. This misclassification is separate from other variables included in the studies, i.e. outcomes, exposures and covariates. The bias that occurs is non-differential if the existing information bias is the same for all individuals or randomly spread.

When there is a likelihood that the participants will be misclassified due to changes in the connection to the studies exposure or outcomes, differential misclassification appears. If a differential information bias is related to the studied outcome, it might affect the associations. This type of

misclassification may lead to either the strengthening of a false association or weakening of a true association. The SNAC-centers intend to avoid these issues by using validated questionnaires and measurements whenever it is possible. They have also several attempts on the tests such as the one-leg standing balance test where the participants attempted to stand on the one leg twice to get a mean value or "a best of". In SNAC they also have regular meetings and training for the staff that are involved in the data collection. This is of course more common in each center but there are also yearly meetings with all four SNAC-centers together. The turnover among the data collection staff in SNAC-K is also very low and the long experience among the staff helps to minimize the information bias.

Confounder. The definition of a confounder is a factor that have the ability to influence both the exposure and the outcome (98). This means that the confounder could either hide a true association or show a false one. By trying to anticipate potential confounders and adjusting to these factors, the risk of having a confounder is reduced. This has been done in both **study I** and **study II** by choosing known confounders based on prior known knowledge from literature. It is, however, not possible to adjust to all possible confounders, this results in residual confounding. This thesis **residual confounding** are factors associated with an injurious fall such as environmental factors e.g. slippery floors or high curbs. It is not possible to fully control and adjust the environmental factors or any other circumstantial factor due to SNACs study design, or any other quantitative cohort study.

The use of longitudinal data aims to control for **reversed causality**, for **study I** and **study II,** we excluded individuals with previous falls at baseline to minimize the risk of reversed causality.

6.2.2.2 Random error

Random error, or lack of precision, are errors that still exist after accounting for systematic errors. These, random errors, refer to the overall errors that can affect the precision of the estimate and occurs in all studies.

Sampling error. The sampling errors are by definition unknown and unpredictable, and can be understood as an error "by chance". The sampling error can, however, be avoided to a greater extent. By using a sample size that is larger and has an increased power, and using 95% CI and having a p-value of 0.05, the effects of the sampling error can have its effects reduced and thus having the risk of the result being affected by "chance" minimized. Both **study I** and **study II** were deemed to have a good power that allows for the precision to be increased. To further assist in strengthening the studies, statistical significance testing was conducted to prove the findings to be clinically relevant. It is also to note that a CI of 95% were used and thus making sure that the findings were, by 95%, not by chance.

Measurement error. Ambiguity in the measurement can come from different variations of the variable assessments, this can be reduced by having the measurements repeated and then averaging the estimates. One assessment is done on the participants of the SNAC-centers during each wave, this in and of it self increases the possibility of an error in the measurement by either the one assessing or the participant. There is a lack of repeated assessments in most of the measurements, though it does not impede on their validity. This may be thanks to trained personnel that follow protocols standardized for the situation and with an aim to reduce any type of error that may occur during the measurement.

6.2.3 External validity

External validity refers to what extent the findings can be generalized to populations other than the one being studied (99). The population differs between all studies in the thesis. The FIF tool was developed and based on a population from a large city with an urban and well-educated population. The validation study was based on a mix of people from small cities and in rural areas in southern Sweden. The differences between the populations and settings in **study I** and **study II** extend the usefulness for the FIF tool and make it suitable to generalize the results for more than the development sample.

6.2.4 Trustworthiness

For both **study III** and **study IV,** one strength in terms of credibility was the detailed description of the analytical process and that, in addition to the first author, two experienced authors were also involved in the process of analyzing the data material.

Regarding dependability, interviews were conducted until both the first and the second author experienced saturation (69). Saturation was reached when the aim of identifying differences and similarities based on the informants' experiences of having tested or using the FIF tool were not seen to change the codes, the categories, subthemes or the final themes analyzed from the data material (69). According to confirmability, both the first and the second author are physiotherapists, and were aware that their pre-understanding of both the clinical environment and the subject affected their analysis of the data material.

