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Comparison of the Effects of Land Use / Land Cover on Water Quality and the Intertidal Marine Macroalgae Communities at the Fluvial Outflows of the Dingle Peninsula

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To determine the predictive accuracy of the FRASE risk assessment tool in identifying older adults at high risk of falls in Community Hospitals/ Nursing Units

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Declaration of Authorship

I hereby declare that this thesis is entirely my own work and has not been submitted for any other degree or professional qualification. To the best of my knowledge this thesis has not breached any law of copyright. In this respect, I now submit this thesis for assessment on the programme leading to the award of MSc by Research.

Signed [redacted] on 24/03/2020

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Glossary of terms and abbreviations

AUC: Area Under the Curve

CI: Confidence Intervals

D*P*A: Data Protection Act

DPC: Data Protection Commission

ED: Emergency Department

EU: European Union

FMAs: Functional Mobility Assessments

FNR: False Negative Rate

FPV: False Positive Rate

FRAT: Fall Risk Assessment Tool

FRATs: Fall Risk Assessment Tools

FRST: Fall Risk Screening Tool

FRSTs: Falls Risk Screening Tools

GDPR: General Data Protection Regulation

HRR: Hazard Rate Ratio

HSE: Health Service Executive

ICO: Information Commissioner Office

IRR: Inter-Rater Reliability

LTC: Long Term Care

MAT: Multifactorial Assessment Tools

NICE: National Institute for Health and Care Excellence

NPV: True Negative, Negative Predictive Value

ORs: Odds Ratios

PPV: True Positive, Positive Predictive Value

RCT: Randomised Controlled Trial

ROC: Receiver Operating Characteristic

SENS: Sensitivity

SPEC: Specificity

TPA: Total Predictive Accuracy

TPR: True Positive Rate

List of Fall Risk Assessments

Ballarat Health Fall Risk Assessment Tool (BHS-FRAT)

Berg Balance Scale (BBS)

Bobath Memorial Hospital Fall Risk Assessment Tool (BMHRAS)

Conley Scale

Demuras Fall Risk Assessment (DFRA)

Downton Index: Downton Index

Easy-Care Risk of Falls (ECRF)

Falls Assessment Risk and Management Tool (FARAM)

Fall Risk Assessment (FRA)

Fall Risk Assessment Scale (FRAS)

Fall Risk Assessment Scale for the Elderly (FRASE)

Fall Risk Screening Model Algorithm

Fall Risk Screening Model

Falls Risk for Older Persons – Community Setting Screening Tool (FROP Com Screen)

Five Repetition Sit to Stand Test (FRSTST)

Five Time Sit-to-Stand Test (FTSS)

FRAT-Up

Functional Reach Test (FRT)

Gait speed measurements

Hendrich Fall Risk Model-I (HFRM-I)

Hendrich Fall Risk Model-II (HFRM-II)

Melbourne Fall Risk Assessment Tool (MFRAT)

Mobility Fall Chart (MFC)

Modified Fall Assessment Tool (MFAT)

Morse Fall Scale (MFS)

Modified Get-Up-and-Go Test

Mobility Interaction Fall Chart (MIFC)

Modified Japanese Nursing Association Fall Risk Assessment

The Ontario Modified STRATIFY (OM)

Peninsula Health Falls Risk Assessment Tool (PHFRAT)

Performance Oriented Mobility Assessment (POMA)

Peter James Centre Falls Risk Assessment Tool (PJC-FRAT)

Postural Sway Test

Queensland Fall Risk Assessment Tool (QFRAT)

Standing Balance

St. Thomas's Risk Assessment Tool (STRATIFY)

Tandem Stance Test

The Northern Hospital Modified Stratify (TNH)

Timed Up-and-Go Test (TUG Test)

Tinetti Balance

Tinetti Gait

Tinetti Mobility

Tullamore

Two Item Screening Tool

Walking Test

Dedication

To Tommy and Mia

“So you see!

There’s no end to the things you might know,

Depending how far beyond Zebra you go!”

On Beyond Zebra, Dr. Seuss

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Abstract

Title: To determine the predictive accuracy of the FRASE risk assessment tool in identifying older adults at high risk of falls in Community Hospitals/ Nursing Units

Author: Susan Daly

Background: The operational effectiveness of Fall Risk Assessment Tools (FRATs)in predicting falls remains unclear due to variation in accuracy when applied in different settings and among different populations (Aranda-Gallardo et al. 2017, Castellini at al. 2017).

Aims: The primary aim of the study is to determine the predictive accuracy of the Falls Risk Assessment Scale for the Elderly (FRASE) risk assessment tool in identifying older adults at high risk of falls in Community Hospitals/ Nursing Units. The secondary aim is to determine the relationship between older adult faller status and the risk factors; gender, age, gait, sensory deficit, falls history, medication, medical history, and mobility as identified in the FRASE risk assessment tool.

Design: A quantitative non-experimental correlational research design

Settings: Convenience sample of 12 Community Hospitals/ Nursing Units.

Method: Collection of 300 Data Collection Tools comprising of FRASE risk assessment data and a falls incident category data.

Results: The FRASE had a sensitivity of 74.0% (95% CI: 64.3% to 82.3%) and a specificity of 66.0% (95% CI: 59.0% to 72.5%). The AUC was 0.698 (95% CI: 0.641, 0.748) demonstrating predictive accuracy. The risk factors gender ($p=0.037$), gait ($p<0.001$), sensory deficit ($p=0.001$) falls history ($p<0.001$), medical history ($p=0.005$) and mobility ($p=0.049$) were significantly associated with faller status. Age presented no statistically significant relationship with faller status ($p=0.434$). Medication failed to reach a statistically significant relationship ($p=0.81$) with faller status.

Conclusion: The FRASE showed predictive accuracy in identifying older adults at high risk of falls in Community Hospitals/ Nursing Units. Age is not a predictor of falls among older adults. A previous history of a fall and unsteady gait are the greatest predictors of a future fall among older adults. The findings in this study recommend clinicians within Long-term care settings review current fall practices and apply increased emphasis on the fall risk variables that established predictive accuracy among older adults aged 65 years and older.

Chapter 1: Introduction to the research study

1.1 Introduction to the research study

The World Health Organisation (WHO) (2018, p.1) defines a fall as "an event which results in a person coming to rest inadvertently on the ground or floor or other lower level". In clinical practice three classifications of patient falls exist: accidental falls, slipping or tripping, usually attributed to some environmental hazard, anticipated physiological falls by persons considered 'at risk' of falling, and unanticipated physiological falls attributed to unexpected physiological factors (Morse, 2009). Anticipated physiological falls account for 78% of hospital falls (Staggs, 2015). Fall related incidents are the second leading cause of accidental injury worldwide (Díaz-Gutiérrez et al., 2017; Patrício et al. 2017) and the leading cause of morbidity and mortality among older adults (WHO, 2007). In Ireland, falls and falls related injuries are the most frequently reported incidents within the Health Service Executive (HSE) and HSE-funded services. In 2016, 28,714 falls were reported, of which 11,876 occurred in acute hospitals and 15,890 in community hospitals/ nursing units (HSE, 2018). Community hospitals/ nursing units are defined as hospitals with no accident and emergency department thus, differentiating them from acute care hospitals (McKeown et al., 2010). Community hospitals/ nursing units are comparable to long term care (LTC) settings, providing continuous nursing care and other services for older people unable to manage independently in the community (Smith et al., 2008).

The World Health Organisation (2002) define an older adult as any person with a chronological age of 65 years or more. Albeit, falls can occur at any age, falls risk increases with age, secondary to reduced mobility, comorbidities and cognitive impairment (National Institute for Health and Care Excellence (NICE), 2013). LTC settings hold the highest falls rates for older adults (Nunan et al., 2018) with falls accounting for 81.5% of the external cause of death (Ibrahim et al., 2017). The consequences of falls in the older adult population include mortality, fractures, pain, loss of confidence, reduced mobility, and dependence. In addition, the potential individual consequences may be compounded by subsequent social consequences such as increased health and social care costs, longer hospital stays, impaired rehabilitation and incapacity to return home following hospitalisation (Matarese et al., 2014).

Owing to the high prevalence and detrimental effects of falls among older adults (Chan and Chan, 2018; Cooper, 2017; Díaz-Gutiérrez et al., 2017; Oliveira et al., 2017) prevention is arguably one of the most significant public health issues in today's aging society (Park, 2018). Indisputably, falls are an inherent risk of an active rehabilitation process and cannot be entirely avoided (Smith et al., 2006). Nevertheless, a number of interventions have been proven to reduce falls incidence (Power et al., 2014). Consequently, minimising occurrence is paramount to the far-reaching effects for those directly and indirectly affected (Cooper, 2017). In clinical practice, nurses are at the forefront of falls prevention (McKechnie et al., 2016). Therefore, an accurate and objective method for assessing an individual's fall-risk is fundamental to this process (Power et al., 2014).

1.2 Rationale

Falls are complex, with interacting predisposing and precipitating factors (Heinze et al., 2009; Callisaya et al., 2011). Two categories of fall risk factors exist, intrinsic factors and extrinsic factors (McKechnie et al., 2016). Intrinsic fall risk factors include impaired mobility, cognitive decline, incontinence, depression, sensory deficits, and orthostatic hypotension. Extrinsic fall risk factors are environmental factors, such as use of assistive devices, psychotropic drugs and antiarrhythmic medication (Woolf and Åkesson, 2003). Many nursing actions to improve safety are easily identified and facilitated in practice, however the acquisition of adequate knowledge and subsequent falls prevention measures remain an area of concern (Chan and Chan, 2018). Some evidence propound falls in hospital can be reduced (Haines et al., 2004; Healey et al., 2004a) thus necessitating the accurate identification of 'high-risk' patients likely to benefit from expensive multidisciplinary interventions (Capezuti, 2004). Fall risk assessment tools (FRATs) and fall risk screening tools (FRSTs) are often utilised by nurses in the clinical setting to identify potential fallers (McKechnie et al., 2016). FRATs and FRSTs are based on specific weighted fall risks, developed to facilitate nurses in the identification of individual patients overall risk, to enable accurate targeting of preventative strategies (Kehinde, 2009; Wagner et al., 2011; Wong Shee et al., 2012; McKechnie et al., 2016).

Assessment and screening are two of the main methods employed by clinicians to identify potential fallers (McKechnie et al., 2016). Although related activities, assessment and screening are separate activities (Australian Commission on Safety and Quality in Health Care, 2009) nevertheless, in relation to falls risk prediction these terms are commonly used interchangeable (McKechnie et al., 2016). Therefore, the terms 'fall risk assessment tools' (FRATs) and 'fall risk screening tools' (FRSTs) describes various types of tools, including numerical risk prediction tools. These tools aim to predict the risk of future falls based on a numerical score, usually proportional to the number of risks identified (Oliver et al., 2010). Scoring is achieved by a dichotomous (low versus high) system or a graded three level (low, medium and high) system (McKechnie et al., 2016). The risks that predict falls in numerical risk prediction tools are not modifiable, and therefore seek only to differentiate between individuals 'at risk' and 'not at risk', so that interventions can be targeted appropriately (Oliver et al., 2008). Evidence recommends that targeting interventions at 'high-risk' individuals prevents more falls and is more cost-effective than applying universal precautions (Thomas et al., 2010; Latt et al., 2016). Cost effective targeting of fall prevention strategies to reduce the risk of harm is the idea behind all FRATs (Healey et al., 2004b). Therefore, it is imperative that FRATs accurately discriminate non-fallers from fallers (Park, 2018) as failure to identify a single risk can expose an individual to a fall or potential injury (WHO, 2007). Furthermore, with an ageing population (Callisaya et al., 2011) fiscal restraints and the rapidly increasing cost of falls (McGarrigle et al., 2017) over estimation of risk can waste limited resources (El Miedany et al., 2011).

Numerous studies indicate the predictive accuracy of various numerical risk prediction tools is often not replicated when explored in different settings, and among different populations (Myers, 2003; Gates et al., 2008; Latt et al., 2016). Discrepancies in predictive accuracy values question the operational usefulness and clinical efficacy of FRATs in clinical practice, and the benefits to be achieved when compared against clinical judgement alone (Myers, 2003; Haines et al., 2007; Healey et al., 2008;

Oliver, 2008; Oliver et al., 2008; Wagner et al. 2011; McKechnie et al., 2016; Aranda-Gallardo et al., 2017; Castellini et al., 2017). As the rate of falls among older adults in LTC settings is three times higher than community dwelling older adults (Wagner et al. 2011; Piglowska et al. 2014) multi-factorial falls prevention programmes in the community have been promoted as the most effective approach to preventing falls among older adults (Russell et al., 2008). Nevertheless, a systematic review by Cameron et al. (2018) suggests the effect of multifactorial interventions in older adults residing in LTC settings is uncertain and their application may not necessarily show the clear results achieved for community dwelling patients. Consequently, despite the importance of FRATs in falls prevention, no valid or reliable tool has been identified and recommended for use with older adults in LTC settings (Power et al., 2014). In clinical practice, the key criteria for successful tool selection and implementation is, applicability of the tool to the setting population, feasibility of conducting the assessment given the space, time and equipment available, validity and reliability, and the predictive accuracy of the tool (Langley and Mackintosh, 2007).

1.3 Predictive accuracy

Establishing the diagnostic accuracy of a risk assessment tool is paramount to determine the usefulness of the tool in clinical practice (Lalkhen and McCluskey, 2008). Quality risk assessment tools accurately predict individuals who will fall as being ‘at risk’ (true positive; positive predictive value (PPV)) while limiting the number of individuals falsely assessed as being ‘at risk’ (false positive). Similarly, the tool must accurately predict individuals who will not fall as ‘not at risk’ (true negative; negative predictive value (NPV)) while limiting the number of individuals falsely assessed as ‘not at risk’ (false negative). Diagnostic accuracy is based on the sensitivity (SENS) and specificity (SPEC) of the tool. Sensitivity represents the tools accuracy in categorising individuals who fall as ‘at risk’ while, limiting false negatives. Specificity represents the tools accuracy in categorising individuals who will not fall as ‘not at risk’ while, limiting false negatives. High false-negative values indicate ‘at risk’ individuals go undetected without necessary preventative measures. In contrast, high false-positive values indicate the unnecessary assignment of preventative measures to individuals ‘not at risk’. Furthermore, irrespective of high specificity (true negative rate) or NPV (true negative; negative predictive value), if PPV (true positive; positive predictive value) is low, scant resources and possibly unwarranted restrictions will be poorly targeted at ‘not at risk’ individuals (Glaros and Kline, 1988; Oliver et al., 2004; Lalkhen and McCluskey, 2008; Oliver et al., 2008; Strupeit et al., 2016).

Analysing the receiver operating characteristic (ROC) curve determines the relationship between sensitivity and specificity. Ideally, predictive values will present a low false negative rate at high sensitivity, the area under the curve (AUC) shows the possibility of the tool accurately distinguishing between PPV and NPV (Kim et al., 2011). A tool commands good accuracy when the AUC graph is closer to 1, successfully distinguishing between diseased or ‘at risk’ individuals and healthy or not ‘at risk’ individuals. A tool is considered to have decisive power if the AUC value is greater than 0.7 however, AUC values below 0.5 hold no decisive power, demonstrating a predictive accuracy no greater than clinical judgment and comparable to random probability (Wray et al., 2010). Baran and Gunes (2018) assert a tool is considered valid when it meets the ‘Gold Standard Criteria’ established by Wyatt and Altman (1995) and Oliver et al., (2004).

Gold Standard Criteria for Quality of Risk Assessment Tools
Validated in a prospective study
Used specificity and sensitivity analyses
Tested in more than one population
Demonstrates good face validity
Demonstrates good inter-rater reliability
Good adherence from staff
Clear and easy to calculate score

Figure 1'Gold Standard Criteria' for Quality of Risk Assessment Tools Wyatt and Altman (1995); Oliver et al., (2004)

1.4 Fall Risk Assessment Scale for the Elderly

FRATs are founded on the premise that individual fall risk increases with the number of risks identified. A risk assessment score indicates the probability of the individual under assessment experiencing the undesired condition of interest within a given time span (Haines et al., 2007). The majority of FRATs categorise individuals as a 'low risk' or 'high risk' of falls (Sherrington et al., 2011). The National Council for the Professional Development of Nursing and Midwifery (now dissolved) recognised the Falls Risk Assessment Scale for the Elderly (FRASE) as the FRAT of choice for assessing falls risk among older adults (National Council for the Professional Development of Nursing and Midwifery, 2006). The FRASE was validated in Ireland during an independent study on a sample of hospital patients aged 65 years and older (n = 141). The study reported the clinical introduction of the FRASE reduced the number of hospitalized older adults experiencing falls by 15% and falls incidents by 22% (Cannard, 1996). The study identified the FRASE as "effective in predicting the likelihood of falls" (Cannard, 1996, p. 37). Nevertheless, the independent validation study of the FRASE did not specifically measure the sensitivity and specificity of the tool. Furthermore, there has been a paucity of research examining the predictive accuracy of the tool (Jester et al., 2005).

1.5 Study aims

The aim of this study is to determine the predictive accuracy of the FRASE risk assessment tool in identifying older adults at high risk of falls in Community Hospitals/ Nursing Units. The secondary aim of the research is to determine the relationship between older adult faller status and the risk factors; gender, age, gait, sensory deficit, falls history, medication, medical history, and mobility as identified in the FRASE risk assessment tool.

1.6 Study structure

The research study is presented over six chapters. Chapter one introduces the research study, summarises the rationale for the research, and presents the research aim. Chapter two presents a comprehensive literature review. It focuses on the function of FRATs to discriminate those at 'at risk' and 'not at risk' of falls rather than reducing fall risk (WHO, 2007). The literature review illustrates discrepancies in the predictive validity of FRATs, with no tool demonstrating statistically superior predictive accuracy over others. In addition, the literature identifies a lack of consensus among FRATs regarding fall risk factors that are predictive of future falls among older adults. The literature highlights the need for external validation to test the accuracy of tools in different settings and among differing populations. In addition, the literature recommends revising existing tools to reflect fall risk factors that are predictive of future falls among older adults rather than focusing on creating new tools. Chapter three outlines the methodological approach undertaken in the research study and the research design. In addition, the chapter imparts a detailed description of the data collection tool, the process of data collection and analyses. The chapter concludes with the ethical procedures and rigour that were upheld during the research process. Chapter four presents the research results. Chapter five reviews the quantitative findings obtained, in combination with the existing literature presented in chapter two.

The study concludes in chapter six with a summary of the research undertaken, acknowledging the study limitations, and highlighting the study's implications for clinical practice, policy development and research.

Chapter 2: Literature Review

2.1 Introduction

The focus of this chapter is to present a review of empirical literature that evaluated the predictive accuracy of FRATs. In section 2.2 the search strategy is presented. This is followed in section 2.3 by a review of studies that evaluated the predictive accuracy of FRATs among older adults. In section 2.4 a review of the relationship between intrinsic falls risk indicators and falls risk among older adults is presented.

2.2 Search Strategy

Polit and Beck (2017) encourage a comprehensive literature review to compile research and create a study with potential to inspire new research ideas. A comprehensive and efficient search to identify valid studies often relies on the key words used (Finfgeld-Connett and Johnson, 2012). The search for relevant literature included databases and manual searches in order to identify and retrieve research literature that was relevant to the study. A comprehensive systematic literature search was undertaken using Cumulative Index Nursing and Allied Health Care (CINAHL), Science Direct, Cochrane Library and Google scholar databases. The search terms, the limits and outputs used are included in Appendix A and B. The initial stage consisted of reading 178 titles and abstracts for their relevance to the study. The reference lists of studies were hand searched and relevant abstracts read for their relevance.

In a second stage, both electronic and paper-based journals were searched. Journals such as the International Journal of Nursing Studies and Journal of Clinical Gerontology and Geriatrics focus specifically on the nursing and older adult care therefore particular emphasis was given to these journals. Studies that incorporated falls risk assessment and / or fall risk were included. Full text articles from inter-library loans were ordered. In a third stage, 65 full text studies were read thoroughly for inclusion in the review. A number of these studies were excluded (n = 37) for example those which had a mean sample age of lower than 65 years which would not be reflective of the older adult population. Exclusion also included studies where the

focus was primarily on a particular illness rather than fall risk predictors or the predictive accuracy of the tool utilised to assess individual falls risk.
This strategy was employed when reviewing the literature and inclusion of literature was also based on a judgement that the study explored older adults' risk of falling in the broader sense, for example predictive probability of falling, irrespective of the key words used. These stages are outlined in Appendix B.