Another strength, in **study III,** the informants should have experienced a sense of security during the interviews, as the location was familiar which improved the conditions for an open atmosphere and facilitated the discussions during the interviews. For **study III,** the choice of primary healthcare rehabilitation clinics at two different locations within the Stockholm region with different socioeconomic conditions increases the study's transferability, and gave a variety of participants from different backgrounds, which in turn may have provided a broader picture with varying opinions. In **study IV,** the choice of three primary healthcare rehabilitation clinics and two primary healthcare centers within the Stockholm region and one public health project in Skåne region increases the study's transferability. It also explored a variety of healthcare professionals of using the FIF tool in different settings, which in turn may have provided a broader picture of the barriers and facilitators for implementing the screening tool.

One weakness for **study III** and **study IV** could be the handling of the authors' subjectivity and pre-understanding, as they were both familiar with the subject discussed during the interviews. It was therefore particularly important for additional authors to be involved during the analysis process. Regardless of whether the authors who carried out the data analysis attempted to be objective and compared their interpretations, the degree of subjectivity will affect their interpretation of the analysis process. In the studies, where the material was primarily manifest, this should not affect the results to any significant degree. Another weakness could be that the informants needed to be able to speak Swedish and would have sought care during the inclusion period, leading to some participants and their perspectives being excluded. A further weakness of the study could be that a couple of interviews only involved a few informants. However, we judged that at least two informants in an interview would be able to contribute valuable information about their experiences of being screened using the FIF tool. A further weakness of the study could be that the healthcare professionals received different kinds of introduction to the FIF tool with orally or

written instructions depending on the practical possibility or specific wishes from the healthcare professionals.

7 RELEVANCE AND CLINICAL IMPLICATIONS

- There is a lack of easy-to-use tools that can predict the onset of first-time injurious falls in older adults. Considering the consequences and increased risk of recurrent falls after a first injurious fall, the perspective of being able to prevent or delay the first injurious fall through preventive efforts have important clinical and public health implications.
- The FIF tool is an easy and quickly used screening tool that works well in clinical and public health settings.
- The FIF tool is suitable for different kind of healthcare professionals which extend it`s usefulness.
- The FIF tool can predict injurious falls with high predicitive capacity.
- Patients in the primary healthcare find the FIF tool to be easily understood and screened with.
- The FIF tool has the ability to predict a fall with a high precision five years in advance. This could enable early primary preventions and with that delay a first-time fall. This will finally help to lower the total number of falls in the entire population.

8 CONCLUSIONS AND FUTURE CONSIDERATIONS

The FIF tool is a valuable screening tool to be used by healthcare professionals for prediction of first-time injurious falls in older adults. To facilitate implementation, the instrument needs to be accessible, easy to document in the medical records, and the support needed from the management to become a new routine due to the limited time in everyday clinical practice.

Falls and injurious falls are a major worldwide issue that needs further research, put into it, to be able to prevent injurious falls in the future. We have focused on injurious falls, which cause the most suffering to the affected individual while also having a major economic impact on society as a whole. The FIF tool has been tested in different contexts but there are still settings in which the FIF tool should undergo further research and investigation.

The FIF tool has been shown to predict the risk of falls with good accuracy. We now hope that this screening instrument continues its implementation journey and reaches out to the settings where you mainly find those who have not yet fallen but have a high risk to suffer from a fall or an injurious fall.

Further research is needed on testing and evaluating different models of facilitation and their effects on the implementation of the FIF tool in different groups. This should be done in order to find out which of these are best suited for the FIF tool. It also needs to explore what specific support healthcare professionals need from their managers, there is a need but there is a gap of research on what exactly what kind of support the healthcare professionals need.