Data was evaluated based on the significance and methodological quality of the study. Primary research published in peer-reviewed journals and dissertations (published or unpublished) and completed in the period 2003 – 2019 were included. The research design, sampling, data collection strategies and the validity and reliability of the research instruments were evaluated. According to Smith and Noble (2016) dividing the literature into common themes facilitates the integration of empirical literature. The content of each study was analysed and common themes across studies were identified. The first theme identified was the variation in predictive accuracy among the diverse FRATs analysed in the studies reviewed. The second theme identified was the variation among the FRATs in identified falls predictors associated with older adult faller status. On completion of this process, a total of twenty eight studies were included for review, consisting of studies determining the predictive accuracy of FRATs (n = 18), and studies comparing the predictive accuracy of FRATs (n = 10). Subsequently, the two themes that emerged from the literature reviewed (n = 28) were firstly the predictive accuracy of FRATs among older adults (n = 18) and secondly, the relationship between older adult faller status and intrinsic falls risk predictors (n = 10).

2.3 Theme One: predictive accuracy of FRATs among older adults

Evidence based falls prevention programs primarily reply on the analysis of patient related factors with criterion-referenced assessment tools (Wang et al., 2018). Several tools have been developed and tested however with no tool superseding another in its application, nursing personnel have the choice of which tool to implement at ward level (Ivziku et al., 2011). Although the studies presented test different risk assessment instruments, all studies explore the predictive ability of the tools to accurately differentiate who might fall (sensitivity) from those who are unlikely to fall (specificity) (Strupeit et al., 2016). Callis (2016) asserts the most commonly used FRATs in clinical practice are the St. Thomas Risk Assessment Tool (STRATIFY) (Oliver et al., 1997), The Hendrich II Fall Risk Model (Hendrich et al., 2003), The Morse Fall Scale (MFS) (Chow et al., 2007) and the Downton Index (Saverino et al., 2006). FRATs are developed to accurately discriminate between those 'at risk' and not 'at risk' of falls, variation in population and setting can impact on the performance of these tools, resulting in inappropriate identification of risk or non-implementation of necessary fall prevention strategies (Callis, 2016). Therefore, the role of nursing in identifying and applying the most suitable FRAT for application at ward level is critical to reducing falls among older adults.

2.3.1 Theme One: review of the literature

Ruggieri et al., (2019) sought to identify and describe the setting, language, pathology and psychometric properties of validated tools that determine falls risk among older adults. Accordingly, a systematic review of observational cohort and cross-sectional studies of validated FRATs on older adults was undertaken between January 1979 and February 2017. The studies (n = 55) comprised of the Falls Efficacy Scale (FES-1) (n = 21), Activities Specific Balance Confidence Scale (ABC) (n = 7), the STRATIFY (n = 3) and other worldwide validated tools (n = 24). The study identified a significant number of FRATs validated at international level (n = 33) of which the FES-1 and ABC were the most frequently used.

The FES-1 assesses the fear of falling among community-dwelling older adults. The results confirm good internal consistency with the Cronback Alpha (Cronbach α) ranging between acceptable (0.78) and excellent (0.98) showing the tool has good reliability in practice. This result is supported by almost all studies showing interclass correlation coefficient (ICC) values >0.80 which signifies good reliability. ICC inter-rater agreement values ranging between 0.75 – 1.00 are interpreted as excellent. The ABC scale also assesses fear of falling among community dwelling older adults with analysed studies confirming good internal consistency with the Cronbach's α ranging between 0.81 and 0.97. Again, ICC values ranging between acceptable (0.76) and excellent (0.981) further confirm the reliability of the scale. In contrast, the

STRATIFY assesses falls risk in the hospital setting through five dichotomic variables (1=yes and 0=no); previous falls, agitation, visual disturbances, frequency of evacuations and transfer/ mobility. A risk of falling is determined by a score ≥ 2. Analysis of studies utilising the STRATIFY showed where Webster et al. (2008) maintained at the recommended cut off point (≥ 2) the tool displayed very good sensitivity (82%) excellent negative predictability (97%) and moderate specificity (62%). Critically, the tool showed a low positive predictability (18%) which signifies a high number of false positives and the mismanagement of limited falls reduction resources on older adults 'not at risk' of falls. Despite completing a setting stratification on the remaining validated tools (n = 24) to identify the most effective clinical tools, the study failed to quantify definitive recommendations. Acknowledging the possibility that not all studies were identified due to database and search strategy limitation, the overall study recommendation was to validate existing scales to reach gold standard rather than striving to create new scales. Significantly, the study excluded many FRATs that were validated among the older adult nursing homes population due to a lack of statistical data.

One such FRAT was the Falls Risk Assessment Scale for the Elderly (FRASE) as the independent validation Cannard (1996) failed to specifically examine the FRATs sensitivity (SENS) and specificity (SPEC). Accordingly, Jester et al. (2005) investigated the predictive accuracy of the FRASE and the STRATIFY to determine if falls prevention strategies reduced the number of falls among older adults with hip fractures. The study was undertaken in England and utilised a quasi-experimental design to compare the incidence of falls between retrospective (n = 30) and prospective (n = 60) older adult patient groups. The STRATIFY was originally validated by Oliver et al. (1997) achieving an excellent sensitivity (93%) and very good specificity (88%) in the local validation study and an excellent sensitivity (92%) and moderate specificity (68%) in the remote validation study. Consequently, Jester et al. (2005) sought to establish the inter rater reliability and predictive accuracy of the two FRATs by using tests of correlation and establishing their Receiver Operator Characteristics (ROC). A convenience sampling technique isolated a sample (n = 90) of older adults admitted to an acute hospital having sustained a hip fracture. The sample (n = 90) was further divided into retrospective (n = 30) and prospective (n = 60) groups with fall prevention strategies.

Statistical analysis using Fisher's exact test compared the falls rates between the prospective (n = 60) and retrospective (n = 30) samples, the findings (p = 0.204) presented no statistical significance. As data for the FRASE was parametric and data for the STRATIFY non-parametric, the inter-rater reliability (IRR) of the FRATS were tested using both Pearson's correlation coefficient and Spearman's rank correlation coefficient. The FRASE achieved good IRR with a correlation value of 0.964 and *p* value 0.001. The STRATIFY achieved a positive IRR with a correlation coefficient value of 0.836 and *p* value 0.01. A correlation coefficient of 0.70 or more is suggestive of good IRR which is imperative to the successful implementation of the FRAT in clinical practice. The predictive value (SENS and SPEC) of the two FRATs was initially calculated using the ROC curve on the prospective (n = 60) and retrospective (n = 30) samples. A tool is considered right or wrong if the area under the ROC curve (AUC) shows a score of 1 or 0. An AUC score of 0.5 demonstrates a predictive accuracy no better than random probability, and comparable to clinical judgement. The nearer to 1 the AUC the greater the predictive accuracy of test, while an AUC > 0.7 shows decisive power.

In the prospective sample (n = 60) the FRASE achieved a moderate sensitivity (62%) and an average specificity, indicating moderate predictive accuracy in identifying fallers (n = 2) as 'high risk' and an average predictive accuracy in identifying non-fallers (n = 58) as not 'high risk'. In comparison the STRATIFY achieved an average sensitivity (50%) and a good specificity (76%). In the retrospective group (n = 30) the FRASE achieved poor sensitivity (1%) and good specificity (74%), thus indicating the tool had poor accuracy in identifying fallers (n = 1) as high risk and a good predictive accuracy in identifying non-fallers (n = 29) as not 'at risk'. In comparison the STRATIFY achieved poor sensitivity (1%) and excellent specificity (92%). In the prospective sample (n = 60) the AUC for the FRASE was 0.560 while the STRATIFY AUC was 0.629, thus indicating the STRATIFY showed greater accuracy than the FRASE. The tools achieved a greater predictive accuracy than random probability (ROC=0.5) but did not achieve decisive power (AUC>0.70) to provide a reliable test.

In theory, the retrospective sample (n = 30) should provide the most accurate predictive accuracy score as minimal falls interventions strategies were in place. Interestingly, the predictive accuracy of both FRATs decreased. The AUC score of the FRASE (0.0.370) and STRATIFY (0.463) among the retrospective sample (n = 30) was less than random probability (ROC=0.5). Although the results refute the local and remote validation study by Oliver et al. (1997) sample differences existed as only femoral neck fracture patients were included and fall prevention strategies were implemented among the prospective group (n = 60). Furthermore, the findings are based on a small sample size (n = 90) and excluded falls incurred after the five-day post-operative period.

Accessing a larger sample Wijnia et al. (2006) conducted a prospective study of older adults (n = 120) admitted to nursing homes in Holland over a 13-week period. The study sought to evaluate the predictive accuracy of the STRATIFY in identifying fall risk among older adults. The sample comprised of men (n = 45) and women (n = 75) with rehabilitation, psychogeriatric, chronically ill or palliative nursing care needs. Overall, data analysis identified the STRATIFY was unsuccessful in predicting falls risk among the older adult nursing home population. The tool achieved an average sensitivity (50%), estimated by comparing the number of older adults with a STRATIFY score of ≥ 2 who experienced a fall (n = 18) to the total number of older adults who experienced a fall (n = 36). The tool demonstrated a good specificity (76.2%) therefore showing greater predictive accuracy at identifying older adults 'not at risk' of falling than older adults 'at risk' of falling. The study questioned if the statistical findings were negatively impacted by the poor health status of the sample (n = 120). Nevertheless, at week five the sensitivity (52%) and specificity (73.7%) of the STRATIFY remained stable until week 13 post admission. Therefore, the possibility of a care paradox was also suggested where nursing staff consciously or unconsciously implement fall prevention interventions for older adults 'at risk' or once a fall has occurred, this would ultimately reduce fall rates thus reducing the sensitivity of the STRATIFY in correctly identifying fallers as 'high risk' of falls. However, the unit of analysis was the 'fall' rather than the 'faller', thus an older adult who experienced multiple falls may have been included for analysis multiple times which may have increased the sensitivity of the STRATIFY. Nevertheless, as the study was undertaken in only one site the findings cannot be representative of other care settings.

To avoid duplication bias for multiple falls Haines et al. (2006) advocate the use of ER predictive accuracy calculations which are sensitive to unequal patient exposure periods, changes in screening tool classifications and multiple falls by individual patients. Accordingly ER calculations were employed by Wong Shee et al. (2012) to evaluate the predictive accuracy and preventative intervention targeting ability of two numerical FRATs, the Ballarat Health Fall Risk Assessment Tool (BHS-FRAT) and the STRATIFY over two six – month audit periods. The retrospective collection of data was undertaken on a sample of older adults (n = 362) requiring semi acute care in Australia. The two-stage study initially collected falls risk data using BHS-FRAT. Thereafter, between July and December 2007 falls risk data was collected using the STRATIFY. The study included a sub-group which comprised of the older adults who experienced a fall during the six-month audit period (fallers), and another group which comprised of older adults who did not experience a fall during the same hospitalisation period (non-fallers). An older adult who experienced more than one fall during the hospitalisation period was considered a recurrent faller. The fall incident data was collected through the health service incident reporting database. In stage two, falls risk data and data relating to falls prevention strategies identified by the two FRATs were collected from the same matched cohorts as stage one, fallers and non-fallers. The ability of the BHS-FRAT to direct falls prevention strategies was assessed through a retrospective audit. While the STRATIFY ability to direct fall prevention strategies was assessed through its implementation as part of a nursing care plan and falls prevention programme. Analysis entailed determination of faller type and the completion rates of each FRAT and associated documentation.

Along with ER calculations, Chi-square statistics were calculated to determine any differences between the two groups in relation to the proportion of older adults identified as "at risk" and the proportion of older adults who received appropriate fall prevention interventions. The study maintained a tool held good predictive accuracy if the sensitivity and specificity values are $\geq$0.70. The Sensitivity^{ER} and sensitivity for the BHS-FRAT was 0.97 and 0.95 showing excellent accuracy in identifying fallers as ‘at risk’. In contrast however, the Specificity^{ER} and specificity for the BHS-FRAT was 0.07 and 0.09 showing very poor accuracy in identifying non-fallers as ‘not at risk’. Similarly, the Sensitivity^{ER} and sensitivity for the STRATIFY was 0.94 and 0.88 showing very good accuracy in identifying fallers as ‘at risk, while the Specificity^{ER} and specificity was very poor at 0.13 and 0.19., showing very poor accuracy in identifying non-fallers as ‘not at risk’. Analysis of the data for stage one therefore showed both tools demonstrated a low predictive accuracy using both ER and standard calculation, failure to identify non-fallers renders a FRAT useless in clinical practice, resulting in unnecessary restrictions and/ or poor allocation of fall prevention resources.

Data analysis for stage two of the study showed high compliance for the BHS-FRAT (97.9%) and STRATIFY (98.3%) on initial assessment. Nevertheless, reassessment compliance was significantly reduced for the BHS-FRAT (5.1%) in comparison to the STRATIFY (64.1%). Although the study cites differing staff and patient characteristics as possible altering influences on the results achieved, the STRATIFY obtained a high IRR thus showing the tools ability to generate similar results regardless of the assessor. Consequently, the study recommends the continued use of the STRATIFY in practice once combined with falls prevention documentation targeting fall prevention strategies.

The practice of combining assessments is also promoted by Park (2018) who compared the diagnostic accuracy of FRATs for predicting fall risk among older adults in acute, long-term care and community-dwelling settings. The study aimed to identify the most frequently used predictively accurate FRATs in clinical practice. The study entailed a systematic review of prospective studies that assessed the predictive accuracy of FRATs in identifying older adults at most risk of falling. Exclusion criteria excluded 98.5% of studies identified (n = 2,571) with chosen studies (n = 33) showing values of FRATs (n = 26) based on the cut-off scores recommended by their developers. The sample of older adults from studies analysed (n = 33, 9,743 subjects) was divided between acute care setting studies (n = 7, 4,067 subjects, mean age 80 years), long-term care (n = 3, 364 subjects, mean age 65 years) and community-dwelling (n = 23, 5,312 subjects, mean age 70 years). The study identified a variety of

FRATs (n = 26) were utilised between acute care (n = 3/26) and community-dwelling settings (n = 23/26) however studies pertaining to FRAT utilisation in long-term care settings (n = 3/33) were too small to analyse. The HFRM-II and STRATIFY were the most popular FRATs for assessing falls risk among older adults in the acute care services. Although a total of twenty-six commonly used FRATs were identified for assessing falls risk among community-dwelling older adults, the Timed Up-And-Go Test (TUG test) and BBS were identified as the FRATs most frequently utilised.

The Berg Balance Scale (BBS) was presented in five community-dwelling setting studies. Analysis of the combined sample (n = 570) showed a good pooled sensitivity of 0.73 with high heterogeneity (82.7%) (p=0.0001) and a very good pooled specificity of 0.90 with a low heterogeneity (31.9%) (p=0.21). The ROC AUC was 0.97, indicating the tools predictive accuracy is nearly always right. The Downton Fall Risk Index emerged. in two studies. Statistical analysis of the combined sample (n = 231) identified a very good pooled sensitivity (84%) but a low pooled specificity (26%). Heterogeneity was moderate at (47.5%) (p=0.15) and 43.7% (p=0.17) respectively. The HFRM-II appeared in all three acute setting studies and held the second largest combined sample size (n = 1,754). The HFRM-II achieved a good pooled sensitivity (0.76), with no heterogeneity (0%) (p=0.58), and a moderate pooled specificity (0.60), with high heterogeneity (97.7%) (p<0.001). The ROC AUC was 0.75 indicating decisive power. The Mobility Interaction Fall (MIF) presented in 2 studies with a small sample (n = 286). The MIF obtained an average pooled sensitivity (0.53), with high heterogeneity (94.8%) (p<0.001), and a good pooled specificity (0.73) with moderate heterogeneity (64.8%) (p=0.09).

Like the HFRM-II, the STRATIFY appeared in all acute care setting studies (n = 3) but held the largest sample size (n = 2,245). The FRAT achieved a very good pooled sensitivity (0.89) with moderate heterogeneity (64%) (p=0.06), and a moderate specificity (0.67) with high heterogeneity (96.5%) (*P*<.001). The ROC AUC was 0.81 indicating very good accuracy. The TUG test was identified in five studies with a small combined sample (n = 427). The TUG test achieved a good pooled sensitivity (0.76) with no heterogeneity 0.0% (p=0.85) however, the pooled specificity (0.49) was below average with high heterogeneity (94.8%) (p<.001). The ROC AUC was 0.80

indicating very good accuracy. The final FRAT to appear more than once was the Tinetti Balance, presenting twice with a small combined sample (n = 284). The FRAT achieved a moderate pooled sensitivity (0.68) with no heterogeneity (0.0%) (p=0.57) however, like the TUG test the Tinetti yielded an average pooled specificity (0.56) with high heterogeneity (79.2%) (p=0.03). The ROC AUC was 0.80 indicating very good accuracy. All other FRATs (n = 20) presented once and were designed for community-dwelling older adults. The combined sample (n = 888) yielded a moderate pooled sensitivity (0.63) with a high heterogeneity (88.4%, p<0.001) and moderate pooled specificity (0.60) however, with a high heterogeneity (98.9%) (p<0.001). The ROC AUC was 0.76 indicating good accuracy.

All FRATs analysed (n = 26) showed a sensitivity ≥ 0.7, with low to no heterogeneity except the MIF and Tinetti Balance. Most FRATs except the BBS, showed higher sensitivity than specificity, however with high inter-study heterogeneity (over 90%) for sensitivity thus suggesting unstable test scores. The primary goal of FRATs is to identify persons 'at high risk' of falling. Therefore, FRATs with high sensitivity achieve the primary goal regardless of poor specificity values. To interpret a test score as stable, inter-study heterogeneity should be low. The BBS showed pooled sensitivity and specificity > 0.7 nevertheless, inter-study heterogeneity was high for sensitivity. The Downton Fall Risk Index had a very good pooled sensitivity (0.84) with moderate a level of inter-study heterogeneity for both sensitivity and specificity suggesting a more stable result. Nonetheless, the pooled sensitivity (0.26) was too low. Although, the HFRM-II showed acceptable sensitivity (0.76) and specificity (0.60) values, like the MIF, inter-study heterogeneity was high indicating unstable results. While the STRATIFY yielded the most accurate pooled sensitivity (0.89) and specificity (0.67), inter-study heterogeneity was high thus indicating unstable results. The TUG test and Tinetti Balance Scale showed moderate sensitivity with no inter-study heterogeneity. However, pooled specificity was low with high inter-study heterogeneity. Overall, good sensitivity was shown by the Downton Fall Risk Index, STRATIFY, TUG test and HFRM-II thus indicating good predictive accuracy for correctly identifying older adults 'at risk' of falling. Similarly, each FRAT showed poor specificity thus indicating poor accuracy in identifying those 'at low risk' of falling. In contrast, the

Berg Balance Scale (BBS) had a very high specificity (0.90), thus showing clinical usefulness in identifying those 'not at risk' of falling.

Consequently, the study deemed the statistical evidence on FRATs available as insufficient to assess falls risk among older adults. Thereby, recommending the utilisation of two FRATs in tandem to maximise the predictability of each test in identifying older adults at high risk of falls. Nevertheless, the study was limited to prospective studies therefore; results achieved are not representative of all FRATs available in practice. In addition, the study did not verify the validity of all FRATs included. Furthermore, the study did not include retrospective or case control studies which may explain how FRATs for community-dwelling older adults (n = 23) dominate the findings with limited studies from the acute (n = 7) and long-term care (n = 3) settings.

The STRATIFY was also identified as the most predictively accurate and frequently completed FRAT in the systematic review by Oliver et al. (2008) of prospective validation studies on falls prevention in hospitalised patients. The inclusion criteria stipulated only prospective validation cohort studies between 1997 and February 2006 with adequate data for calculating predictive validity. Predictive validity necessitates, sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), total predictive accuracy (TPA) and 95% confidence intervals (CI)). Accordingly, a systematic review of eligible studies (n = 8) of hospitalised adults who experienced a fall was undertaken by two assessors independently with consensus resolving any discrepancies. Statistical analysis showed operational properties varied extensively between populations and cut-off scores employed. Falls prediction data varied between SENS (42.9% - 76.9%), SPEC (43.2% - 59%), PPV (12.5% - 29.9%), NPV (80% - 93%) and TPA (43.2% - 60%).

The study subsequently undertook a meta-analysis of clinically homogeneous studies based on fallers age and setting (geriatric rehabilitation units) (n = 4) from within the systematic reviews (n = 8). Clinically, heterogeneous populations accounted for the exclusion of three studies which included surgical patients and younger adults within the sample population. Critically, the original local and remote validation cohorts by

Oliver et al. (1997) for STRATIFY was also not pooled for meta-analysis due to ambiguity, as the data referred to a “discrete event” rather than “patients who fell” or “fallers”. A chi-squared test for heterogeneity was not significant for SENS (p=0.36). Nevertheless, between-study heterogeneity for SPEC, PPV and NPV (p<1) warranted a random effects model with pooled estimates of 95% CI SENS (67.2%), SPEC, (51.2%), PPV (32.1%), NPV (86.5%). Although an average SPEC (51.2%) and good NPV (86.55%) were achieved, the low PPV (23.1%) suggests most patients were categorised as ‘high risk’. The findings therefore suggest the STATIFY presents poor clinical efficacy in accurately identifying potential fallers for targeted falls prevention interventions. Significantly, this study published the first meta-analysis of a FRAT in the older adult rehabilitation population. Arguable, the sample for inclusion was small (n = 4), lacking the initial development and validation cohorts, and founded on published aggregated data rather than individual patient data. Nevertheless, the operational limitations of FRATs among older adult populations require consideration. The study recommends validation of FRATs in a clinical setting and population prior to clinical use. In addition, the study cautions once off STRATIFY risk assessment values which may be dubious due to the non-static components such as urinary frequency and agitation.

Cautious practice in the application of FRATs is advised by Matarese et al. (2014) following a systematic review to identify the most accurate FRSTs for identifying older adults ‘at risk’ of falls in acute care settings. The study included prospective validation studies undertaken between January 1981 and April 2013 which reported the sensitivity and specificity of FRSTs exclusively. Like FRATs, FRSTs provide a scoring system that indicates the cumulative effect of known fall risk predictors as low, medium or high risk of falls (Haines et al., 2007). Although several studies have been undertaken on screening tools to predict falls risk in hospitalised patients, few have focused on the older adult specifically, but rather the adult population extended to included older adults. The study inclusion criteria stipulated only English or Italian language studies based solely on older adult inpatients aged 65 years and over in acute care settings were included. All meta-analysis articles and review articles were excluded. The exclusive sample restrictions excluded the evaluation of many tools resulting in a small sample of studies (n = 7) examining three screening tools, the

STRATIFY (n = 4), the Hendrich Fall Risk Models (n = 3), and the Conley Scale (n = 1).

The STRATIFY (n = 4) considers five fall risk factors, previous falls, agitation, visual impairment, frequency of toileting and transfer and mobility abilities. Risk of falling is identified by a cut off ≥ 2 (Oliver et al., 1997). Four prospective studies assessed falls risk among older adults aged 65 years and over using the STRATIFY (Chiari et al., 2002; Papaioannou et al., 2004; Milisen et al., 2007; Webster et al., 2008) and presented a broad range of sensitivity (20% – 91%) and specificity (49% - 87%) values. Three prospective studies assessed the risk of older adults falling using two different versions of the Hendrich Fall Risk Model (HI-FRM and HII-FRM) (Heinze et al. 2009, Ivziku et al. 2011, Caldevilla et al. 2013). In the first version of the model (HI-FRM) using a cut off score ≥ 3 to signify falls risk Heinze et al. (2009) achieved a excellent sensitivity (97%) but low specificity (9%) against six fall risk predictors; recent fall, depression, incontinence, vertigo, confusion and non-adaptive mobility/ generalised weakness. The second version of the model (HII-FRM) was examined by Ivziku et al. (2011) and Caldevilla et al. (2013). Both studies used a cut off score ≥ 5 to signify falls risk against eight fall risk predictors; male gender, mental status, emotional status, vertigo, symptoms of dizziness, antiepileptic use, benzodiazepine use, and ability to stand from sitting. Respectively the studies showed very high sensitivity (86% and 93%) but below average specificity (43% and 35%). The Conley scale (n = 1) categorizes older adults at high risk of falls with a cut off score > 2 when assessed against six fall risk predictors; history of falling, cognitive impairment, agitation, altered elimination, vertigo/ dizziness and use of walking aids (Conley et al., 1999). The scale produced a moderate sensitivity (69%) and below average specificity (41%).

Due to the overall heterogeneity and small number of studies (n = 7) a meta-analysis was undertaken for the STRATIFY (n = 4) and HII-FRM (n = 2). Critically, the studies were only homogeneous in terms of age, thus presenting less robust pooled results. The STRATIFY showed a lower sensitivity than the HII-FRM (61% vs 92%) but a higher specificity (71% vs 37%). The results show the HII-FRM offered excellent accuracy in detecting older adult ‘at risk’ of falling (SENS 92%) but poor accuracy in detecting older adults ‘not at risk’ of falling (SPEC 37%). In contract, the STRATIFY offered moderate accuracy in detecting older adults ‘at risk’ of falling (SENS 61%) but good accuracy in detecting older adults ‘not at risk’ of falling (SPEC 71%). Nevertheless, the Youden index (Sensitivity^{ER} and Specificity^{ER}) for both tools were significantly lower than 1.0 (0.27 and 0.34 respectively) signifying low predictive accuracy for both tools. Consequently, the study cautioned that no FRAT displayed a statistical accuracy to warrant a recommendation for routine clinical use with older adult inpatients. Nevertheless, Matarese et al. (2014) acknowledged wise and judicious use of screening tools may support clinician’s decision making when seeking to modify or eliminate individual older adult patients fall risk predictors. The study recommendations advised testing a FRAT prior to implementing within clinical practice to clarify the tools usefulness in relation to the population, case mix, staffing, fall prevention measures and the environmental characteristics of the ward.

This view is compounded by the findings of Strupeit et al. (2016) prospective longitudinal study to measure the predictive accuracy and clinical usefulness of the STRATIFY relative to clinical assessment and self-report assessment. Data collection was undertaken for all three risk assessment methods in a German geriatric rehabilitation hospital on a sample of older adults (n = 124) with a three week follow up (n = 115). Differentiation between older adults “at risk” and “not at risk” of falling was determined separately for each assessment method. The STRATIFY discriminated through answering five multifactorial items, clinical assessment was differentiated solely on the nurse’s professional expertise, and the self-report assessment was differentiated specifically on whether or not the older adult experienced a fear of falling in the previous two week period. Critically, the diagnostic accuracy (SENS, SPEC, PPV and NPV) of the three risk assessment methods was found to be insufficient.

The STRATIFY and clinical assessment showed no relation to decreased falls. The highest values were achieved by the self-report assessment, with a good sensitivity (70.7%) and PPV (70.7%), thus indicating that a ‘fear of falling’ showed good accuracy at identifying fallers as being “at risk” of falls. However, the NPV (50.7%) showed a weakness in the methods ability to identify non-fallers as “not at risk” of falls and consequently resulted in a moderate specificity (64.6%). The clinical assessment method displayed a moderate sensitivity (67.1%) and PPV (65.3%) indicating nurses professional expertise presented a moderate accuracy in identifying fallers as ‘at risk’ of falls. The below average NPV (47.7%) and specificity (45.7%) values however indicate unnecessary fall prevention interventions and unwarranted restrictions were prescribed to older adults ‘not at risk’ of falls. Finally, the structured risk assessment method was the least accurate at identifying older adults “at risk” of falls, based on the low sensitivity (28.1%) of the STRATIFY. Nevertheless, with a moderate specificity (68.4%) the structured risk assessment method reduces the probability of clinicians unnecessarily allocating scant resources to older adults who are ‘not at risk’.

The study acknowledged that mobility improvement techniques routinely practiced in the rehabilitative setting may have influenced the older adults (n = 115) fall risk. Reducing fall risk may have reduced the number of falls and thus influenced the sensitivity value achieved by the three risk assessment methods. This potential limitation may have been further compounded by the small sample size (n = 115) and possible intraobserver variation. Regardless of limitations cited, no risk assessment method was recommended based on the predictive accuracy values achieved. Furthermore, the study questioned the effectiveness and ongoing practice of time-consuming fall risk assessment methods in older adult care services.

A systematic review by da Costa et al. (2012) sought to identify the clinical usefulness of FRATs utilised among older adults in rehabilitation hospitals through a systematic review of prospective investigations published in the English language between 2003 – 2008. Of the data identified (n = 1,257) only those potentially eligible (n = 786) were considered, with three studies (n = 3) satisfying the inclusion criteria. The following methodological quality characteristics were assessed for all studies (n = 3), clearly defined reference for a ‘fall’ or ‘faller’ (n = 2), blinded adjudication (n = 2), other relevant patient characteristics (n = 1), pre-defined cut-score (n = 1) and comparison of risk prediction score against intuitive estimates (n = 1). Three studies (n = 3) examined the predictive properties of the STRATIFY (Coker and Oliver, 2003; Haines et al., 2006; Vassallo et al., 2008). In addition, two of the studies also examined the

Downton Fall Risk Index and 'clinical judgement' (Vassallo et al., 2008) and the Peter James Centre Falls Risk Assessment Tool (PJC-FRAT) (Haines et al., 2006).

In Vassallo et al. (2008) study (n = 81) the Downton Fall Risk Index with a cut-off score of ≥ 3 showed excellent sensitivity (92%), followed by very good sensitivity (82%) by the STRATIFY with a cut-off score of ≥ 2. Clinical judgement however yielded a below average sensitivity (43%). In contrast, clinical judgement achieved an excellent specificity (91%) while the DOWNTON and STRATIFY achieving below average specificity values of 36% and 34% respectively, thus questioning the usefulness of the two FRATS in identifying 'not at risk' older adults. In Coker and Oliver (2003) study (n = 432) the STRATIFY with a cut-off score of ≥ 1 showed excellent sensitivity (95%) but poor specificity (17%). Applying a cut-off score of ≥ 2 sensitivity (66%) reduced to moderate but specificity (47%) increased from low to below average, while using a cut-off score of ≥ 3 sensitivity (36%) reduced further to below average but the specificity (85%) increased to very good accuracy. In the Haines et al. (2006) study (n = 122) using a cut-off score of ≥ 1 the STRATIFY showed the excellent sensitivity (96%) and the low specificity (20%). Similarly, applying a cut-off score of ≥ 2 and ≥ 3 respectively decreased sensitivity (77%, 42%) to good accuracy and below average accuracy and correspondingly increased specificity (51%, 78%) to average accuracy and good accuracy. The PJC-FRAT which comprises of four elements showed values for falls risk alert card (SENS 73%, SPEC 75%), exercise programme (SENS 12%, SPEC 84%), education programme (SENS 27%, SPEC 68%) and hip protectors (SENS 31%, SPEC 90%).

Comparison between SENS and SPEC across all studies (n = 3) shows no single FRAT is superior to the other in falls prediction among older adults. The trade-off between SENS and SPEC is best when FRATS correctly differentiate patients at 'high risk of fall' from patients at 'low risk of falling'. da Costa et al. (2012) assert the optimal SENS for clinical relevance in falls prediction is ≥ 80%, however in the studies reviewed (n = 3) the corresponding SPEC is extremely low. The low specificity suggests many older adults at 'low risk' of falls were falsely labelled 'high risk' which results in unnecessary restrictions, misuse of targeted interventions and overloading staff. Albeit, some study limitations exist, the low number of studies (n =

3) published in the English language and the scarcity of effective FRATs available to clinicians for a population at particular risk. Nevertheless, no study on language bias in systematic reviews exists therefore; it remains unlikely that language restriction would potentially threaten the validity of a study. Further research is required to examine whether clinical judgement, addressing reversible risk or prediction tools are better at reducing falls in practice. Rather than simply classifying older adults' level of falls risk, the provision of fall reduction interventions would be beneficial to clinicians. As the implementation of FRATs in the clinical setting is a timely and expensive process, to be cost effective, the chosen FRAT must yield significantly better results than intuitive expertise (da Costa et al., 2012).

Similar findings were identified in the systematic review conducted by Scott et al. (2007) to examine the validity and reliability of FRATs among older adults in acute, community, home support and long-term care (LTC) settings. The study was restricted to prospective validation studies published in the English language between January 1980 and July 2004 where the primary or secondary purpose examined the predictive accuracy of one or more FRATs. Falls risk assessment generally includes multifactorial assessment tools (MATs) that consist of a checklist and consider a wide range of risk factors, or functional mobility assessments (FMAs) that concentrate on the functional and psychological domains of postural stability and require a physical demonstration of ability. In total, thirty-four studies (n = 34) examined 38 FRATs across four settings, of which 27 were FMAs and the remaining 11 MATs.

The most common setting for risk assessment testing (n = 14) was the community setting which included subjects residing independently in their own homes or retirement communities. In total, 23 FRATs delivered sensitivity results between 14% – 94% with specificity results ranging between 38% – 100%. Six studies reported a strong IRR score of $\geq$ 80% for one or more FRATs. Within the supportive housing setting (with on-demand services rather than on-site nursing support) four studies (n = 4) examined 4 FRATs. No study showed a sensitivity or specificity greater than 70% and no reliability scores were established. In LTC settings which included residential/ nursing homes, six studies (n = 6) examined 10 FRATs of which only 1 reported reliability scores ranging from 56% – 98%. Sensitivity and specificity values were only reported by 3 studies and ranged from 43% – 91% and 39% – 82% respectively. Finally, the acute care setting which included geriatric rehabilitation services, twelve studies (n = 12) examined 8 FRATs of which two studies identified sensitivity and specificity values greater than 70%. Predictive values across all 12 studies ranged from 66% – 93% sensitivity and 25% – 88% specificity. In addition, high IRR measures ranging between 74% – 99% agreement between raters were reported. This is important for clinical practice as it indicates that the tool will present the same or similar results irrespective of variation in assessor(s).

High predictive values for FRATs as recommended by Perell et al. (2001) have sensitivity measures greater than 80% and specificity measures greater than 75%. In contrast, high predictive values for FRATs as recommended by Oliver et al. (2004) have sensitivity and specificity measures greater than or equal to 70%. Guided by the lower cut off 70% or higher, six FRATs examined in 4 studies (n = 4) showed strong predictive accuracy. Three FRATs (5 min walk, five-step test and the Functional Reach), were examined in the community. The Mobility Fall Chart was examined within a LTC setting while the STRATIFY and the Fall Risk Assessment Tool (FRAT) fall risk assessment were examined in acute care settings. Nevertheless, many studies (n = 28) claim to demonstrate evidence to promote the use of FRATs but fail to present validity or reliability measures to substantiate these recommendations. In conclusion, no FRAT can be reliably applied across different settings to accurately predict falls risk.

This view is upheld in the findings of Harper et al. (2017) prospective cohort study to compare the predictive accuracy of the Falls Risk for Older Persons - Community Screening Tool (FROP COM Screen) against the Two Item Screening Tool in identifying falls risk and predicting future falls risk among Australian older adults presenting to the emergency department (ED). A convenience sample of older adults (n = 201) aged sixty-five years were drawn from the control arm of a separate randomised controlled trial (RCT) that explored the effects of a short fall intervention in the ED to prevent falls post discharge. Participation exclusion criteria included non-English speaking, residing in a community residential aged care facility/ LTC setting or inability to give consent. Of the 201 older adults recruited, 34% (n = 69) had presented to the ED with a fall. On discharge, as a number of older adults failed to maintain contact (n = 8), withdrew from the study (n = 2) or died (n = 6), therefore follow up falls data was gathered on smaller sample (n = 185). Follow up data identified 36% (n = 67) of the older adults (n = 185) reported a fall following discharge, of which 14% (n = 26) reported two or more falls and 0.5% (n = 1) reported more than four falls. Although women experienced more falls (34%, n = 63) than men (32%, n = 59) demonstrating a p value >0.05 no statistical significance was found between gender and falls risk (p = 0.56). Analysis of the 36% (n = 67) of older adults who experienced a fall post discharge showed 23% (n = 43) reported a previous fall.

Analysis of the percentages and frequencies of the falls risk screening tool variables showed similar percentages of 'high risk' and 'low risk' classifications. The FROP Com Screen classified 67% (n = 124) of the follow up sample (n = 185) as 'low risk' versus 55% (n = 102) receiving a 'low risk' classification by the Two-Item Screening Tool. Cross referencing the two tools showed limited accuracy by both among the general sample (n = 185). One older adult who did not experience a fall was classified as 'high risk' on the FROP Com yet achieved a 'low risk' rating on the Two-Item Screening Tool. The Two-Item Screening Tool classified 38% (n = 71) of the sample (n = 185) as 'low risk' however, 35% (n = 25) reported further falls at the 6-month review. In addition, 14 older adults deemed 'low risk' of falls were classified as a 'high risk' of falls by the FROP Com, with 21% (n = 3) reporting further falls. In contrast, the Two-Item screening tool deemed 7 older adults 'high risk' of falls in contradiction to a 'low risk' classification from the FROP Com, subsequently 34% (n = 3) reported further falls. In total, both tools classified 15 older adults as 'high risk' of falls, of which 53% (n = 8) reported further falls.

Overall, in the assessment of all older adults (n = 201) who presented to the ED, the FROP-Com achieved a low sensitivity (39%) and good specificity (70%), showing low predictive accuracy in identifying fallers as 'high risk' of falling but good predictive accuracy in identifying non-fallers as 'low risk'. Accordingly, the FROP-Com achieved a low PPV (0.43), representing the number of 'high risk' older adults who thereafter experienced a fall. The FROP-Com achieved a moderate NPV (0.67) representing the number of 'low risk' older adults who thereafter did not experience a fall. The Two Item Screening Tool by comparison achieved a below average sensitivity (48%) and an average specificity (SPEC=57%) which led to a lower PPV (0.39) and NPV (0.66).

Analysis based specifically on older adults who presented to the ED following a fall (n = 69) and more specifically a fall with injury (n = 54) altered the predictive accuracy of both tools. The FROP-Com showed below average sensitivity (45%, 48%) and average to good specificity (58%, 70%). The Two Item Screening Tool showed a good to average sensitivity (79%, 57%) and below low to average specificity (39%, 60%). In the same way the PPV for the FROP-Com (46%, 88%) and Two Item Screening Tool (50%, 89%) increased. Although both tools showed limited accuracy in the general population, greater accuracy was demonstrated in the population that presented with a fall (n = 69) and a fall with injury (n = 54), thus suggesting a previous fall is a notable indicator of future falls. Critically, the study used convenience sampling thus, one cannot rule out the possibility of selection bias. Furthermore, the preventative interventions briefly discussed during the RCT may have reduced falls, thus reducing sensitivity and creating the low PPVs. Also, the study reliability was based on self-reported falls, which carries the risk of recall bias. Nevertheless, the study findings suggest screening tools have limited ability in predicting future falls for older adults presenting with or without falls to the ED.

This view is also held by Chow et al. (2007) following a cross sectional study to evaluate the predictive accuracy and reliability of the MFS in identifying falls risk among Asian older adults. As validity is not inherent to an instrument the study aimed to determine if a FRAT validated in western countries is equally as suitable for clinical use among Asian subjects. The study utilised a convenience sample (n = 954) of older adults which comprised of males (n = 41%) and females (n = 58.4%) with a mean age of 70.2 years. All older adults (n = 954) were assessed with the MFS fall risk assessment on admission and again thereafter if their condition changed. The unit of analysis was the older adult who experienced a fall rather than the number of falls experienced, thus only one fall per older adult was included. The fall incidence reports within the hospital distinguished fallers from non-fallers. The study comprised of three stages, stage one concentrated on content validation to rate the relevance and representativeness of the MFS for the sample population. Stage two focused on educating the raters and the assessment of IRR, while stage three established the psychometric properties of the MFS.

The discriminative power of the MFS was determined by the tools ability to correctly differentiate those ‘at risk’ of falls from those ‘not at risk’ of falls. Sensitivity refers to the true positive value, the likelihood of a predicted event occurring. The low sensitivity (31%) obtained during statistical analysis confirmed the MFS failed to accurately capture fall risk factors among the sample (n = 954) to correctly predict fall incidents. Specificity refers to the true negative value, the likelihood of an unpredicted event not occurring. The very good specificity (83%) obtained demonstrates the MFS correctly identified non-fallers as ‘not at risk’ of falls. Reliability refers to the degree to which individual deviation scores remain reasonably constant during repeated administration of the same test or from one occasion of measurement to another. The MFS displayed good reliability; thus indicating individual patient scores remained relatively consistent over repeated administration. In addition, a high IRR (r=0.97) verified the MFS was easy for raters to understand and apply in the clinical setting. Nevertheless, with a low sensitivity (31%), statistically the MFS failed to capture falls risk adequately. The study acknowledges that advanced and high-quality nursing practices may account for the low sensitivity values achieved. Nevertheless, the study concluded that fall risk predictors may not be independent, and caution needs to be applied when transferring FRATs from one population to another, as caucasian fall risk predictors may not reflect fall risk predictors among the other populations.