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10 REFERENCES

1. World Health Organization. WHO Global Report on Falls Prevention in Older Age. Geneva; WHO Press;2019.

2. Nevitt MC, Cummings SR, Hudes ES. Risk factors for injurious falls: a prospective study. *J Gerontol*. 1991;46(5):164-170.

3. Kannus P, Sievanen H, Palvanen M, et al. Prevention of falls and consequent injuries in elderly people. *Lancet (London, England).* 2005;366(9500):1885-93.

4. Ambrose AF, Paul G, Hausdorff JM. Risk factors for falls among older adults. *Maturitas.* 2013;75:51-61.

5. Welmer AK, Rizzuto D, Laukka EJ, et al. Cognitive and Physical Function in Relation to the Risk of Injurious Falls in Older Adults: A Population-Based Study. *J Gerontol A Biol Med Sci.* 2017;72(5):669-75.

6. Peeters G, van Schoor NM, Lips P. Fall risk: the clinical relevance of falls and how to integrate fall risk with fracture risk. *Best Pract Res Clin Rheumatol.* 2009;23(6):797-804.

7. Hartholt KA, van Beeck EF, Polinder S, et al. Societal consequences of falls in the older population: injuries, healthcare costs, and long-term reduced quality of life. *The Journal of trauma*. 2011;71(3):748-53.

8. Stenhagen M, Ekstrom H, Nordell E, Elmstahl S. Accidental falls, healthrelated quality of life and life satisfaction: a prospective study of the general elderly population. *Arch Gerontol Geriatr*. 2014;58(1):95-100.

9. Roe B, Howell F, Riniotis K, et al. Older people and falls: health status, quality of life, lifestyle, care networks, prevention and views on service use following a recent fall. *J Clin Nurs.* 2009;18(16):2261-72.

10. Hawkins K, Musich S, Ozminkowski RJ, et al. The burden of falling on the quality of life of adults with Medicare supplement insurance. *J Gerontol Nurs*. 2011;37(8):36-47.

11. Peel NM. Epidemiology of falls in older age. *Can J Aging.* 2011;30(1):7-19.

12. 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.

13. Ganz DA, Bao Y, Shekelle PG, Rubenstein LZ. Will my patient fall? *Jama*. 2007;297(1):77-86.

14. Tinetti ME, Kumar C. The patient who falls: “It’s always a trade-off”. *Jama*. 2010;303(3):258-66

15. Montero-Odasso, M, van der Velde N, Martin FC, et al. World guidelines for falls prevention and management for older adults: a global initiative. *Age and Ageing.* 2022;51(9):afac205.

16. Ek S, Ek S, Rizzuto D, et al. Risk profiles for injurious falls in people over 60: a population-based cohort study. *J Gerontol A Biol Sci Med Sci*. 2018;73:233-239.

17. Welmer AK, Rizzuto D, Calderon Larrañaga A, Johnell K. Sex Differences in the Association Between Pain and Injurious Falls in Older Adults: A Population-Based Longitudinal Study. *Am J Epidemiol*. 2017;186:1049-1056.

18. 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;45:789-794.

19. Ek S, Rizzuto D, Calderon-Larranaga A, et al. Predicting First-Time Injurious Falls in Older Men and Women Living in the Community: Development of the First Injurious Fall Screening Tool. *JAMDA.* 2019;20(9):1163-8.e3.

20. Wagner H, Melhus H, Gedeborg R, Pedersen NL, Michaelsson K. Simply ask them about their balance--future fracture risk in a nationwide cohort study of twins. *Am J Epidemiol.* 2009;169(2):143-149.

21. Finkelstein JS, Brockwell SE, Mehta V, et al. Bone mineral density changes during the menopause transition in a multiethnic cohort of women. *J Clin Endocrinol Metab*. 2008;93(3):861-868.

22. 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 Jul-Aug;101:104713.

23. Park SH. Tools for assessing fall risk in the elderly: a systematic review and meta-analysis. *Aging Clin Exp Res*. 2018;30(1):1-16.