This theory is not supported by the findings of the prospective observational study by Baran and Gunes (2018) which compared the psychometric properties of the Fall Risk Assessment (FRA), MFS and HFRM-II. The study assessed a sample (n = 159) of older adults aged 65 years and older residing in nursing homes in Turkey on the three FRATs (FRA, MFS and HFRM-II) daily over a two-month period. Statistical analysis identified the FRA achieved a very good sensitivity (88.24) and moderate specificity (64.81). Accordingly, ROC analysis resulted in an AUC score of 0.76, showing decisive power and leading to the conclusion that the FRA is a suitable tool for predicting falls risk among the older adult nursing home population. The MFS showed good sensitivity (74.51) and specificity (71.30%) rendering the tool less accurate at identifying those “not at risk” of falling. Nonetheless, the MFS achieved an AUC score of 0.72, showing decisive power and supporting its use in LTC settings. Similar to the FRA and MFS the HFRM-II showed good sensitivity (80.39) but below average specificity (43.52%). Although the values achieved were comparable to the results achieved in the validation study (Hendrich et al., 2003) ROC analysis resulted in an AUC score of 0.62, thus the tool failed to reach decisive power rendering the tool unsuitable for determining falls risk among older adults in LTC settings. Critically, the study was undertaken in a single centre, therefore the significant discriminative power achieved for the FRA and MFS cannot be generalised to other settings or populations.

To compare the usefulness of the STRATIFY, Downton, Tullamore and Tinetti FRATs (n = 4) Vassallo et al. (2005) undertook a prospective open observational study. The sample comprised of older adult (n = 135) with a mean age of 83.3 years admitted in two medical wards in England. A clinician prospectively assessed participants (n = 135) using the four FRATs, the level of completion and completion time required for each FRAT was recorded. Through simultaneous assessment by the same assessor, under the same conditions, the study anticipated identification of inefficiencies between FRATs and whether an increased complexity equated to increased accuracy. The sample (n = 135) comprised of males (n = 49) and females (n = 86) with a mean length of stay of 7.5 days. In total twenty-two older adults experienced twenty-nine falls, with six older adults experiencing recurrent falls. Total predictive accuracy (TPA) is expressed as a percentage and represents the total number of patients correctly identified as high or low risk of falls. The Tullamore showed highest accuracy in identifying fallers as ‘high risk’ with a very good sensitivity (90.9%) however a below average specificity (40.7%) indicates poor accuracy in identifying non-fallers as ‘low risk’. The STRATIFY was the least accurate at correctly identifying fallers as ‘high risk’ with a moderate sensitivity (68.2%) however, a moderate specificity (66.4%) indicates the tool shows greater accuracy in the identifying non-fallers as ‘low risk’. Consequently, the STRATIFY achieved a moderate TPA (66.6%) which was the highest TPV value achieved. The moderate sensitivity (68.2%) value achieved by the STRATIFY underwent separate analysis with 1 or above as a cut-off point. Manipulation of cut-off points significantly altered the predictive values of the STRATIFY, yielding a very good sensitivity (86%) but very low specificity (25%) and low TPA (35%) rendering the tool inferior to the Tullamore.

Statistically a low specificity is expected in high-quality care environments where patients are prevented from falling. Therefore, the sensitivity is the most important value of any FRAT. Consequently, despite displaying the highest TPA (66.6%) the STRATIFY showed the lowest sensitivity (68.2%) among the FRATs (n = 4) by failing to accurately identify the highest number of fallers as ‘high risk’ of falls. Notedly, the time required to complete the STRATIFY was significantly less than the time required for the Downton ($P<0.001$), Tullamore ($P<0.001$) and Tinetti ($P<0.001$). In addition, the STRATIFY was the only FRAT to be completed in full for all patients (n = 135), as not all patients were able to achieve the constituents within the Downton (n = 130), Tullamore (n = 130) and Tinetti (n = 17). Thus, the complexity among the FRATs differed, and the inability to complete fully may have influenced the predictive accuracy results achieved. Accordingly, the study recommends the development of accurate, simple and non-time-consuming FRATs, however not all available FRATs were included in the study. Furthermore, as each tool was only completed once on admission, changes in medical status were not captured by repeat assessment. In addition, the possibility of replicating the study is low due to differing staff and patient characteristics.

Narayanan et al. (2016) undertook a systematic review to evaluate the different FRATs implemented within the English National Health Service (NHS) mental health trusts and Welsh healthcare boards and review and appraise their predictive validity and comprehensiveness. The study invited all NHS mental health trust (n = 56) and Welsh health boards (n=6) to submit policies and other relevant documentation pertaining to falls. Risk variables within the tools submitted were compared against the NICE (2004) guidance. Although the study set no year of publication limitation, only policies in the English language that included prospective investigations outlining the predictive properties of the FRAT used were included. Environmental and non-clinical risk assessment tools were excluded. Each FRAT identified within the studies was analytically reviewed (SENS, SPEC, PPV and NPV). Of the 62 invited trusts, 46 provided policies, NHS mental health trusts (n = 44) and health boards in Wales (n = 2) with the majority (n = 42) endorsing specific FRATs as part of their falls prevention strategy. Although 35 policies were accepted for analysis, compliance with inclusion and exclusion criteria permitted 14 studies for review that ratified the STRATIFY (n = 10), Falls Risk Assessment Scale for the Elderly (FRASE) (n = 1), Morse Falls Scale (MFS) (n = 5) and numerous versions of the Falls Risk Assessment Tool (FRAT) (n = 1). All permitted studies (n = 14) were published prior to 2008, the majority (n = 9) evaluated and validated FRATs on older adults aged 65 years and older in acute, rehabilitation and geriatric wards. No study (n = 0) evaluated a FRAT in an acute mental health setting, while one study (n = 1) partially evaluated a FRAT in a community setting.

The STRATIFY (n = 10) developed and validated in England measured five fall risk factors with each risk scoring 1 (prior history of falls, gait instability, agitation, visual impairment and incontinence). Patients scoring ≥2 or 3 were considered a risk of falls. Among the studies analysed (n = 10) sensitivity ranged from excellent (91%) to very low (20%) while specificity ranged from very good (87%) to a low (34%). The PPV ranged from moderate (65%) to low (28%) while the NPV ranged from excellent (97%) to good (74%). The MFS (n = 5) was validated in three clinical care settings, acute, long-term care and rehabilitation. The MFS measures six falls risk variables (history of falls, presence of secondary diagnoses, the use of mobility aids, impaired gait and mental health status). Three different cut off scores predict falls risk severity from a total score of 125 (<25 low risk, 25 – 50 medium risk, ≥ 51 high risk). The predictive accuracy of the MFS varied between validation studies and clinical setting, sensitivity ranged from average (55%) to very good (83%), specificity ranged from low (29%) to excellent (91%). The PPV range was very low (6% – 10%) while the NPV ranged between very good (81%) and perfect (100%). The FRASE (n = 1) originated through a survey in Ireland with ROC statistics available from one quasi-experimental study. A good IIR was achieved (coefficient of 0.964) showing the FRATs ability to deliver similar results regardless of variation in assessors. Nevertheless, the FRASE achieved a ROC score of 0.560 which signifies no decisive power and a predictive accuracy only slightly higher than random probability (0.5). The FRAT (n = 1) falls risk assessment tool was developed and validated for older adults in primary care settings. The FRAT consists of two parts, part one consists of five falls risk variables (previous history of falls, four or more prescribed medications, stroke or Parkinson's diagnoses, balance impairment and difficulty rising from chair without using arms). Part two of the FRAT offers guidance for additional assessment and care planning. Although the FRAT was the most commonly used fall risk assessment tool, implemented in 24 mental health trusts, few utilised validated versions (n = 5/24) with many trusts devising non validated adapted versions minus predictive scoring (n = 10/24) or with additional predictive risk numeric scales (n = 9/24).

Despite the inclusion of 68% of falls policies, the findings must acknowledge that screening for inclusion did not consider the methodological quality of studies or explore clinical practice and failed to include two of the six healthcare boards in Wales. Nevertheless, only 77% of policies submitted had a falls risk assessment that incorporated a medication review despite NICE (2013) guidance advising review and discontinuation if possible, of psychotropic medication among older adults to reduce falls risk. Other falls risk predictors poorly acknowledged within the policies and FRATs examined were fear of falling (34%), postural hypotension (37%), urinary incontinence (49%), environmental hazards (40%) and osteoporosis screening (40%). Largely, the validated FRATs examined showed inconsistencies in predictive validity with no tool undergoing validation within a mental health setting, thus questioning the operational usefulness of FRATs among this cohort and necessitating further research. Overall, the FRATs showed a high NPV and moderate SPEC, which indicates good accuracy at identifying older adults at low risk of falls. The low PPV values indicate most older adults were deemed 'high risk', thus overestimating falls risk and encouraging poor targeting of falls reduction interventions.

El Miedany et al. (2011) assert it is possible to predict an older adults risk of falling and promotes the use of the Fall Risk Assessment Scale (FRAS) to guide individualised fall prevention interventions. The FRAS was developed by El Miedany et al. (2011) for older adults in England. The case control study sample comprised of fallers (n = 559) aged 65 years and older from outpatient (n = 373) and inpatient (n = 186) environments. The control group (n = 426) comprised of non-fallers (n = 426) aged 65 years and older. The outpatient group (n = 373) included older adults (n = 165) who resided in LTC settings. The prevalence of the reference event (falls) depends on both the negative and positive predictive values. Reassurance can be achieved for ‘low risk’ patients by a high specificity and high NPV. This should be paralleled by a high sensitivity and high TPA, which confirms the screening tools predictive value in the identification of persons at ‘high risk’ of falls. The study advocated a predictive accuracy value of 80% or over was paramount to deem a screening tool operationally useful. Analysis of the FRAS with a cut off value of “3.5” yielded an excellent sensitivity (96.2%) and very good specificity (86.0%), thus conceding the least number of falls and a low false positive. The study acknowledged that professional competence and fall prevention measures are required from all healthcare professionals to reduce falls risk however, the study proclaimed FRATs as the initial step in the fall prevention process. Therefore, the study identified the FRAS was a sensitive and specific predictor of future falls and may assist to minimise the negative impact of falling on older adults.

The operational usefulness of FRATs in clinical practice is further promoted by the comparative study by Palumbo et al. (2016) across four European cohorts. The study sought to evaluate the ability of the FRAT-up fall risk assessment tool in predicting falls in multiple cohorts of older adults. To calculate the FRAT-up of individual participants a sample (n = 5,908) comprising of Activity and Function in the Elderly (ActiFE) (n = 1,506) older adults from Germany, Longitudinal Study of Aging (ELSA) (n = 3,303) older adults from England, Invecchiare nel Chianti (InCHIANTI) (n = 890) older adults from Italy and Longitudinal Study on Aging (TILDA) (n = 209) older adults from Ireland were included in the study. Four harmonisation blocks were developed to derive common variables from the four cohort studies which differed in both design and implementation. As the study sample is not always fully representative of the target population in health surveys, sample weights were applied to ensure the sample estimates represented their target populations. The discriminative ability of prediction for the FRAT-up was evaluated and quantified by the AUC. The AUC ranged from 0.61 to 0.71, thus deeming the tool to be a valid approach to estimating falls risk in community dwelling older adults. Nevertheless, heterogeneous discrimination was observed across the studies possibly due to the lack of consistent data across the four datasets and occasional imperfect harmonisation. Therefore, the study recommended further research to refine a more standardised tool that performs homogeneously with higher accuracy across different populations.

Nunan et al. (2018) undertook a systematic review to compare the psychometric testing and feasibility of FRATs. The review focused on studies published in the English language between January 1980 and October 2015 in LTC settings with sample populations ≥ 60 years. The inclusion criteria considered all FRATs once psychometric properties were examined rather than just the individual risk factors within the FRATs. In accordance with (Oliver, 2007) the study necessitated that eligible FRATs were feasible within a clinical context i.e. showed good face validity, were quick and easy to complete, provided transparent calculations with good inter-rater reliability, and were validated within the cohort of use with good predictive validity (high SENS, SPEC, PPV, NPV and TPV). FRATs with a SENS and SPEC ≥ 70% were deemed to have 'high' predictive values (Oliver et al., 2004). Although a FRATs completion time is an important factor within a clinical context, it is not the focus of this study. The selection criteria excluded many studies (n = 151) from the initial search (n = 282) with strict adherence to the eligibility assessment producing a small sample of prospective validation studies (n = 15) ranging in duration from 3 – 12 months. The combined sample population ranged from 18 – 1,946 older adult participants, with a mean age ranging from 74.5 years – 87.3 years. Females accounted for 58 – 83% of the overall population. In total, the study associated 16 FRATs from three fall risk assessment categories with LTC settings, Multifactorial Assessment Tools (MATs) (n = 8/16), Functional Mobility Assessments (FMAs) (n = 5/16) and algorithms (n = 3/16).

MATs (n = 8/16) appeared in 7 LTC studies however only 1 MAT FRAT was completed by the nursing team, with all others requiring completion by physiotherapists (n = 3), physicians (n = 1) or collaboration between physiotherapists and nursing personnel (n = 3). The variables within the MATs ranged from 5 – 30 and required between 2 - 5 minutes to complete. MATs included the Downton Index, Easy-Care Risk of Falls (ECRF), Queensland Fall Risk Assessment Tool (QFRAT), Melbourne Fall Risk Assessment Tool (MFRAT), Peninsula Health Falls Risk

Assessment Tool (PHFRAT), Falls Assessment Risk and Management Tool (FARAM), Modified Fall Assessment Tool (MFAT) and STRATIFY. Overall, IRR ranged from a low 0.52 (MFRAT) (QFRAT) to high 0.94 (MFAT) while sensitivity ranged from average (50%) (MFRAT) – excellent (91%) (Downton Index) with specificity ranging from low (32%) (FARAM) – excellent (90%) (PHFRAT). Several FRATs displayed moderately good predictive validity with sensitivity and specificity values close to 70%. The ECRF presented a very good sensitivity (86%) and moderate specificity (65%). Nevertheless, the applicability of values achieved is questionable due to spectrum bias as the sample population excluded older adults with cognitive and mobility impairments and therefore was non-representational of older adults in LTC settings. Similarly, the MFAT attained moderate sensitivity (61%) and good specificity (80%) however spectrum bias was evident within the study as the sample inclusion criteria excluded older adults who were unable to mobilise independently.

The Downton Index achieved excellent sensitivity (91%) while a very good sensitivity was achieved by the FARAM (80%) indicating good identification of older adults at ‘high risk’ of falls however with low specificity (39% and 32% respectively) the tools showed poor identification of older adults at ‘low risk’ of falls. In contrast, the STRATIFY and MFRAT showed equally average sensitivity values (50%) against good specificity values (76% and 80% respectively). The QFRAT presented a moderate sensitivity (61%) and below average specificity (49%). The PHFRAT presented an ER analysis which is a better indicator of predictive validity; the tool yielded a good $SENS^{ER}$ (69%) and $SPEC^{ER}$ (70%) with good IRR and feasibility. Nonetheless, the tool achieved a below average standard sensitivity (58%) with an excellent standard specificity (90%). Critically, a risk of bias exists in the values achieved as the retrospective nature of the validation design may have inflated the predictive accuracy of the tool. Nevertheless, the PHFRAT proved useful in identifying modifiable risk predictors and targeting falls reduction interventions, resulting in the Australian Commission on Safety and Quality in Healthcare promoting its use in LTC settings.

FMAs (n = 5/16) appeared in 6 LTC studies however no FMA FRAT was solely undertaken by the nursing team, with all studies requiring physiotherapists (n = 5/6) or collaboration between physiotherapists, physicians, and the nursing team (n = 1/6). The FMAs included Performance Oriented Mobility Assessment (POMA), the Timed Up-and-Go test, the Modified Get-Up-and-Go test, the Mobility Interaction Fall Chart (MIFC), the Five Repetition Sit to Stand Test (FRSTST). The variables within all the FMAs were considered complex resulting in lengthy completion times of up to 15 minutes. Overall FMA sensitivity ranged from below average (43%) to very good (86%) while specificity ranged from average (56%) to excellent (91%). IIR ranged from low (0.55, Modified Get-Up-and-Go test) to high (0.97, POMA). The MIFC was examined in two studies, initially presenting a very good sensitivity (85%) and specificity (82%) however a later study displayed a below average sensitivity (43%) and moderate specificity (69%). Although a very good sensitivity (86%) and excellent specificity (91%) was achieved by the FRSTST the values were based on a small sample (n = 18) of highly functioning older adults. Both the MIFC and FRSTST displayed feasibility issues relating to clinical administration. Compliance concerns exist where nurses are required to administer FRATs primarily used and tested by physicians and physiotherapist. In addition, the level of extra training and time required to accurately undertake mobility assessments must not be underestimated. The POMA was examined in two studies, yielding a moderate sensitivity (64%) and specificity (66%) with a cut off score of 19. Nevertheless, spectrum bias was identified by the exclusion of cognitively impaired older adults. In the second study the POMA achieved a very good sensitivity (85%) and average specificity (56%) with a cut off score of 21. Similarly, spectrum bias occurred with the exclusion of older adults requiring assistance to stand and mobilise. In addition, feasibility issues pertaining to older adults with moderate-severe dementia existed.

Algorithms (n = 3/16) appeared in 2 LTC studies, of which all were completed by the nursing team. Critically, no IRR was recorded. The Becker et al. (2005) study examined the sensitivity and specificity of an algorithm based on three sub-groups. The first sub-group ‘participants not able to transfer without assistance’ achieved an average sensitivity (60%) and very good specificity (82%). The second sub-group ‘participants able to transfer without assistance and no history of falls in previous 12 months’ yielded a good sensitivity (72%) and average specificity (57%). Critically, the third sub-group ‘participants able to transfer without assistance and history of falls in previous 12 months’ achieved a low sensitivity (32%) and excellent specificity (93%).

In contrast, the Fall Risk Screening Model algorithm for residents who cannot stand unaided showed a very good sensitivity (87%) and low specificity (29%). Whilst the Fall Risk Screening Model algorithm for residents who can stand unaided showed a good sensitivity (73%) and average specificity (55%). Overall, a moderate to high sensitivity was not achieved across all studies thus indicating ‘high risk’ people who experienced a fall went undetected and may not have received targeted fall prevention interventions. In addition, although no feasibility issues were noted within the algorithm category, like the FMA issues and consequent training in relation to the accurate allocation of older adults within sub-groups would impact the feasibility of algorithms in practice. Consequently, due to sub-standard predictive accuracy values, spectrum bias and feasibility concerns the literature failed to strongly recognise a FRAT of choice for use in LTC. Nevertheless, the PHFRAT is highly recommended by Australian best practice guidelines although further research is necessary to establish the PHFRAT as the LTC setting FRAT of choice.

2.3.2 Theme One: summary

The literature (n = 18) presented in theme one identified numerous types of FRATs (n = 37) with varying feasibility and psychometric properties among the older adults population. The literature identified research was primarily undertaken in the acute care setting (n = 10) (Jester et al., 2005; Vassallo et al., 2005; Chow et al., 2007; Scott et al., 2007; Oliver et al., 2008; Wong Shee et al., 2012; Matarese et al., 2014; Harper et al., 2017; Park, 2018; Ruggieri et al., 2019) The next most prevalent setting was residential care (including nursing homes) (n = 6) (Wijnia et al., 2006; Scott et al., 2007;, El Miedany et al., 2011; Baran and Gunes, 2018; Nunan et al., 2018; Park, 2018). Thereafter, research focused on community dwelling (n = 5) older adults (Scott et al., 2007;, El Miedany et al., 2011; Palumbo et al., 2016; Park, 2018; Ruggieri et al., 2019), followed by the rehabilitation setting (n = 4) (Scott et al., 2007, Oliver et al., 2008; da Costa et al., 2012; Strupeit et al., 2016). In the literature presented (n = 18) only one study was conducted in a mental health setting (Narayanan et al., 2016).

Wong Shee et al. (2012) deem a tool to have good predictive accuracy if the sensitivity and specificity values are ≥ 0.70. In contrast, El Miedany et al. (2011) assert a predictive accuracy value ≥ 0.80 is required for a FRAT to be deemed operationally useful. Accordingly, with an excellent sensitivity (96.2%) and very good specificity (86%). El Miedany et al. (2011) recommended the FRAS as an operationally useful tool to assess falls risk among older adults in outpatients and hospitalised inpatient settings. The PHFRAT was accentuated by Nunan et al. (2018) despite an average standard sensitivity (58.0) ER analysis identified good predictive accuracy ($SENS^{ER}$ 69%, $SPEC^{ER}$ 70%) promoting its use among older adults in residential care settings. In addition, the PHFRAT is endorsed by the Australian Commission and Quality in Healthcare however further research is warranted to establish the PHFRAT as the FRAT of choice for assessing falls risk among older adults in residential care settings. Ruggieri et al. (2019) systematic review identified the FES-1 and ABC as the most utilised and most reliable FRAT for predicting falls among community-dwelling older adults. The systematic review highlighted that many validated FRATs utilised within residential care settings lacked predictive accuracy data and therefore could not be included.