24. Gates S, Smith LA, Fisher JD, Lamb SE. Systematic review of accuracy of screening instruments for predicting fall risk among independently living older adults. *J Rehabil Res Dev.* 2008;45(8):1105-16.

25. Vellas BJ, Wayne SJ, Romero L, et al. One-leg balance is an important predictor of injurious falls in older persons. *J Am Geriatr Soc*. 1997;45(6):735-8.

26. Ward RE, Leveille SG, Beauchamp MK, et al. Functional performance as a predictor of injurious falls in older adults. *J Am Geriatr Soc.* 2015;63(2):315-20.

27. Muir SW, Berg K, Chesworth B, Klar N, Speechley M. Application of a fall screening algorithm stratified fall risk but missed preventive opportunities in community-dwelling older adults: a prospective study. *J Geriatr Phys Ther*. 2010 Oct-Dec;33(4):165-72.

28. Nandy S, Parsons S, Cryer C, et al. Development and preliminary examination of the predictive validity of the Falls Risk Assessment Tool (FRAT) for use in primary care. *J Public Health (Oxf)*. 2004;26(2):138-43.

29. Pluijm SM, Smit JH, Tromp EA, et al. A risk profile for identifying community-dwelling elderly with a high risk of recurrent falling: results of a 3-year prospective study. *Oseoporosis Int*. 2006;17(3):417-25.

30. Russell MA, Hill KD, Day LM, et al. Development of the Falls Risk for Older People in the Community (FROP-Com) screening tool. *Age and ageing.* 2009;38(1):40-6.

31. Tromp AM, Pluijm SM, Smit JH, et al. Fall-risk screening test: a prospective study on predictors for falls in community-dwelling elderly. *J Clin Epidemiol*. 2001;54(8):837-44.

32. P H, Suther M, Peterson E, et al. 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.

33. National Cancer Institute. https://www.cancer.gov/publications/dictionaries/cancer-terms/def/screening. Accessed may 10, 2021.

34. Tengland P-A. Health Promotion and Disease Prevention: Logically Different Conceptions? *Health Care Anal*. 2010 18:323–341.

35. Seely JM, Alhassan T. Screening for breast cancer in 2018-what should we be doing today? *Curr Oncol.* 2018;25(Suppl 1):S115-S124.

36. Altman DG, Bland JM. Diagnostic tests 2: predictive values. *BMJ.* 1994. 309(6947):102. doi: 10.1136/bmj.309.6947.102.

37. Kenny R, Rubenstein LZ, et al. Summary of the Updated American Geriatrics Society/British Geriatrics Society Clinical Practice Guideline for Prevention of Falls in Older Persons. *J Am Ger Soc*. 2011;59:148-57.

38. Stubbs B, Brefka S, Denkinger MD. What Works to Prevent Falls in Community-Dwelling Older Adults? *Phys Ther.* 2015;95:1095-110.

39. Gillespie LD, Robertson MC, Gillespie WJ, et al. Interventions for prevention falls in older people living in the community. *Cochrane Database Syst Rev*. 2012:408.

40. Sherrington C, Michaleff ZA, Fairhall N, et al. Exercise to prevent falls in older adults: an updated systematic review and meta-analysis. *Br J Sports Med*. 2017;51:1749-+.

41. Culver CM, Gert B. (1982). Philosophy in medicine. Oxford: Oxford University Press.

42. Melnyk BM, Fineout-Overholt E, Gallagher-Ford L, Kaplan L. The State of Evidence-Based Practice in US Nurses Critical Implications for Nurse Leaders and Educators. *Nurs Adm.* 2012;42:410-7.

43. Li FZ, Eckstrom E, Harmer P, Fitzgerald K, Voit J, Cameron KA. Exercise and Fall Prevention: Narrowing the Research-to-Practice Gap and Enhancing Integration of Clinical and Community Practice. *J Am Geriatr Soc.* 2016;64(2):425-31.