Within the Irish context, the Irish Longitudinal Study on Aging was included in the comparative study by Palumbo et al. (2016) however, analysis was based on falls risk predictors derived from a cohort of community dwelling older adults which does not represent the older adult population in LTC settings. In contrast, the independent validation of the FRASE was conducted among hospitalised older adults in Ireland by Cannard (1996) however the evaluation did not measure the sensitivity and specificity of the FRAT. Nevertheless, the predictive accuracy of the FRASE was examined in one quasi-experimental study within the acute setting in England (Jester et al., 2005) and subsequently included in a systematic review by Narayanan et al. (2016) of FRATs utilised within the National Health Service mental health trusts in England. Although the FRASE delivered a high inter-rater reliability, the predictive accuracy was poor among the retrospective group and deemed only slightly better than random probability among the prospective group (Jester et al., 2005). Irrefutably, the literature highlights a scarcity of effective FRATs (da Costa et al., 2012) and fails to identify a

FRAT of choice for assessing falls risk among older adults (Nunan et al., 2018). No FRAT demonstrated exceptional predictive accuracy (Vassallo et al., 2005; Wijnia et al., 2006; Scott et al., 2007; Oliver et al., 2008; Wong Shee at al., 2012; Matarese et al., 2014; Narayanan et al., 2016; Harper et al., 2017; Baran and Gunes, 2018; Park, 2018). Consequently, academics and clinicians question the effectiveness of time-consuming assessments in clinical settings where fall prevention interventions are standard care (Wijnia et al., 2006; Strupeit et al., 2016).

2.4 Theme Two: The relationship between older adult faller status and intrinsic falls risk predictors

Evidence suggests the greater the number of intrinsic impairments, the greater the risk of falling (Callisaya et al., 2012). The studies presented describe the relationship between older adult's faller status and the intrinsic fall risk variables assessed within the FRATs. Many studies identify falls risk predictors that are reflected in the falls risk variables in the FRASE risk assessment tool. The fall risk predictors are also evident in studies of other FRATs, namely gender and age (Castellini et al., 2017), gait and balance (Power et al., 2014), impaired vision (Aranda-Gallardo et al., 2017), previous history (Wijnia et al., 2006), medication (Higaonna, 2014), mental status and medical history (Ivziku et al., 2011). Although, targeted multifactorial fall prevention programs are recommended to prevent falls among older adults, the effectiveness of this approach is reliant on the appropriateness of the falls risk predictors identified for the population of interest (Russell et al., 2008). Therefore, it is of paramount importance that the FRATs applied in clinical practice assess fall predictors that show an acceptable level of sensitivity and specificity for the population of interest (Callis, 2016).

2.4.1 Theme Two: review of the literature

Smith et al. (2006) advocate the development of disease specific FRATS following a prospective cohort study to evaluate the predictive validity and reliability of the STRATIFY within stroke rehabilitative units. The sample (n = 378) included all patients with a diagnosis of acute stroke admitted to any of the six participating stroke rehabilitation units. The three-stage study investigated falls risk in hospital, post hospital discharge in conjunction with the tools test-retest reliability. Inclusion exclusion criteria for stage one necessitated a hospital admission period of less than 28 days during the 6-month study period and no omissions within the patients STRATIFY assessment data. Stage one involved a weekly assessment of falls risk using the STRATIFY falls risk assessment tool and again within 48 hours of the included samples (n = 225) anticipated discharge. To avoid bias through variation in exposure to falls risk, the predictive validity of the STRATIFY for stroke inpatients (n = 225) was established during the 4 weeks following baseline assessment. To avoid duplication bias, the unit of analysis was the patient rather than the fall, with 30% (n = 108) experiencing at least one fall during their hospitalisation period. Analysis of stage one showed a low sensitivity (11.3%) and PPV (25%) for the STRATIFY while the ROC curve was virtually a straight line thus indicating a test with poor discrimination.

Stage two, post discharge study replicated the analysis of diagnostic validity measures based on the 82% (n = 234) of patients who consented to remain in the study for 3 months post discharge. Statistical analysis showed no improvement in the predictive accuracy of the STRATIFY with a low sensitivity (16.3%) and PPV (38.2%). The ROC curve remained a straight line indicating a test with poor discrimination. Reliability testing showed good agreement (kappa = 0.639) when comparing the discharge scores against the scores obtained during the week preceding discharge.

Although the application of the STRATIFY on older adults following a stroke yielded poor psychometric properties, several potential limitations require consideration. Older adults are most likely to fall shortly after their admission to hospital (Vasallo et al., 2003). Consequently, as the participating stroke units received transfers rather than direct admissions, falls which occurred prior to admission to the stroke unit may not have been captured during the initial assessment. As falls data was based on the hospital's incident reports system possible inaccuracies due to under reporting may have occurred. In addition, inter-rater and intra-rater reliability testing was not undertaken and inconsistencies in the completion of the STRATIFY may have influenced the poor predictive accuracy results achieved. Finally, the constituents of the STRATIFY were not relevant for all stroke patients and may also account for the poor validity scores achieved. Consequently the study recommends the development of disease specific FRATs however, the study accepts that restricting primary analysis made no significant improvement to the sensitivity of the tool.

To support the identification of accurate falls risk predictors Aranda-Gallardo et al. (2017) undertook a longitudinal, multicentre prospective cohort study. The study aimed to evaluate the predictive accuracy of the STRATIFY and Downton Index FRATs in determining falls risk and evaluate the diagnostic performance of both FRATs through periodic re-evaluation. The initial sample recruited (n = 1,247) consisted of adult patients with an expected hospital stay exceeding forty-eight hours. The adult patients were assessed for falls risk by both FRATs within forty-eight hours of their admission and thereafter every seventy-two hours until their discharge. To minimise the risk of under reporting, the occurrence of falls was verified by consulting with patients and / or relatives directly, detailed examination of the patient's clinical notes, analysis of the hospitals falls record and finally consulting with the nursing team. Incomplete data and failure to reassess at seventy-two-hour intervals resulted in a reduced sample size (n = 977) comprising of males (53%, n = 518) and females (47%, n = 459) with an average age of sixty-five years.

The data collection period was twenty-one months and the total number of falls recorded was twenty-four with one patient identified as experiencing more than one fall. All recorded falls (n = 24) were experienced between the patient's initial assessment and their follow up assessment on day twenty-one of their hospital stay. Analysis of the falls recorded (n = 24) shows a peak in falls incidences on day three of admission (n = 9), with a total of fifteen falls occurring during the first week. Fallers (n = 23) were significantly older than non-fallers (n = 954). The mean age of fallers (n = 23) was seventy-three years. Women experienced more falls (n = 14) than men (n = 10) however the difference was not statistically significant ($p = 0.565$). The STRATIFY identified a "risk of falls" in 16.2% of cases (n = 548) however, only 1.8% (n = 10) experienced a fall. Similarly, the Downton index identified a "risk of falls" in 45% of patients (n = 1541) however, only 0.9% of these cases experienced a fall (n = 14). ROC analysis presented an AUC of 0.69 for the STRATIFY which was higher than the AUC of the Downton Index (0.6) indicating the STRATIFY showed greater predictive accuracy.

A subgroup of patients (n = 597) aged sixty-five years and older were further analysed due to the statistically significant age increase between fallers (n = 23) (73.57 years) and non-fallers (n = 954) (65.39 years). Analysis compounded the previous results, awarding an AUC of 0.63 to the STRATIFY and a lower AUC of 0.55 to the Downton index. Referring to the original study group (n = 997) the fall risk variable most associated with falls incidences of falls (n = 24) was identified using hazard analysis where a HRR <1 indicates a 'protectives factor', HRR=1 signifies 'no influence' and a HRR >1 indicates a 'relative risk'. In addition, a *p* value <0.05 indicates a statistically significant difference between two groups, fallers (n = 23) and non-fallers (n = 954). The STRATIFY measured agitation, confusion, and frequent toileting as potential risk factors, while the Downton Index measured medication use and sensory deficit. The discrimination of a 'high risk of falls' varied between the two FRATs, although the STRATIFY and Downton index both acknowledged previous falls and present mobility as risk factors. Showing HRR >1 and *p* values <0.05 age (HRR 1.02, p=0.033), previous falls history (HRR 2.02, p = 0.013), visual impairment (HRR 3.00, p=0.000) and the need for frequent toileting (HRR 2.11, p = 0.005) were all identified as a significant fall predictor. Women experienced more falls (n = 14) than men (n = 10) no statistically significant difference was identified as the HRR was <1 (HRR 0.77) and the p value was > 0.05 (p = 0.208).

The observational design of the study however may lead to infer conclusions devoid of the clear cause-effect relation which is characteristic of experimental study designs. Consequently, residual confounding variable may be associated with the results, which must be interpreted with caution due to the limited statistical power derived from the low occurrence of falls (n = 24). In addition, findings may have been influenced by the possibility that falls incidence were underreported and/ or consciously or unconsciously prevented by the systematic establishment of protective measures. Nevertheless, the study concludes that a valid instrument which conforms with the recommendations of the NICE (2013) guidelines has yet to be developed to quantify falls risk among hospitalised adults. The study's recommends focusing predominantly on a previous history of falls when examining individuals' falls risk predictors.

This recommendation is shared by Demura et al. (2011) following a cross sectional data set study which examined the validity of the fall risk assessment items (n = 50) in the Demuras Fall Risk Assessment Chart (DFRA). The study was undertaken on a sample of healthy Japanese older adults (n = 1,122) comprising of males (n = 380) and females (n = 742) with an average age of 70.3 years. In total, 15.8% (n = 177) experienced a fall in the previous year. The study assessed fall experience and the five risk variables represented by the falls risk assessment items (n = 50) within the DFRA, symptom of falling (n = 3), physical function (n = 22), disease and physical symptoms (n = 13), environment and behaviour and character (n = 4). The three falls risk assessment items that assessed symptoms of fall were stumble, feel like falling in the preceding year or look like falling. The falls risk assessment items (n = 22) for physical function were derived from three components (fundamental function, advanced function and gait) and eight elements (balancing ability, muscular strength, lower limb strength, walking ability, going downstairs, changing and holding posture, upper limb function and gait). The falls risk assessment items (n = 13) for physical function were derived from six components (medication, dizziness and blackout, sight/hearing and cognition disorder, cerebral vascular, circulatory disease, and arthritic and bone disease). The environment assessment falls risk items (n = 4) were categorised within two components (surrounding environment and clothing). Finally, the behaviour and character falls risk assessment items (n = 8) were derived from four components (inactivity, frequent urination, fear of falling and risk behaviour). A dichotomous scale (yes or no) was used for all questions therefore a response of 'yes' in a in high risk category was considered a high-risk response.

The overall score was calculated by totalling the DFRA item score (n = 50), while fall risk scores were calculated by collating the items representing the five risk variables, symptom of falling (n = 3), physical function (n = 22), disease and physical symptoms (n = 13), environment (n = 4) and behaviour and character (n = 8). The frequency and odds ratio for every total (fall risk factor score) was calculated. Critically, the study identified significant differences between the group of fallers (n = 177) and non-fallers (n = 945). Relative frequency refers to the proportion of times a value appears in a specific data set, among the group of fallers (n = 177), symptoms of falling was the most prominent fall risk variable. In addition, distinctive distribution was found in physical function, disease and physical symptoms and behaviour and character. In contrast, in relation to environment as a fall risk factor no significant difference was identified between the two groups. Discriminant analysis was undertaken using fall experience as a dependent variable and the five fall risk variables, symptom of falling (42.5%), physical function (0.6%), disease and physical symptoms (0.6%), behaviour and character (1.1%) and environment (0.0%) as the independent variable.

The odds ratio (OR) and incidence of fall experience was calculated for every point of the total or risk variable scores to confirm the relationship between fall experience (fall risk) and the total and risk variable scores. An OR is a relative measure of effect when comparing two groups. The OR score equals 1 if there is no difference, an OR score < 1 deems the intervention better than the control and an OR score > 1 deems the control better than the intervention. The OR ranged from 0.0 to 74.8 when calculated for every point of the total score. The OR of all 5 fall risk factors was ＞5 at 24 points or more of the total score, and 50% when the total score was at 27 points. The OR results showed increasing falls incidences with increasing total score. In addition, increasing each risk factor score increased the tendency of falls incidences in each risk factor with physical function (78%), disease and physical symptoms (75%) and symptoms of falling (73%) acquiring the highest values. Significantly, behaviour and character (41%) and environment (33%) produced lower values suggestion their impact as a falls risk predictor is lower. Overall, among the 15.8% of healthy older adults who experienced a fall (n = 177), the symptom of falling score (42.5%) provided the best predictor of fall risk. The study concluded that almost all risk items in the DFRA (n = 50) could be explained by assessment items (n = 3) associated with the symptom of falling risk factor. Therefore, the assessment of symptoms of falling may be superior at predicting falls among the healthy older adult population.

Impaired balance was identified in Ivziku, et al. (2011) prospective descriptive study to evaluate the predictive accuracy and IRR of the HFRM-II. The sample (n = 179) comprised of males (n = 74) and females (n = 105) aged sixty-five years and older with a mean age of 79.47 years who were admitted consecutively over an eight-month period to an older adult care setting. The principal investigator provided specific training to all nurses involved in the screening process of older adults admitted (n = 179) with the HFRM-II. To ensure full completion of the tool, older adults confined to bed or unconscious were excluded. IRR was achieved through the application of the HFRM- II by two nurses independently to a convenience sample of older adults (n = 24) admitted during the first two weeks of the eight-month study. The screening process categorised the older adults into two groups, those ‘at risk’ of falls (n = 106) and those ‘not at risk’ of falls (n = 73). The most prevalent falls risk factors screened on the sample (n = 179) were vertigo (49%), incontinence (48%), depression (46%), and confusion (32%). In total, 14 falls incidences occurred, with males (n = 7) and female (n = 7) experiencing equal number of falls. The mean age of the older adults who experienced a fall (n = 14) was 81 years, with no significant age difference between the mean age of males (n = 7) (81.4 years) and females (n = 7) (80 years). The odds ratio of each risk variables identified within the HFRM-II (confusion, depression, incontinence, vertigo, gender (male), benzodiazepines, antiepileptics and get up and go score ≤ 3) were calculated to identify the falls risk variables that affected falls (n = 14) in the older adult sample (n = 179). Consistent to the weight attributed to these risk factors, confusion with a score of 4 and depression with a score of 2 where the only two risk factors significantly related to the falls (n = 14) yielding an OR value of 4.26 and 3.22, respectively.

Among the group of older adults deemed ‘at risk’ of falls (n = 106), 11% (n = 12) experienced a fall whilst 2.7% (n = 2) experienced a fall within the group of older adults deemed ‘not at risk’ (n = 73). Statistical analysis yielded a very good sensitivity (86%) showing the HRFM-II had very good accuracy at identifying older adults who experienced a fall as ‘at risk’. The HRFM-II yielded a low PPV (11%) however as only 12 older adults that experienced a fall were categorised as ‘at risk’ of falls (n = 106). A high NPV (97.26%) was achieved through seventy-one older adults that did not experience a fall being correctly categorised as ‘not at risk’ of falls (n = 73). Specificity represents the total number of non-fallers, correctly categorised as ‘not at risk’ of falls. Data analysis identified ninety-four non-fallers were categorised as ‘at risk’, thus resulting in a false positive value (FPV) of 54% and below average specificity (43%). The low specificity achieved may be due to many factors including ward prevention measures, increased awareness among the older adults and their families of fall risk in the hospital setting, improvement in older adults' condition during their hospital admission and treatment paradox. Inter-rater reliability was based on the older adults admitted over a two-week period (n = 24) and yielded a kappa index of 0.87 which showed a rater disagreement. The study acknowledges the small size (n = 179) as a limitation and suggest enhanced statistical analysis may be achieved through a larger sample. In addition, the findings cannot be generalised due to the small number of falls experienced (n = 14). Nevertheless, despite the ease of application, calculation, and good sensitivity (86%), based on the low specificity (43%) achieved the study can only moderately recommend the HFRM-II to screen older adults in acute care settings for falls risk.

Cognitive impairment and agitation were also identified as fall risk factors among older adults in Wijnia et al. (2006) prospective study to evaluate the performance of the STRATIFY in assessing fall risk among older adults residing in nursing homes. The sample (n = 120) comprised of men (n = 45) and women (n = 75) with an average age of 74.5 years. On admission, each older adult was categorised according to their care requirements, rehabilitation (n = 40), psychogeriatric, (n = 42), palliative (n = 17) and chronically ill (n = 21). Subsequently, data collections recorded the older adult's admission category, age, gender, length of stay, number of falls and STRATIFY score. Data analysis of fall predictors involved the hazard rate ratio (HRR) where a HRR score < 1 indicates 'protective factor', a HRR score = 1 suggests no influence and finally a HRR score > 1 signifies relative risk. Although the small sample (n = 120) prevented a detailed analysis of sub-groups, the study identified a history of falling (HRR 2.38), a STRATIFY score greater than 2 (HRR 2.35), and agitation (HRR 2.29) as fall risk predictors among the sample of older adults (n = 120) residing in the nursing home. Critically, the study showed no connection between age (HRR 1.0) and falls risk in the older population. Overall 30% (n = 36) of older adults experienced one or more falls and 12.5% (n = 15) experienced two or more falls.

Analysis identified 12 older adults with a STRATIFY score of 0 which indicated 'no risk' of falls, experienced a fall. The majority (n = 8) were categorised as psychogeriatric due to their dementia diagnosis. In addition, 25% (n = 9) of fallers who experienced one fall (n = 36) resided in the psychogeriatric care unit. Older adults admitted for palliative care (n = 17) experienced the least number of falls (n = n = 2) possibly due to confinement to bed however the ambulatory ability of the older adults was not systematically examined. Significantly, despite the active nature of the environment only a small number of older adults (n = 4) admitted to the rehabilitation ward (n = 40) with a STRATIFY score of ≥ 2 (n = 14) experienced a fall. In comparison, more than double the number of older adults (n = 9) admitted to the psychogeriatric ward (n = 42) with a STRATIFY score ≥ 2 (n = 14) experienced a fall. A possible explanation for the lower number of fallers within the rehabilitation ward were ambulation support from physiotherapy sessions and the conscious or unconscious application of fall prevention measures as standard care within the ward**.** Nevertheless, as the study was undertaken in one setting the findings cannot be generalised to represent the older adult population residing in nursing home. In addition, no specific calculations were undertaken to analyse falls risk among the older adults who experienced repetitive falls.

Cognitive impairment as a predictor of future falls was also evident in Castellini et al. (2017) retrospective study to determine the suitability of the STRATIFY and a fall risk prevention programme in detecting falls risk among acute care inpatients. The study was undertaken in one acute care hospital between January 2014 and March 2015. The hospitals policy instructed all patients aged seventy-five years and older and all patients admitted to neurology or neurosurgery units warranted a STRATIFY fall risk assessment. In addition, the policy recommended falls screening to be undertaken on any patients with a history of falls, cognitive disorders, arthritis, visual or balance deficits. The STRATIFY comprises of five predictors of fall risk, history of falling, agitation, visual impairment, incontinence, and mobility (Oliver et al., 1997). The tools clinical usefulness has been the subject of many studies with conflicting predictive accuracy results (da Costa et al., 2012; Matarese et al., 2014).

The hospitals incident reporting database was retrospectively searched for falls incidences (n = 365) that occurred during the specified data collection period. Once fall incidences (n = 365) were confirmed, fall incidence data pertaining to the older adult males (n = 207) and females (n = 158) who experienced a fall were cross referenced against their STRATIFY score to identify the true positive rate (TPR) and false negative rate (FNR). The TPR represents the proportion of older adult patients who were deemed at 'high risk' of falls and thereafter experienced a fall. The FNR represents the proportion of older adult patients deemed a 'low risk' of falls yet thereafter experienced a fall. Only 79.6% of the fall incidence reports (n = 365) had an admission STRAIFY fall risk assessment score (n = 284) therefore, the cumulative frequency presented a TPR of 35.6% (n = 101) and an FNR of 64.4% (n = 183). Analysis of older adult patients that had no fall risk assessment on admission showed 20.4% (n = 74) had at least one of the five predictors of fall risk as per the STRATIFY, history of falling, agitation, visual impairment, incontinence, and mobility. Absolute frequency refers to the number of times a value appears in a specific dataset. The majority of fallers (n = 365) were men (56.7%, n = 207). The median age by gender was comparable (males 72 years, females 71 years). The most common fall risk predictors among fallers (n = 365) were cognitive impairment (n = 130), balance disorders (n = 102), neuromuscular and musculoskeletal disorders (n = 100). Critically, as per the STRATIFY, the fall risk predictors of falls history (n = 81), incontinence (n = 26) and sensory impairment divided into vision (n = 25) and hearing (n = 15) were significantly less common among the fallers (n = 365). Accordingly, these findings question the clinical usefulness of the STRATIFY in assessing fall risk across different patient populations.

This finding is further compounded by the prospective inception cohort study by Sherrington et al. (2011). The study aimed to develop an internally validated fall prediction tool to assess fall risk among older adults on discharge from an inpatient aged care rehabilitation setting. Possible fall predictors were collected at two hospitals from a sample (n = 442) of women (n = 313) and men (n = 129) with a mean age of 81.6 years. In the three months post discharge 150 older adults (34%) experienced 316 falls. Eighty-one older adults (18%) experienced one fall, while sixty-nine older adults (61%) experienced two or more falls. A fifteen-predictor model was utilised to discriminate fallers from non-fallers. Three variables were identified as significant fall predictors as their odds ratios (ORs) were >1 and their coefficient interval (CI) crossed 1 which also implies alteration. The three fall predictors identified were male gender (OR 2.32, 95% CI = 1.00 - 4.03), Central Nervous System medication (OR 2.04, 95% CI = 1.00 – 3.30) and increased postural sway (OR 1.93, 95% CI= 1.00 – 3.26). Statistical analysis relating to age resulted in an OR of 1 between the group of fallers (n = 150) and non-fallers (n = 288) thus implying age is not a predictor of fall risk and suggests physiological functioning and comorbidity may be greater fall predictors than chronological age. The study proposed possible behavioural differences between males and females, with males presenting frailer for rehabilitation as a possible explanation for their increased disposition to falls. Although the study presented interesting findings, external validation is warranted to test the tools ability in other settings.

In contrast age was significantly associated with faller status in the retrospective cohort design study by Higaonna (2014) to identify and compare the predictive accuracy of a Modified Japanese Nursing Association Fall Risk Assessment against the STRATIFY, MFS and HFRM-II. A sample of older adults (n = 4,144) in acute hospital settings were assessed at observation periods of seven, fourteen, twenty-one and twenty-eight days over a six-month period. Inclusion and exclusion criteria reduced the sample size (n = 3,266) due to incomplete fall risk assessment data. Statistical analysis of falls recorded (n = 49) during the six-month period, showed more than half (n = 28) were experienced by older adults aged sixty-five years and older (n = 1,266). Furthermore, fallers (n = 28) were significantly older (median age 72 years) than non-fallers (n = 1,238) (median age 60). The Modified Japanese Nursing Association tool identified twenty-one significantly larger variables between fallers and non-fallers, most of which were common to the risk factors identified by NICE (2013). Medication use showed the most statistically significant variation with anti-hypertensives (49.5%), analgesics (38.8%), hypnotics/ tranquilisers (24.5%) and diuretics (14.4%) showing a strong association with faller status. The predictive accuracy of the tool was accessed at periods of seven, fourteen, twenty-one and twenty-eights days. The AUC was highest at week seven (AUC= 0.81) and decreased thereafter. Likewise, a very good sensitivity (0.82) and good specificity (0.71) decreased proportionally. At week seven the sensitivity remained very good (0.83) but the specificity was reduced to moderate (0.66). At week twenty-eighty the sensitivity was reduced to good (0.78) and the specificity was reduced to below average (0.53).

The reduction in sensitivity and specificity suggests the tools accuracy decreased as the patient's length of stay increased. Nevertheless, the tool shows greater sensitivity and specificity on initial assessment when compared against the predictive accuracy values highlighted in the meta-analysis study by Aranda-Gallardo et al., (2013) of the STRATIFY (SENS 0.80, SPEC 0.68), MFS (SENS 0.76, SPEC 0.68) and HFRM-II (SENS 0.63, SPEC 0.64). The similarity between the fall predictors within the Japanese Nursing Association Fall Risk Assessment and the NICE (2013) guidelines may explain the tools predictive accuracy. However, as the study was conducted in a single hospital these findings cannot be generalised. The number of patients who experienced a fall (n = 49) was based on the hospital's incident reports, and the possibility of under-reporting must be considered, which may have undervalued the sensitivity and overvalued the specificity. In addition, the possibility of measurement errors must also be considered as multiple raters were used to access data.

A relationship between medication and falls risk was also identified in the prospective study by Latt et al. (2016). The validity and clinical variables of the STRATIFY, Ontario Modified STRATIFY (OM) and The Northern Hospital Modified STRATIFY (TNH) in predicting falls was examined in an acute/ subacute aged care unit in Australia. The study included all older adult patients aged sixty-five years and older admitted consecutively over a three-month period. Data was collected from each admission (n = 217) rather than each older adult patient (n = 206). Data collection was undertaken within three days and included age, gender, mobility status, accommodation prior to admission, past medical history, issues leading to admission, and treatments commenced or continued following admission for each older adult (n = 206) on each admission (n = 217). The study analysed the difference in age and length of stay between fallers and non-fallers using the *t*-test while the x^2 test was used to examine all other clinical indices. Two clinical indices, 'presentation with a fall' (OR 4.05, p=0.013) and 'use of psychotropics' (OR 5.47, p=0.001) demonstrated a significant difference between the fallers (n = 20) (9.2%) and non-fallers (n = 197). Consequently, both clinical indices were included in further analyses of diagnostic validity within the study.

Although the OM and TNH were designed to improve the sensitivity and specificity of the STRATIFY in identifying older adults at risk of falls (Barker et al., 2010), the study's diagnostic validity measures yielded opposing results.

The sensitivity of the OM (80%), TNH (85%) and STRATIFY (80%) was very good. The specificity however of the OM (37.1%) was low, in comparison to the average specificity of the TNH (51.3%) and moderate specificity of the STRATIFY (61.4%). Although the predictive values of the screening tools did not differ significantly the TNH (SENS 85.0%, SPEC 51.3%) showed greater predictive accuracy than the OM (SENS 80%, 37.1%). The STRATIFY (SENS 80%, SPEC 61.4%) showed the greatest predictive accuracy. Overall, data analysis for all three FRATs yielded low PPVs (OM 11.4; TNH 15.0; and STRATIFY 17.4) and high NPVs (OM 94.8; TNH 97.1; and STRATIFY 96.8). The below average accuracy of the OM (41%) was significantly lower than the average accuracy of the TNH (54%). Yielding a moderate accuracy of (63.1%) the STRATIFY achieved the greatest accuracy.

No significant difference was observed between the FRATs ability to differentiate between 'at risk' and not at risk' older adults (OM AUC 0.692; TNH AUC 0.715; STRATIFY AUC 0.732). Research by Oliver (2008) suggests FRATs and clinical predictors are ineffective in identifying potential falls among hospitalised older adults. The findings by Latt et al. (2016) indicate the diagnostic values of the clinical predictors 'presentation with a fall' (SENS 50.0; SPEC 80.2; accuracy 77.4) and 'use of psychotropics' (SENS 55.0; SPEC 81.7; accuracy 79.3) showed a lower sensitivity but a substantially higher specificity and accuracy than the three screening tools examined. Therefore, the clinical predictors of 'presentation with a fall' and 'use of psychotropics showed greater predictive accuracy in identifying older adults 'not at risk' of falls. Nonetheless, among the faller group (n = 20) up to 10% were misclassified as 'low risk' of falls by the OM (n = 1), TNH (n = 1) STRATIFY (n = 2) and 'presentation with a fall'. In addition, up to 15% of fallers (n = 20) were misclassified as 'low risk' of falls by both the OM (n = 3), TNH (n = 2) STRATIFY (n = 3) and 'use of psychotropic'.

Limitations encountered include the variation in length of hospital stay, as fallers (n = 20) experienced a significantly longer hospital stay than non-fallers (n = 197). This variation would have influenced the evaluation of the screening tools as repeat screening was not undertaken to account for changes among the older adults' clinical predictors and associated risk of falling. Furthermore, ethically nursing staff were not blinded to the OM scores, thus conscious or unconscious implementation of falls prevention strategies by nursing personnel may have lowered the predictive accuracy of the OM. The low PPVs achieved within the study can be linked to the low percentage of fallers (9.2%). In conclusion, Latt et al. (2016) question if FRATs should be discarded and all older adults considered 'high risk' of falls. Nonetheless, the study lacked a control group and therefore cannot recommend whether screening is better than not screening for resource allocation and falls prevention among hospitalised older adults. However, as data analysis identified the misclassification of up to 50% (n = 10) of fallers (n = 20) Latt et al. (2016) only recommends the use of screening tool when supplemented by clinical judgement.

A history of previous falls as a predictor of future falls was also identified in the systematic review of prospective studies on falls risk prediction among community dwelling older adults by Gates et al. (2008). The review focused on studies published in the English language between January 1966 and May 2007 that contained data fall incidences with a follow-up duration of at least three months. Hospital populations were excluded, as were studies based on specific diagnoses however studies of substantially independent older adults in residential care environments were included. Of the citations (n = 3,363) identified, 125 were extracted for abstract analysis, of which 25 studies were eligible for inclusion (n = 25).

Critically, the review analysis showed poor reporting measures with few studies (n = 4/25) studies specifying measures implemented to prevent knowledge of screening test results influencing falls outcomes. Most studies (n = 21/25) incurred a 20% loss or exclusion of participants. Attrition bias must be considered for some studies (n = 3/25) with reported losses and exclusions greater than 30%. Furthermore, the possibility of reporting bias lead to failures in reporting all screening tests performed (n = 8/25). While methodological issues may account for discrepancies between participants and reported results (n = 10/25). In total, 29 different screening tests were evaluated within the study sample (n = 25). The most commonly evaluated tests included the Tinetti Gait, Balance and Mobility Scales (n = 8), TUG (n = 4), MIFC (n = 2), Functional Reach Test (FRT) (n = 2), Tandem Stance (n = 2) and Walking Tests (n = 2). Significantly, despite Lamb et al. (2007) identifying the FRASE as one of the most commonly applied screening tools in the United Kingdom, no study included in the review (n = 25) evaluated the FRATs predictive ability (Gates et al., 2008). The review showed all screening tools achieved higher specificity than sensitivity thus implying greater accuracy in the identification of non-fallers than fallers. A sensitivity and specificity <80% was only achieved by two studies (Murphy et al. 2003; Panzer et al., 2011).

Review of the Tinetti Gait, Balance, and Mobility Scales studies (n = 8) showed the sensitivity range was poor (20% - 68%, 23% – 80%, 27% – 76% respectively) for all three tests. The specificity range was average to very good (63% – 95%, ≥ 66%, 52%-83% respectively. The NPV range was overall good (80% – 85%, ≥ 78%, 67% – 88% respectively). Critically, the PPV range was low (43% – 46%, 33% – 86%, 31% – 68% respectively). The Mobility Interaction Fall Chart studies (n = 2) sensitivity ranged between below average (43%) and very good (85%) while specificity ranged between moderate (69%) and very good (82%). Conflicting results were identified in the studies pertaining to FRT. Murphy et al. (2003) small scale study (n = 50) identified good sensitivity (73%) and very good specificity (88%) however a larger study by Lin et al. (2004) (n = 1,200) yielded a ROC value of 5.1 which suggests the test offers no discriminatory ability between fallers and non-fallers. Diagnostically the Walking Test studies (n = 2) identified excellent sensitivity (93%) but low PPV (21%). The Tandem Stance test showed average sensitivity (55%) but excellent specificity (94%). No meta-analysis was performed on the TUG test studies (n = 4) due to different versions and cut-off versions used.

Although numerous studies existed (n = 25) due to methodological issues, incompatible data, and poor reporting, the study was unable to present a quantitative summary of the predictive accuracy of the fall risk screening tools examined. Nevertheless, the study identified a history of falls and reported abnormalities of balance or gait are consistently the best predictors of a future fall. Accordingly, the study concludes that further research is warranted to provide a sound evidence base for the continued use of screening tools in clinical practice, as complex screening tests may provide little or no additional value.

Abnormalities of balance or gait were also identified by Power et al. (2014) as the most accurate task performance measures for identifying falls risk among community dwelling older adults. The systematic review of studies (n = 37) between 1996 – 2013 explored task performance in relation to falls incidence. The studies were divided into three categories, clinical based assessments (n = 20), laboratory-based assessments (n = 7) and assessment tools with a mixture of both (n = 10). Within the clinical environment the most frequently observed performance measures were the TUG (n = 13), Five Times Sit-to-Stand Test (FTSS) (n = 10), assessment of standing balance (n = 9), gait speed measurements (n = 8) and the Berg Balance Scale (BBS) (n = 6). The most frequently used measures within the laboratory-based assessments were postural sway and gait analysis.

The TUG necessitates completion in less than 13.5 seconds (s), otherwise one is classified as ‘at risk’ of falls. A high sensitivity (87%) and specificity (87%) was noted with a cut off time between 12 s to 13 s (Shumway-cook et al., 2000). While healthy older adults were described by pooled reference times of 8.1 s to 11.3 s (Bohannon, 2006) only the time, rather than the quality or safety of the performance was measured (Power et al., 2014).

The FTSS demands completion within 15 s for identifying recurrent fallers based on their previous work (Buatois et al., 2008). Single and multiple falls are predicted should an older adult fail to complete the test (Zhang et al., 2013). To achieve the standing balance test, one must maintain one-legged balance for 5 s, failure to achieve indicates a risk of recurrent falls (Buatois et al., 2010). Critically, observation of changes in arm position during tandem stance yield greater sensitivity and specificity as a predictor of recurrent falls (Beauchat et al., 2010). Studies pertaining to gait speed showed strong association between slow speeds (<0.6 m/s) and fast speeds (>1.3 m/s) and falls risk (Kelsey et al., 2010, Viccaro et al. 2011, Quach et al., 2011).

Despite widespread use only one study identified the BBS as a useful predictor of falls (Kelsey et al., 2010). Research suggests the BBS fails to challenge community dwelling older adults, with a cut off score of less than 40 indicating moderate fall risk (Shumway-cook et al. 2000). The FRT identifies poor maximal reach distances, suggesting a functional reach ≤ 15cm approximately doubles an older adults' risk of falling base on incorrectly judging one's own reaching ability. However, Inoue et al., (2012) argue prospective discrimination between fallers and non-fallers cannot be deciphered between functional nor lateral reach.

Among the laboratory-based assessments, although greater postural sway was associated with increased fall-risk (Swanenburg et al., 2010), total length of sway, sway area and excursion (Panzer et al., 2011) varied between studies thus reducing its usefulness as a predictor of falls (Power et al., 2014). Force-sensitive insoles (Herman et al., 2010), body-worn sensors (Doi et al., 2013) and instrumental walkways (Callisaya et al., 2012) were employed throughout the studies that analysed gait. Analysis showed wider step length, fast walking speed and shuffling pattern indicated greater falls risk. Gait variability measures such as stride time and swing time, double support phase time and overall step time were also deemed to predict falls (Callisaya et al., 2011). Nevertheless, the recording of such parameters is beyond most clinical settings ability due to the equipment required and therefore of no assistance to falls prediction or prevention (Power et al., 2014).

As the review intended to focus particularly on falls prediction, only prospectively monitored incidences were included. Nevertheless, as falls incidence measurements relied on recall-based methods for eleven studies the possibility of significant underreporting cannot be ruled out. Although an extensive and inclusive search was undertaken, potentially relevant articles may have been omitted in error. Similarly, published studies on the broader assessment of falls among older adults or assessment tool designed for older adults with specific conditions or residing in settings other than the community were excluded. Nonetheless, as the studies included were of high methodological quality, clinicians may be guided by the findings when selecting appropriate tests for predicting falls among community dwelling older adults (Power et al., 2014).

2.4.2 Summary of Theme Two

The literature (n = 10) presented in theme two describes FRATs (n = 14) however no FRASE risk assessment tool was identified for inclusion. The studies included examined the relationship between older adult faller status and various falls risk predictors in acute (n = 5) (Ivziku et al., 2011; Higaonna, 2014; Aranda-Gallardo et al., 2017; Castellini et al., 2017; Latt et al., 2016), rehabilitation (n = 2) (Sherrington et al., 2011; Smith et al., 2006), community (n = 3) (Demura et al., 2011; Power et al., 2014; Gates et al., 2008) and LTC (n = 1) (Wijnia et al., 2006) settings.

The most commonly identified predictor of a future fall among older adults in the literature presented was a history of a previous fall (n = 4) (Wijnia et al., 2006; Aranda-Gallardo et al., 2017; Latt et al., 2016; Gates et al., 2008) including the symptom of falling (n = 1) (Demura et al., 2011). The second most commonly identified predictor of a future fall among older adults in the literature presented was medical history (disease/ physical symptoms) (n = 4) (Wijnia et al., 2006; Demura et al., 2011; Ivziku et al., 2011; Castellini et al., 2017). The disease/ physical symptoms identified were confusion/ cognitive impairment (n = 3) (Wijnia et al., 2006; Ivziku et al., 2011; Castellini et al., 2017), depression (n = 1) (Ivziku et al., 2011), neuromuscular and musculoskeletal disorders (n = 1) (Castellini et al., 2017), vertigo (Ivziku et al., 2011), agitation (Wijnia et al., 2006). The third most commonly identified predictor of a future fall was a balance deficit or postural sway (n = 3) (Sherrington et al., 2011; Castellini et al., 2017; Gates et al., 2008) and medication (n = 3) (Sherrington et al., 2011; Higaonna, 2014; Latt et al., 2016).

In the literature presented, gait abnormalities (n = 2) (Gates et al., 2008; Power et al., 2014) and frequent toileting (n = 2) (Aranda-Gallardo et al., 2017; Ivziku et al., 2011) were the next most commonly identified predictors of a future fall among older adults. Similarly, gender (n = 2) was statistically associated with faller status (Sherrington et al., 2011; Castellini et al., 2017). However, the longitudinal prospective cohort study (n = 977) on the Downton Index by Aranda-Gallardo et al. (2017) identified no statistically significant difference between older adult faller status and gender. Latt et al. (2016) suggested the practice of considering all older adults as 'high risk' of falls. Indeed Aranda-Gallardo et al. (2017) identified age as a significant fall predictor and Higaonna (2014) identifying fallers (n = 28) as significantly older than non-fallers. Nevertheless, a number of studies (n = 2) identified no statistically significant relationship between age and faller status (Wijnia et al., 2006; Sherrington et al., 2011). A number of other predictors of a future fall among older adults were identified, reduced mobility/ physical function (n = 1) (Demura et al., 2011), a STRATIFT score > 2 (n = 1) (Wijnia et al., 2006), behaviour and character (n = 1) (Demura et al., 2011), length of stay (n = 1) (Higaonna, 2014), and visual impairment (n = 1) (Aranda-Gallardo et al., 2017).

Castellini et al. (2017) assert the FRATs currently available to clinicians fail to comprehensively capture fall risk predictors for older adults. Demura et al. (2011) emphasize accurate identification of individual risk is paramount to the provision of a comprehensive fall risk profile among the older adult population. This view is replicated in many studies with both Wijnia et al. (2006) and Sherrington et al. (2011) cautioning the introduction of FRATs validated in other settings or among different populations. Accentuating the need for accurate fall predictors to ensure accurate assessment, Smith, et al., (2006) recommend the development of disease specific FRATs. This view is supported by Ivziku et al. (2011) urging further research, development and validation of FRATs to create revised scales that accurately reflect the fall risk predictors of older adults in diverse clinical environments.

Demura et al. (2010) note that excessive emphasis on immutable fall risk predictors within FRATs may limit the development of countermeasures to prevent falls, especially among the healthy older adult population. This view is compounded by Aranda-Gallardo et al. (2017) recommendation to promote a programme of prevention based on known fall risk predictors. Nevertheless, Higaonna (2014) recommends further research is warranted on the frequency of falls, while Sherrington et al. (2011) assert further research on gender as a predictor of future falls is warranted. Although Power et al. (2014) recommend the TUG test, FTSS and gait speed assessment for assessing falls risk, these tests were designed for community dwelling older adults and can be difficult to implement in the clinical setting. Conversely, Gates et al. (2008) assert the best predictor of a future fall among older adults is a history of falls and abnormalities of balance or gait.