44. Guse CE, et al. Translating a Fall Prevention Intervention Into Practice. *Am J Public Health*. 2015;105:1475-81.

45. Davies HTO, et al. Learning more about how research-based knowledge gets used. New York: WT Grant Foundation 2008.

46. Thabane L, Ma J, Chu R, et al. A tutorial on pilot studies: the what, why and how. *BMC Med Res Methodol.* 2010;10:1.

47. Vandervelde S, Vlaeyen E, de Casterlé BD, et al. Strategies to implement multifactorial falls prevention interventions. *Implement Sci*. 2023;18:4.

48. Moore GF, Audrey S, Barker M, et al. Process evaluation of complex interventions. *BMJ*. 2015;350.

49. Shields GE, Brown L, Wells A, Capobianco L, Vass C, et al. Utilising Patient and Public Involvement in Stated Preference Research in Health. *Patient*. 2021;14:399-412.

50. Socialstyrelsen. About the Swedish system. https://www.socialstyrelsen.se/en/about-us/healthcare-for-visitors-to-sweden/about-the-swedish-healthcare-system/updated 2020-09-01. Accessed march 20, 2021.

51. Folkhalsomyndigheten. Our mission – to strengthen and develop public health. https://www.folkhalsomyndigheten.se/the-public-health-agency-of-sweden/. Accessed march 20, 2021.

52. Kitson A, Harvey G, McCormack B. Enabling the implementation of evidence based practice: a conceptual framework. *Qual Health Care.* 1998;7:149–59. doi: 10.1136/qshc.7.3.149.

53. Harvey G, Kitson A. PARIHS revisited: from heuristic to integrated framework for the successful implementation of knowledge into practice. *Implement Sci.* 2016;11:13

54. Denzin NK, LincolnYS. *The SAGE Handbook of qualitative research*. SAGE Publications, 2018.

55. Lagergren M, Fratiglioni L, Hallberg IR, et al. A longitudinal study integrating population, care and social services data. The Swedish National study on Aging and Care (SNAC). *Aging Clin Exp Res.* 2004;16(2):158-68.

56. Stenhagen M, Ekstrom H, Nordell E, Elmstahl S. Falls in the general elderly population: a 3- and 6- year prospective study of risk factors using data from the longitudinal population study 'Good ageing in Skane'. *BMC geriatrics.* 2013;13:81.

57. Ekstrom H, Elmstahl S. Pain and fractures are independently related to lower walking speed and grip strength: results from the population study "Good Ageing in Skane". *Acta orthopaedica.* 2006;77(6):902-11.

58. Youden WJ. Index for rating diagnostic tests. *Cancer.* 1950;3(1):32-5.

59. Franchignoni F, Tesio L, Martino MT, Ricupero C. Reliability of four simple, quantitative tests of balance and mobility in healthy elderly females. *Aging (Milano).* 1998. 10(1):26-31.

60. Jonsson E, Seiger Å, Hirschfeld H. One-leg stance in healthy young and elderly adults: a measure of postural steadiness? *Clin Biomech (Bristol, Avon).* 2004. 19(7):688–94.

61. Centers of disease control and prevention. *STEADI: Stopping Elderly Accidents, Deaths and Injuries.* https://www.cdc.gov/steadi/index.html Accessed December 16, 2021.

62. Rubenstein LZ, Vivrette R, Harker JO, Stevens JA, Kramer BJ. Validating an evidence-based, self-rated fall risk questionnaire (FRQ) for older adults. *J Safety Res.* 2011. 42(6):493-9. doi: 10.1016/j.jsr.2011.08.006.

63. Bergstrom MF, Byberg L, Melhus H, Michaelsson K, Gedeborg R. Extent and consequences of misclassified injury diagnoses in a national hospital discharge registry. *Inj Prev.* 2011;17(2):108-13.