2.5 Chapter conclusion

The literature discussed in this chapter identified two prominent themes within the context of identifying older adults at high risk of falls. The application of a FRAT validated in a setting besides the LTC setting (where it was conducted) requires caution due to the unknown sensitivity and specificity of the FRAT when implemented in a new setting (Wijnia et al., 2006, Scott et al., 2007, Matarese et al., 2014). The diagnostic accuracy of the independent validation study on the FRASE risk assessment tool (Cannard, 1996) is uncertain as the sensitivity and specificity of the FRAT was not specifically examined (Jester et al. 2005). Furthermore, no national or international study was sourced that determined the predictive accuracy of the FRASE risk assessment tool among the older adult population in LTC settings. In addition, no study was sourced that specifically explored the relationship between older adult faller status and intrinsic fall risk predictors in the LTC settings in Ireland. Therefore, this study will determine the predictive accuracy of the FRASE risk assessment tool in identifying older adults at high risk of falls within the LTC setting of Community Hospitals/ Nursing Units in Ireland. In addition, the study will determine the relationship between older adult faller status and the intrinsic falls risk predictors of gender, age, gait, sensory deficit, falls history, medication, medical history, and mobility as identified within the FRASE risk assessment tool. Chapter three details the methodological approach taken in this study to investigate the research questions proposed.

Chapter 3: Methodology

3.1 Introduction

This chapter justifies the research methodology employed to determine the predictive accuracy of the FRASE risk assessment tool in identifying older adults at high risk of falls. Section 3.2 clarifies the philosophical underpinnings of the study. In section 3.3 the research paradigm selected is presented. It explores the research method employed and articulates the suitability of the method chosen for the study. The study aims, objective and research questions are presented in section 3.4. This is followed by section 3.5 which describes the research design, the research tool developed for data collection and the validity and reliability of the research. In section 3.6 the sampling method employed, access and recruitment of a HSE Data Controller and Data Processors is outlined in accordance with Article 6 of General Data Protection Regulations (GDPR) (GDPR, 2018, Government of Ireland, 2018). Section 3.7 attests the study's adherence to the ethical dimensions of the research.

3.2 Philosophical position of the research

Polit and Beck (2017) define nursing research as a systematic inquiry to create trustworthy evidence relating to issues of importance to the nursing profession. Clinical nursing research guides nursing practice to improve the quality of life and health of patients (Tingen et al., 2018). Nursing research is differentiated in its research approach and contribution to knowledge by ontological, epistemological and methodological differences (Welford et al., 2011). Crotty (1989) defined ontology as the study of being. In research, ontological assumptions are founded on what constitutes reality (Scotland, 2012). In this study a single objective reality of realist ontology was used. A realist ontology is opposite to that of a constructionist (Nicholls, 2009a). Constructionists embrace a multiple and subjective reality, mentally constructed by individuals, with no cause and effect (Grant and Giddings, 2002). In contrast, realists embrace a single reality, driven by real natural causes and subsequent effects (Polit and Beck, 2017). The realist ontology is founded on the belief that objects/ phenomena are comprised of physical properties that exist regardless of our ability to perceive them. The realist ontology commands to see the truth and has been the basis of clinical trials, validity and reliability tests, experimental and quasi-experimental designs, and a plethora of other quantitative designs since the 17th century (Nicholls, 2009a). The realist ontology reflects the aim of this study, to determine the predictive accuracy of the FRASE risk assessment tool in identifying older adults at high risk of falls. The application of a realist ontology enabled detached analysis of the usefulness of the FRASE without considering the subjective experiences of the older adults, their interconnections with others or social and cultural systems.

The ontological position of a study influences the epistemological position (Grant and Giddings, 2002) which is the mode of inquiry (Wakefield, 1995, Rawnsley, 1998, Cohen et al., 2007) and manner in which knowledge is produced, obtained and communicated (Converse, 2012, Scotland, 2012). The epistemological assumptions subsequently constrain the methodological approach of the study, and the choice of research paradigms through which to view or accomplish the investigation (Welford et al., 2011). Mackenzie and Knipe (2006) refer to paradigms as a loose group of understandably related assumptions and beliefs that orient thinking and research. Nursing research recognises many paradigms with no single paradigm unequivocally superior to another (Weaver and Olson, 2006). Paradigm choice is guided by the critical appraisal of existing literature concerning a particular area of nursing and the purpose of the inquiry (Welford et al., 2011). International research presented in Chapter 2 indicated limited clinical efficacy among FRATs in predicting falls risk among older adults (Vassallo et al., 2005; Wijnia et al., 2006; Scott et al., 2007; Oliver et al., 2008; Wong Shee at al., 2012; Matarese et al., 2014; Narayanan et al., 2016; Harper et al., 2017; Baran and Gunes, 2018; Park, 2018). The literature review affirms, establishing the predictive accuracy of FRATs necessitates the creation of objective knowledge in order to determine the clinical efficacy of the tools in identifying falls risk among older adults.

3.3 Post positivist paradigm

Research recognises numerous paradigms (Weaver and Olson, 2006; Clark and Creswell, 2015; Denzin and Lincoln, 2018) often presented as a trajectory, illustrating the continuum from positivism/ post positivism which focuses primarily on objective research predominantly through quantitative methods, to constructionism/ interpretivism which focuses primarily on subjective research predominantly through qualitative methods (Kelly et al., 2018). Weaver and Olson (2006) consider the postpositive paradigm appropriate for the study of nursing questions that require the systematic gathering and analysis of data from representative samples, practical clinical information relating to precise interventions and predictive theories for 'at risk' populations and individuals. Despite maintaining the positivist emphasis on defined concepts and variables, Willis (2007) described post positivism as a 'milder form' of positivism. Post positivism is a modified scientific method for the social sciences, producing objective and generalisable knowledge and seeking to affirm the presence of relationships amongst pre-defined variable (Taylor and Medina, 2011).

The inquiry approaches open to a researcher within a particular paradigm is defined by the paradigm itself (Rawnsley, 1998). Accordingly, methodology is the theory behind the choice of methods employed for yielding information to achieve epistemological aims (Crotty, 1989; Rawnsley, 1998). This study is founded on the post positivist paradigm, reflecting the ontological underpinnings of realism and epistemological underpinnings of objectivity (Weaver and Olson, 2006). The post positivist paradigm is deemed synonymous with quantitative research methods (Grant and Giddings, 2002). A post positivist epistemology is demonstrated through quantitative research designs that employ treatment, outcome measures and experimental units without random assignment to create comparison from which treatment caused change is inferred (Taylor and Medina, 2011).

Consequently, a quantitative approach was deemed most appropriate to answer the aim and objectives of this research study. Quantitative research celebrates objectivity, rationalism, value-neutrality, detachment and logical reasoning (Nicholls, 2009a). Quantitative research is centred on empirical evidence which is rooted in objective reality rather than the researchers' personal beliefs (Polit and Beck, 2017). Theories in research are produced and tested by two distinct forms of reasoning, qualitative research utilises inductive reasoning to produce theories while quantitative research utilises deductive reasoning to test theories. Like quantitative research, deductive reasoning characteristically begins with a testable hypothesis which requires the collection and analysis of a substantial volume of data to produce a specific outcome applicable to a discrete population. Deductive reasoning allows for the generalisation of findings within quantitative research due to strict adherence to the experimental method employed (Nicholls, 2009b).

3.4 Study aims, objectives and research question

3.4.1 Study aims

The primary aim of this research study is to determine the predictive accuracy of the FRASE risk assessment tool in identifying older adults at high risk of falls in Community Hospitals/ Nursing Units. The secondary aim of the research study is to determine the relationship between older adult faller status and the risk factors; gender, age, gait, sensory deficit, falls history, medication, medical history and mobility as identified in the FRASE risk assessment tool. For the purpose of this study from here-in as used in the literature, older adults who do not experience a fall will be referred to as 'non-fallers' and older adults who experience a fall will be referred to as 'fallers'.

3.4.2 Study objectives

Based on the aims of the study the following objectives were developed,

- To describe the sample of older adult data and the fall incident category information.

- To determine the predictive accuracy of the FRASE risk assessment tool in identifying older adults at high risk of falls.

- To determine the relationship between older adult faller status and the following risk factors; gender, age, gait, sensory deficit, falls history, medication, medical history, and mobility.

3.4.3 Research question

A research question is a concise interrogative statement developed to direct a study (Grove et al., 2015). Analysis of previous published research instigate the formulation of a hypothesis and development of a research question (Polit and Beck, 2017). Considering the preceding literature review and ongoing ambiguity in the evidence base surrounding the predictive accuracy of FRATs the two-fold research question is,

What is the predictive accuracy of the FRASE risk assessment tool in identifying older adults at high risk of falls?

What is the relationship between older adult faller status and the risk factors; gender, age, gait, sensory deficit, falls history, medication, medical history and mobility as identified in the FRASE risk assessment tool?

3.4.4 Research hypotheses

The positivist researcher aims to develop and statistically test a hypothesis, a proposition of cause (independent variable) and effect (dependent variable) about a problem (Grant and Giddings, 2002). The research question is driven by the hypothesis (Lash et al., 2011). A research hypothesis is a statement created by the researcher(s) upon speculating on / predicting the outcome of a research or experiment (Hollins Martin and Fleming, 2010). Research within the post positivist paradigm focuses on falsifying hypotheses (Weaver and Olson, 2006), therefore the study hypotheses are presented as null hypotheses and are presented as follows:

H1: There is no relationship between faller status and gender as determined by the FRASE risk assessment tool

H2: There is no relationship between faller status and age as determined by the FRASE risk assessment tool

H3: There is no relationship between faller status and gait as determined by the FRASE risk assessment tool

H4: There is no relationship between faller status and sensory deficit as determined by the FRASE risk assessment tool

H5: There is no relationship between fallers status and falls history as determined by the FRASE risk assessment tool

H6: There is no relationship between faller status and medication as determined by the FRASE risk assessment tool

H7: There is no relationship between faller status and medical history as determined by the FRASE risk assessment tool

H8: There is no relationship between faller status and mobility as determined by the FRASE risk assessment tool

3.5 Research Design and Data Collection tool

3.5.1 Research design

The research design is the plan for achieving answers to the research question (Polit and Beck, 2017). The positivist researcher develops a detailed protocol, from the derived hypotheses to the proposed statistical analysis process (Grant and Giddings, 2002). A quantitative methodology approach was undertaken due to its suitability to measure and evaluate the degree to which certain phenomena occur (Grove et al., 2013). Quantitative methodologies may be experimental, descriptive, or correlational in design. In experimental research, a treatment or intervention is actively introduced by the researcher while in non-experimental research the data is collected without the researcher interfering. Non-experimental research includes descriptive studies that review the significance of phenomena and correlational studies that examine the relationship between variables, with no manipulation of the independent variable

(Grant and Giddings, 2002). Descriptive correlational studies describe the relationship between phenomena without citing a casual explanation (Polit and Beck, 2017).

As stated in 3.4.1, the aim of this study is to determine the predictive accuracy of the FRASE risk assessment tool in identifying older adults at high risk of falls. However, the remaining objectives of this study focused on determining relationships and correlations between the variables. Therefore, these objectives necessitate a correlational design. Correlational studies seek to establish whether or not relationships exist between variables (Grant and Giddings, 2002). Clark and Creswell (2015) posited that the correlational research design is well suited to studying a problem requiring the identification of the direction and degree of association between two sets of scores. Correlational designs, while not determining causality, give rise to prospective casual factors that can be ascertained from the extent and direction of relationships among demographic and environmental variables. In this research study, the hypothesis contains two variables; variables are included in the hypothesis and can affect or change the results of a study (Flannelly et al., 2014). In correlational studies, the independent variable is not controlled by the researcher (Polit and Beck, 2017). Consequently, the falls risk variables of gender, age, gait, sensory deficit, falls history, medication, medical history, and mobility within the FRASE risk assessment tool are the independent variable as they will influence the older adults' risk of falling (dependent variable). The correlational research design is most appropriate to describe the relationship among the variables as there is no manipulation of attributes or treatments and no random assignment (Clark and Creswell, 2015).

3.5.2 Data Collection Tool

The quality standards of the post positivist paradigm are objectivity, validity and reliability (Taylor and Medina, 2011). The Data Collection tool is described in this section along with the validity and reliability of the tool. The Data Collection tool (Appendix C) comprised of two sections. Section 1 contained the FRASE risk assessment tool information (Cannard, 1996). Section 2 contained fall incident category information from the National Incident Management Systems (NIMS) National Incident Report Form (NIRF) – 01 Person (HC NIRF 01V10, 2018). The

Data Collection tool facilitated the gathering of FRASE fall risk data and as applicable fall incident category data relating to older adults in Community Hospitals/ Nursing Units in the South/ Southwest of Ireland. The Data Collection tool combined the FRASE risk assessment tool with the fall incident category information from the NIRF – 01 Person form.

3.5.2.1 Data Collection Tool: Section 1

Section 1 of the Data Collection tool captured fall risk information related to the study population. Section 1 consists of tick box questions on the eight fall risk variables; gender, age, gait, sensory deficit, falls history, medication, medical history and mobility and their associated weighted risk score as per the FRASE risk assessment tool (Cannard, 1996). Each fall risk variable is divided into a number of categories. The format of section 1 facilitated the collection of the weighted scores assigned to each fall risk category catalogued within the independent fall risk variables. Each category is represented by a box which may be assigned a weighted risk score. A weighted risk score is a score of between 0 and 3. The weighted scoring represents the level of risk the category contributes to an older adult's risk of falling. The higher the numerical score the higher the risk of falling. Each variable is described below.

Gender

Gender is divided into two categories, male and female. Only one category was assigned a weighted risk score of either 1 or 2. A score of one (1) was assigned to the male category, and a score of two (2) was assigned to the female category. The higher the numerical score assigned to the category the higher the level of risk of falling. Therefore, the weighted scoring of the FRASE projects female older adults are a higher risk of falls than male older adults (Cannard, 1996).

Age

Age is divided into four categories; adults aged 60 years and under, older adults aged between 60 – 70 years, older adults aged between 71-80 years and older adults aged 81 years and older. Only one category was assigned a weighted risk score. A score of either 1 or 2 was assigned. A score of 1 was assigned to three of the categories; older adults aged below 60 years, aged between 60-70 years and aged 81 years and older. A score of 2 was assigned to older adults aged between 71-80 years. Therefore, the weighted scoring of the FRASE projects older adults within the 71-80 years category are at a higher risk of falls (Cannard, 1996). The research inclusion and exclusion criteria stipulated only data pertaining to older adults aged 65 years and older therefore, no data was obtained that represented adults aged below 65 years. Accordingly, the age fall risk variable was assessed under three categories, 60 – 70 years (score=1), 71- 80 years (score=2) and 81years and older (score=1).

Gait

Gait is divided into four categories, steady, hesitant, poor transfer and unsteady. Multiple categories were assigned a weighted risk score in this variable. A score of zero (0) was assigned to the category steady gait. A score of one (1) was assigned to the category hesitant gait. Two categories, poor transfer and unsteady gait were assigned a weighted risk score of three (3). Therefore, the weighted scoring of the FRASE projects older adults with a poor transfer and/ or unsteady gait are a higher risk of falls than older adults with a hesitant gait only. Accordingly, in comparison to older adults with one weighted fall risk category, older adults with the combined risk of two weighted fall risk categories project a higher risk of falls. Therefore, older adults with a combined risk of three weighted fall risk categories project the highest risk of falls (Cannard, 1996).

Sensory deficit

Sensory deficit is divided into three categories, sight deficit, hearing deficit and balance deficit. Multiple categories were assigned a weighted risk score in this variable. A score of 1 was assigned to the hearing deficit category. The sight deficit and balance deficit category were assigned a weighted risk score of 2. Therefore, the weighted scoring of the FRASE projects older adults with sight deficit and/ or balance deficit are a higher risk of falls than older adults with a hearing deficit only. Accordingly, in comparison to older adults with one weighted fall risk category, older adults with the combined risk of two weighted fall risk categories project a higher risk of falls. Therefore, older adults with a combined risk of three weighted fall risk categories project the highest risk of falls (Cannard, 1996).

Falls history

Falls history is divided into four categories, none, at home (in the past 12 months), in ward/ unit and both, i.e. a fall at home in the previous 12 months and a fall in the ward or unit. Only one fall history category was assigned a weighted risk score. A score between 0 and 3 was assigned with a score of 0 assigned to the category ‘none’. A score of 2 was assigned to the categories ‘at home in the previous 12 months’ or ‘in the ward or unit’. A score of 3 was assigned to the category ‘both’, i.e. a fall at home in the previous 12 months and a fall in the ward or unit. Therefore, the weighted scoring of the FRASE projects older adults who experienced a fall ‘at home (in the past 12 months)’ or in the ‘ward/ unit’ are at a higher risk of falls than older adults who have not experienced a fall. In addition, older adults who experience ‘both’, i.e. a fall at home (in the past12 months) and a fall in the ward/ unit project the highest risk of falls (Cannard, 1996).

Medication

Medication is divided into five categories: hypnotics, neuroleptics, tranquillisers, anti-hypertensives, and diuretics. Multiple categories were assigned a weighted risk score in this variable. A score of 1 is assigned to each category. Therefore, the weighted scoring of the FRASE projects each category contributes an equal level of risk to an older adults’ risk of falling. As multiple categories can be assigned a weighted risk score, the greater the number of fall risks categories, the higher the risk of falls. Therefore, the weighted scoring of the FRASE projects the greater the number of fall risk medication categories associated with an older adult, the higher the older adults risk of falls (Cannard, 1996).

Medical history

Medical history is divided into four categories: ‘diabetes/ cardiovascular disease’, ‘organic brain disease/ confusion’ (mental test score <3), ‘seizure/ fits’ and ‘risk of fracture’. Multiple categories were assigned a weighted risk score in this variable. A score of 1 is assigned to each category. Therefore, the weighted scoring of the FRASE projects each category contributes an equal level of risk to an older adults’ risk of falling. As multiple categories can be assigned a weighted risk score, the greater the number of risk categories, the higher the risk of falls. Therefore, the weighted scoring of the FRASE projects the greater the number of fall risk medical history categories associated with an older adult, the higher the older adults’ risk of falls (Cannard, 1996).

Mobility

Mobility is divided into four categories, full mobility, uses aids, restricted and bedbound. Multiple categories were assigned a weighted risk score in this variable. A score of 1 was assigned to two categories: full mobility and bedbound. A score of 2 was assigned to the category uses aids. A score of 3 was assigned to the category restricted. Therefore, the weighted scoring of the FRASE projects the ‘restricted’ category presents the greatest single risk within the mobility fall risk variable. As multiple categories can be assigned a weighted risk score, the greater the number of risk categories, the higher the risk of falls. Accordingly, compared to older adults with one weighted risk category, older adults with a combined risk of two categories project a higher risk of falls. Therefore, older adults with a combined risk of three categories project the highest risk of falls (Cannard, 1996).

Overall FRASE risk score

In accordance with the FRASE risk assessment tool guidelines (Cannard, 1996) the value of the combined weighted risk scores equate to the overall risk score. Therefore, once the assessment is completed, the weighted scores for each variable are combined to achieve the overall FRASE risk score.

- An overall FRASE risk score of between 3 and 8 is categorised as 'low risk' of falls.
- An overall FRASE risk score of between 9 and 12 is categorised as 'medium risk' of falls.
- An overall FRASE risk score of 13+ is categorised as 'high risk' of falls.

The overall FRASE risk score is a calculation of the older adults probability of experiencing a fall during their admission. Therefore, the weighted scoring of the FRASE projects older adults categorised as a 'low risk' of falls present a low probability of experiencing a fall during their admission. Accordingly, older adults categorised as a 'medium risk' of falls present a medium probability of experiencing a fall during their admission. Finally, older adults categorised as a 'high risk' of falls present a high probability of experiencing a fall during their admission.

3.5.2.2 Data Collection Tool: Section 2

Section 2 of the Data Collection tool captured the fall incident category information related to the study sample. The fall incident category information consisted of three sub sections; Type of fall, Type of hazard the fall related to and Outcome at the time of the fall.

Each sub section was divided into a number of tick box categories. Only one category can be assigned a tick per sub section. This data was deemed necessary in order to confirm the older adult had experienced a fall. Each sub section is described below (HC NIRF 01V10, 2018).

Type of fall

This section required the type of fall experienced to be specified. The type of fall consisted of six categories, from height, from equipment/ furniture, same level/ ground, on stairs, on steps and other (HC NIRF 01V10, 2018). **Type of hazard the fall incident was related to**

This section required the type of hazard the fall incident was related to. The type of hazard consisted of thirteen categories; unknown, pre-existing medical condition, inadequate supervision, obstruction / protruding object, surface contaminants, rough terrain/ irregular surface, inappropriate equipment use, failure/ malfunction of equipment, horseplay, physical training/ sport, weather condition, inadequate lighting/ design and other (HC NIRF 01V10, 2018) .