64. Ludvigsson JF, Otterblad-Olausson P, Pettersson BU, Ekbom A. The Swedish personal identity number: possibilities and pitfalls in healthcare and medical research. *Eur J Epidemiol*. 2009;24(11):659-67.

65. Baek ET, Yang HJ, Kim SH, et al. Survival time prediction by integrating cox proportional hazards network and distribution function network. *BMC Bioinformatics.* 2021 15;22(1):192.

66. Harrell FE, Jr, Califf RM, et al. Evaluating the yield of medical tests. *Jama*. 1982;247(18):2543-6.

67. DW H. Applied Logistic Regression. 3rd ed: Hoboken, NJ: Wiley; 2013.

68. Favourate Y. Sebele-Mpofu. Saturation controversy in qualitative research: Complexities and underlying assumptions. A literature review. *Cogent Social Sciences*, 6:1, 1838706, DOI: 10.1080/23311886.2020.1838706.

69. Kvale S. *InterViews: Learning the craft of qualitative research interviewing (2nded).* Los Angeles: Sage Publications; 2009.

70 Elo S, Kyngas H. The qualitative content analysis process. *J Adv Nurs.* 2008;62 (1):107-115. doi:10.1111/j.1365-2648.2007.04569.x

71. Graneheim UH, Lundman B. Qualitative content analysis in nursing research: concepts, procedures and measures to achieve trustworthiness. *Nurse Educ Today*. 2004;24 (2):105–112.

72. Braun, V.; Clark, V. Using thematic analysis in psychology. *Qual. Res. Psychol.* 2006, 3, 77–101.

73. Braun V, Clarke V. Reflecting on reflexive thematic analysis. *Qualitative Research in Sport, Exercise and Health*. 2019;11(4):589-97.

74. Vaismoradi M, Jones J, Turunen H, Snelgrove S. Theme development in qualitative content analysis and thematic analysis. *J Nurs Educ Pract*. Jan 16, 2015, Doi 10.5430/jnep.v6n5p100.

75. Declaration of Helsinki - Ethical principles for medical research involving human subjects. [Internet]: World Medical Association; 1964 [updated 6th September 2022; cited 2022 September 15th]. Available from: https://www.wma.net/policies-post/wma-declaration-of-helsinki-ethicalprinciples-for-medical-research-involving-human-subjects/.

76. Orb A, Eisenhauer L, Wynaden D. Ethics in qualitative research. *J Nurs Scholarsh.* 2001;33(1):93-6.

77. Dicicco-Bloom B, Crabtree BF. The qualitative research interview. *Medical Education*. 2006;40(4):314-21.

78. Tiedemann A, Lord SR, Sherrington C. The development and validation of a brief performance-based fall risk assessment tool for use in primary care. *J Gerontol A Biol Sci Med Sci.* 2010;65(8):896-903.

79. Palumbo P, Klenk J, Cattelani L, et al. Predictive Performance of a Fall Risk Assessment Tool for Community-Dwelling Older People (FRAT-up) in 4 European Cohorts. *JAMDA*. 2016;17(12):1106-13.

80. Peeters GM, Pluijm SM, van Schoor NM, Elders PJ, Bouter LM, Lips P. Validation of the LASA fall risk profile for recurrent falling in older recent fallers. *J Clin Epidemiol*. 2010;63(11):1242-8.

81. Stalenhoef PA, Diederiks JP, Knottnerus JA, Kester AD, Crebolder HF. A risk model for the prediction of recurrent falls in community-dwelling elderly: a prospective cohort study. *J Clin Epidemiol*. 2002;55(11):1088-94.

82. Frisendahl N, Ek S, Rosendahl E, et al. Predictive performance of the FIF screening tool in 2 cohorts of community-living older adults. *J Am Med Dir Assoc.* 2020. 21(12):1900-1905. doi: 10.1016/j.jamda.2020.04.037.

83 Lundin H, Sääf M, Strender L-E, et al. One-leg standing time and hip-fracture prediction. *Osteoporos Int*. 2014. 25(4):1305-11.

84. Kozinc Ž , Löfler S, Hofer C, Carraro U, Šarabon N. Diagnostic balance tests for assessing risk of falls and distinguishing older adult fallers and non-fallers: a systematic review with meta-analysis. *Diagnostics (Basel).* 2020. 10(9):667.

85. Delbaere K, Close JCT, Brodaty H, Sachdev P, Lord SR. Determinants of disparities between perceived and physiological risk of falling among elderly people: cohort study. *BMJ.* 2010;341. 2010;341:c4165.

86. Leavy B, Roaldsen Skavberg K, K Nylund K, Hagströmer M, Franzén E. “Pushing the Limits”: Rethinking Motor and Cognitive Resources After a Highly Challenging Balance Training Program for Parkinson Disease. *Phys Ther.* 2017;97(1):81-89. doi: 10.2522/ptj.20160090.

87. Halvarson A, Ståhle A, Halén E, Roaldsen Skavberg K. “Better safe than sorry”: a qualitative content analysis of participant's perspectives of fallrelated concerns and balance in older women with osteoporosis after balance training. *Disabil Rehabil.* 2016;38:8, 796-802.

88. Ellmers TJ, Wilson MR, Norris M, Young WR. Protective or harmful? A qualitative exploration of older people's perceptions of worries about falling. *Age Ageing.* 2022;1;51(4):afac067. doi: 10.1093/ageing/afac067.

89. Bandini JI, Schulson BJ, Ahluwalia SC, et al. Patient, Family Caregiver, and Provider Perceptions on Self-Assessment Screening for Cognitive Impairment in Primary Care: Findings From a Qualitative Study**.** *Gerontol Geriatr Med.* 2022;8:23337214221131403.

90. Hamed K, Roaldsen Skavberg K, Halvarsson A. “Fear of falling serves as protection and signifies potential danger”: a qualitative study to conceptualise the phrase “fear of falling” in women with osteoporosis. *Osteoporos Int.* 2021;32(12):2563-2570.

91. Matchar DB, Duncan PW, Lien CT, et al. Randomized controlled trial of screening, risk modification, and physical therapy to prevent falls among the elderly recently discharged from the

emergency department to the community: the steps to avoid falls in the elderly study. *Arch Phys Med Rehabil.* 2017;98:1086-96.

92. Johnston A, Reome-Nedlik C, Parker EM, et al. Preventing Falls Among Older Adults in Primary Care: A Mixed Methods Process Evaluation Using the RE-AIM Framework. *Gerontologist.* 2023;63(3):511-522.

93. Grimes DA, Schulz KF. Bias and causal associations in observational research. *Lancet*. 2002;359(9302):248-52.

94. Lincoln YS, Guba EG. Naturalistic inquiry. Beverly Hills, Calif.: Sage Publications; 1985.

95. Cummings SR, Nevitt MC, Kidd S. Forgetting falls. The limited accuracy of recall of falls in the elderly. *J Am Geriatr Soc*. 1988;36(7):613-6.

96. Kamitani T, Yamamoto Y, Fukuma S, et al. Association between the discrepancy in self-reported and performance-based physical functioning levels and risk of future falls among community-dwelling older adults: the Locomotive Syndrome and Health Outcomes in Aizu cohort study (LOHAS). *J Am Med Dir Assoc*. 2019. 20(2):195-200. doi: 10.1016/j.jamda.2018.09.009.

97. Tripepi G, Jager KJ, Dekker FW, Zoccali C. Selection bias and information bias in clinical research. *Nephron Clin Pract*. 2010;115(2):c94-9.

98. Vetter TR, Mascha EJ. Bias, Confounding, and Interaction: Lions and Tigers, and Bears, Oh My! *Anesth Analg*. 2017;125(3):1042-8.

99. Henricson M. Vetenskaplig teori och metod: från idé till examination inom omvårdnad. Lund: Studentlitteratur AB; 2017. 510 p.