The outcome at the time of the fall

This section required the injury sustained as a result of the fall. The type of injury consisted of eight categories, near miss, no injury, injury not requiring first aid, injury or illness requiring first aid, injury requiring medical treatment, long term disability/ incapacity, permanent incapacity, and death (HC NIRF 01V10, 2018).

3.5.3 Validity of the Data Collection tool

Quantitative research necessitates completion of predetermined objectives to maximise integrity (Polit and Beck, 2017). In quantitative research, study rigour is determined by the validity and reliability of the tool or instrument used (Heale and Twycross, 2015). Validity describes the degree to which a test measures what it claims to measure (Clark and Creswell, 2015). Validity is one of the main concerns with research as valid claims are solid claims (Hollins Martin and Fleming, 2010). The attributes of validity include, content validity, criterion-based validity and construct validity (Heale and Twycross, 2015).

3.5.3.1 Content validity

Content validity is part of construct validity and concerns the appropriateness of the items in an instrument for the construct being measured and how adequately the items cover the construct domain (Polit and Beck, 2017). The aim of this research study is to determine the relationship between faller status and the fall risk variables included in the FRASE risk assessment tool. Therefore, the study design did not allow for the identification of all fall risk variables that could predict falls among older adults. Nevertheless, content validity was achieved through measuring the AUC of each of the falls risk variables within the FRASE risk assessment tool. Thereby establishing whether gender, age, gait, sensory deficit, falls history, medication, medical history and mobility are predictive of falls. These findings are presented in section 4.4 of the findings chapter.

3.5.3.2 Criterion-based validity

Criterion-based validity is part of construct validity, identified by comparable scores on an external criterion (Polit and Beck, 2017). ROC curves, sensitivity and specificity are used to describe criterion-based validity (Kim, 2017). In the quasi-experimental design study by Jester et al. (2005) the FRASE achieved a moderate sensitivity (62%) and average specificity (50%) with the prospective group (n = 60). ROC analysis presented an AUC of 0.560 indicating predictive accuracy. Although decisive power was not achieved (AUC >0.7) the AUC value surpassed random probability and clinical judgement (AUC < 0.5). The FRASE achieved no sensitivity (1%) but good specificity (74%) with the retrospective group (n = 30). ROC analysis presented an AUC of 0.370 indicating no discrimination. The primary aim of this study necessitates establishing the sensitivity, specificity, and AUC of the FRASE. These findings are presented in section 4.3 of the findings chapter.

3.5.3.3 Construct validity

To determine construct validity, which represents the overall measure of validity, independent sample t-tests and Fisher's Exact test were used (Kim, 2017). In the quasi-experimental design study by Jester et al. (2005) no statistically significant difference (p = 0.204) was identified between the prospective (n = 60) groups fall incidences (n = 2) and the retrospective groups (n = 30) falls incidences (n = 1). To achieve the aims of this study, independent sample t-test and Fisher's Exact test were undertaken. These findings are presented in section 4.3 and 4.3 of the findings chapter.

3.5.4 Reliability of the Data Collection tool

Reliability relates to the consistency of a measure, or the accuracy of an instrument, and although exact calculations are unachievable, an estimate of reliability can be achieved through homogeneity, stability and equivalence (Heale and Twycross, 2015). In this study homogeneity which refers to the internal consistency among the items that make up the FRASE was not applicable, as an item on the FRASE risk assessment may be predictive of falls but not necessarily related to other items on the FRASE risk assessment. The attribute of stability which refers to test-retest reliability was not applicable as the research study did not collect data at two different time points. Finally, the attribute of equivalence which indicates the correlation between scores from different versions of the same scale could not be estimated as the research study did not gather data from different versions of the FRASE risk assessment. However, in the quasi-experimental design study by Jester et al. (2005) the FRASE achieved good IRR using Pearson's correlation coefficient (0.964, p=0.001).

3.6 Sample

3.6.1 Sampling

Sampling is an important and complex part of the research process; an appropriate target population must be captured in order to ensure a valid and robust sample is selected (Kandola et al., 2014). The term population in research refers to the total number of all the people who have certain attributes that are of interest to the researcher (Grove and Burns, 2015). A sample is a subgroup of the population whilst sampling denotes a statistical method of attaining data or observations that are representative of the population of interest (Parahoo, 2014). In this study the population of interest are older adults aged 65 years and older. The sample therefore refers to data pertaining to older adults aged 65 years and older in Community Hospitals/ Nursing Units in the South/ South West of Ireland. The sampling method employed involved the collection of a random sample of FRASE risk assessment data and as applicable falls incident category data from older adults, within a convenience sample of 12 Community Hospitals/ Nursing Units in the South/ South West of Ireland.

The sampling process is supported by sampling designs which are classified as probability sampling or nonprobability sampling (Polit and Beck, 2017). The study entailed two sampling designs. Initially, a convenience sample of Community Hospitals/ Nursing Units in the South/ South West of Ireland was secured. Convenience sampling is non-random or nonprobability sampling where the target population fulfil specific practical criteria for the purpose of the study, such a geographical proximity, uncomplicated accessibility, availability at a given time, or willingness to participate (Kandola et al., 2014). Convenience sampling is suitable for both qualitative and quantitative studies, although more commonly used in quantitative studies while purposive sampling is frequently used in qualitative studies (Etikan et al., 2016).

In research, quantitative methods aim to achieve breadth of understanding while qualitative methods primarily aim to achieve a depth of understanding (Patton, 2002). The primary emphasis of convenience sampling is ensuring that the knowledge achieved is representative of the population from which the sample was drawn (Etikan et al., 2016). Nevertheless, while purposive sampling selects subjects based on study purpose, convenience sampling selects subjects based on accessibility. Therefore, generalisation of results to the population is weakened as the opportunity to participate is not equal for all eligible subjects in the target population (Sedgwick, 2013). Conversely, in contrast to purposive sampling where data saturation determines sample size, the statistical power of convenience sampling increases in accordance with the sample size. Therefore, the sampling technique employed depends on the type and nature of the study.

Convenience and purposive sampling share certain limitations, including the non-random selection of subjects which ultimately impedes the study's ability to draw inferences about a population (Etikan et al., 2016). Consequently, the study also utilised a probability sampling design of random sampling to increase the representativeness of the population (Polit and Beck, 2017). Thus, a register of older adults from the convenience sample of Community Hospitals / Nursing Units was formed as a sampling frame to facilitate the selection of a random sample. LoBiondo-Wood and Haber (2017) describe inclusion criteria as the factors utilised by the researcher to limit the sample by eligibility. The researcher stipulated the following data inclusion and exclusion criteria

Inclusion criteria:

- FRASE data pertaining to older adults aged 65 years of age and older
- NIRF falls incident category data pertaining to older adults aged 65 years of age and older

Exclusion criteria:

- FRASE data pertaining to older adult aged less than 65 years of age
- NIRF falls incident category data pertaining to older adults aged less than 65 years of age

3.6.2 Sample size justification

An important step in the research process is accessing a sufficient sample in order to generate statistically significant findings (Cormack, 2015). There are strategies established to calculate the sample size required for correlational analysis (Columb and Atkinson, 2016). These strategies include determining the effect size, examining other studies closely related to the present investigation and using conventional definitions of 'small', 'medium' and 'large' effects (Cohen, 1992). Statistical power analysis utilizes the relationship between the four elements involved in statistical inference, sample size (n), significance criterion, population effect size and statistical power, each is a function of the other three (Columb and Atkinson 2016). Establishing the sample size is necessary to attain the desired power for the required significance criterion (0.5) and hypothesised population effect size (Cohen, 1992). In accordance with Cohen's guidelines, for an independent samples t-test, the effect size represented the difference in means between the group of older adults who did not experience a fall (n = 200) and the group of older adults who did experience a fall (n = 100) / pooled standard deviation. Sample size (n) increases along with an increase in the power desired and a decrease in the significance criterion and population effect size (Sihoe, 2015). Therefore, the smaller the effect you want to detect, the larger the sample size required; hence, a small effect is 0.2, a medium effect is 0.5 and a large effect is 0.8 (Cohen, 1992). Subsequently, a sample size of 300 older adults (200 controls and 100 cases) was deemed sufficient to detect a small to medium effect size. A small effect is not so small to be trivial while a medium effect is likely to be visible to a careful observer and a large effect (Cohen, 1992).

Correlational analysis and regression analysis were used to investigate the relationships between faller status (n = 100) and the fall risk variables within the FRASE risk assessment tool; gender, age, gait, sensory deficit, falls history, medication, medical history, and mobility. Comparison of FRASE scores between non-fallers (n = 200) and fallers (n = 100) were undertaken using an independent samples t-test, with a power of 80%, a level of significance of 0.05 and a 2-tailed test. In addition, a sample size of 100 cases (i.e. fallers) would allow for the construction of a 95% confidence interval (CI) for sensitivity, with a margin of error of 10% (i.e. total width of CI of 20%) assuming a sensitivity of 60%. A sample size of 200 controls (i.e. non-fallers) would also allow for the construction of a 95% confidence interval (CI) for specificity, with a margin of error of 7% (i.e. total width of CI of 14%) assuming a specificity of 0.6. The sample size calculation was performed using the G-Power 3.1 program[2] which was guided and developed by Erdfelder et al. (1996).

3.6.3 Data Management

Prior to commencing the study, Ethical approval was sought and granted (Appendix D and E) from the relevant Clinical Research Ethics Committees in the South West of Ireland. In accordance with the sampling method previously outlined in section 3.6.1, the study was undertaken across a convenience sample of Community Hospitals/ Nursing Units (n = 12) in the South/ South West of Ireland. The study involved the aggregating of data from 2 separate forms already completed by nurses, the FRASE risk assessment tool (Cannard, 1996) and the NIRF-01 Person (HC NIRF 01V10, 2018). Therefore the basis for processing the personal data from the 2 forms was followed according to Article 6 of General Data Protection Regulation (GDPR) (General Data Protection Regulation, 2018, Government of Ireland, 2018). The Data Protection Act (DPA) (2018) imposed obligations on organisations that process personal data (Government of Ireland, 2018). The Data Protection Commission (DPC) is the national independent authority responsible for upholding the fundamental right of individuals in the EU to have their personal data protected. The DPC is the Irish supervisory authority for GDPR. The DPC also has functions and powers related to other important regulatory frameworks including the Irish ePrivacy Regulations (2011) and the EU Directive known as the Law Enforcement Directive (DPC, 2019a). Communication took place between the researcher and the DPC via phone calls and emails to ascertain the basis for processing personal data. The recommendation was to ensure personal data was anonymised and could no longer relate to the identified older person. This meant that data that no longer related to identifiable persons was outside the scope of the data protection law.

Personal data is defined as any information relating to an identified or identifiable individual (Government of Ireland, 2018). This individual is also known as a ‘data subject’ (DPC, 2019a). An identifiable individual is one who can be identified, directly or indirectly. An identifier may be a name, an identification number, location data, an online identifier or one or more aspects specific to the physical, physiological, genetic, mental, economic, cultural, or social identity of that individual (GDPR 2018, Government of Ireland, 2018). Therefore, data about living individuals which has been anonymised such that it is not possible to identify the data subject from the data or from the data together with certain other information, is not governed by the GDPR or the Data Protection Act 2018. Accordingly such data is not subject to the same restrictions on processing as personal data. Therefore, it was important that the data collected for this research study was anonymised (European Commission, 2018).

Anonymisation of data means processing it with the aim of irreversibly preventing the identification of the individual to whom it relates. Data can be considered effectively and sufficiently anonymised if it does not relate to an identified or identifiable natural person or where it has been rendered anonymous in such a manner that the data subject is not or no longer identifiable (DPC, 2019b).

GDPR (2018) states that the appropriate anonymisation technique has to be done on a case by case basis and to the intended purpose of the anonymised data. Organisations have to balance the need to retain all information necessary for the purpose for which the anonymised data is to be used with the identification risks presented by the inclusion of more detailed information in a dataset. Therefore it was up to the individual data controller in consultation with the researcher to ensure that the anonymisation process was sufficiently robust (Article 29 Working Party's opinion on Anonymisation Techniques (Opinion 05/2014)) (DPC, 2019b). The researcher discussed the process of data collection in the first instance with the Chief Officer of the HSE Area, the General Manager of the HSE area and the Directors of Nursing of the Community Hospitals/ Nursing Units (Appendix F and J). Spencer and Patel (2019) assert Article 6 of GDPR requires that there must be a basis for processing personal data. Therefore, permission was sought and granted from the Data Controller in the HSE to oversee the research data management process and compliance with the completed Data Collection tools (Appendix G). The Data Controllers' contact details were made available to all the data subjects involved in the research as per European Commission (2018). The researcher and her academic supervisors acted as Data Controller for the data for the duration of the study and the designated HSE Data Controller supervised data management compliance was adhered to.

No personal data was included in this data set therefore ensuring anonymisation. The anonymised Data Collections tools were only shared with the researcher once the HSE Data Controller was satisfied that all stipulations under Article 6 GDPR and HSE policies had been upheld (Clarke et al., 2019). No linkage tool was available to the researcher to map the data collection tools to the original data.

On receiving authorisation to collate data, the researcher in accordance with the post positivist paradigm and new GDPR guidelines required the assistance of Data Processors to gather and anonymise the data on behalf of the HSE Data Controller (Appendix H – J). The Clinical Nurse Managers within the convenience sample of Community Hospitals/ Nursing Units agreed to act as the Data Processors. Accordingly, the researcher briefed the Clinical Nurse Managers on their role and responsibility as Data Processors and clarified any concerns or questions in relation to the nature or design of the study. The HSE Data Controller was an nominated person within the HSE to oversee the application to gather data, the process of data collection and the outcome anticipated (DPC, 2019a, Spencer and Patel, 2019). The researcher briefed the HSE Data Controller on his/ her role and responsibility, outlined the particulars of the proposed study and the principles of GDPR and clarified any concerns or questions the HSE Data Controller had in relation to the nature or design of the study (Information Commissioners Office (ICO), 2018, DPC, 2019a, DPC, 2019b). A timeframe for data collection was agreed once the researcher was assured the HSE Data Controller and Data Processors had a clear understanding of the aims and objectives of the study, the data collection tool and their role and responsibilities in the data collection process. Subsequently, the Data Processors accessed data pertaining to older adults at risk of falls from the convenience sample of participating Community Hospitals/ Nursing Units (n = 12) between March 11th, 2019 and May 10th, 2019.

Trajectory of the Data Collection process ensuring anonymity of data:

- The HSE Data Controller within the HSE sites supervised the data management process compliance was adhered to. The researcher was responsible for validating anonymisation of the data in her role as data controller.
- The Data Processors (Clinical Nurse Managers) accepted responsibility for collecting the data, undertaking anonymisation at the point of collection.
- The Data Collection Tool consisted of information collated by the Data Processors from the FRASE Risk Assessment form and the NIRF-01 Person Form related to older adults aged 65 years and older.

- The anonymised Data Collection Tools were gathered by the HSE Data Controller from all the Data Processors within the participating Community Hospitals/ Nursing Units (n = 12).
- The HSE Data Controller reviewed each Data Collection Tools to verify anonymisation had been undertaken.
- The HSE Data Controller ensured no personal data was included in the data set that could be attributed to a specific data subject or Community Hospital/ Nursing Unit.
- The HSE Data Controller ensured no linkage tool was available to the researcher to map the data to the original older adults' data or the Community Hospitals/ Nursing Unit (n = 300).
- The HSE Data Controller ensured that compliance was adhered.

3.6.4 Pilot of the Data Collection tool

Once Ethical Approval was granted from the Clinical Research Ethics Committee, the researcher gained permission for the data collection process to commence with the support of the HSE Data Controller and Data Processors. Prior to commencing data collection, the researcher co-ordinated a pilot study on March 9th, 2019 to identify any potential problems pertaining to the data collection process. According to Polit and Beck (2017) a pilot study is useful in identifying unforeseen problems with a study and informs the design and planning phase. The pilot study involved a small-scale version of the main study, to enable the researcher to identify any problems with both the research process and the Data Collection tool.

The pilot study was undertaken across all 12 Community Hospital/ Nursing Unit participating in the research study. Gatekeeper approval was sought and granted from the Director of Nursing of each participating Community Hospital/ Nursing Unit. In addition, the Directors of Nursing accepted the researchers request to seek the assistance of the Clinical Nurse Managers to collect data, thus fulfilling the role of Data Processors within the research study. Accordingly the researcher sought Data Processor assistance from each Clinical Nurse Manager within the participating Community Hospitals/ Nursing Units. On accepting same, the researcher briefed each

Data Processor on the Data Collection tool and the importance of ensuring all data was anonymised at the point of collection. Thereafter, the researcher issued all participating Data Processors with two Data Collection tools to pilot the process of gathering and anonymising FRASE data and NIRF data relating to two falls incidents within their ward/ unit.

The Data Processors populated 30 Data Collection tools with FRASE data and NIRF data representative of 30 falls incidents within the 12 Community Hospitals/ Nursing Units. In order to accurately inform the time required to complete the data collection phase of the research, the Data Processors recorded the length of time taken to access the data and complete the Data Collection tool including the anonymisation of the data. In accordance with the ethical approval granted from the Clinical Research Ethics Committees (Appendix D and E) the Data Processors submitted the completed anonymised Data Collection tools to the HSE Data Controller. The HSE Data Controller on receipt fulfilled the verification process to ensure no identifiable information was recorded on the Data Collection tools. Once the verification process was complete the HSE Data Controller released the data to the researcher for data analysis.

The pilot study indicated the average length of time required to access, anonymise, and record the data onto the Data Collection tool ranged between 10 – 20 minutes. The completion of Section two (i.e. fall incident category information) increased the completion time by 5-10 minutes. The Data Processors confirmed that Section 1 and Section 2 of the Data Collection tool were clear. The Data Processors confirmed the text in Section 1 of the Data Collection tool mirrored the text and associated risk scoring in the FRASE risk assessment tool and Section 2 mirrored the fall incident category information within the NIRF-01 Person. Based on the pilot study there was unanimous agreement that no amendments were required to the layout or information requested in the Data Collection tool. All data collected during the pilot study was held by the HSE Data Controller and not included in the study data sample. The Data Processors were advised that the data submitted during the pilot study could not be recaptured during the data collection process.

3.6.5 Data Collection

All data was collected using the Data Collection tool. The Data Processors assigned a number to each Data Collection tool at the point of data collection which facilitated the process of gathering fall incident category information thereafter, no personal data was recorded thus fully anonymising the data at the point of collection. The Data Collection tools were thereafter collected and reviewed by the HSE Data Controller to ensure anonymisation had been undertaken and that no identifiable details were recorded. Anonymity occurs when the researcher cannot link participants to their data thus providing the most secure means of protecting confidentiality (Polit and Beck, 2017).This process ensured no personal information that could identify the older adults or Community Hospital/ Nursing Units were shared with the researcher. Once the data gathering process was completed by the Data Processors and approved by the HSE Data Controller, the researcher accessed the 300 Data Collection tools to commence the analytic phase of data analysis.

3.7 Ethical Considerations

Undertaking research involves an ongoing process, from identifying the topic to publication (Grove et al., 2013). Ethical research is imperative in nursing as patients, staff and / or students are generally involved (Greaney et al., 2012). Therefore, human rights must be protected and an ethical conduct of research needs to be exercised (Polit and Beck, 2017). Nursing research must conform to the Declaration of Helsinki, and federal regulations designed by the National Commission for the Protection of Human Subjects of Biomedical and Behavioural Research (Grove et al., 2015). The Irish nurse researcher must also uphold the principles of the professional code of conduct set out by An Bord Altranais agus Cnaimhseachais (Nursing and Midwifery Board of Ireland (NMBI), 2014). These principles indicate that nurses need to ensure privacy and confidentiality of those participating in research. Accordingly, this study necessitates a process of anonymisation to ensure the privacy and confidentiality of data obtained is upheld.

Nurses' are obliged to acknowledge ethical policies and procedures, ensuring appropriate bodies sanction their research, while continuously protecting the rights of patients (NMBI, 2014). Consequently, ethical approval was sought and granted from the Research Ethics Committees of the Institute of Technology Tralee (Appendix D) and Cork University Teaching Hospitals (Appendix E) prior to commencement of the research. In addition, access approval from the Health Service Executive General Manager Residential Services for Older Persons (Cork/ Kerry) (Appendix G) was obtained. Ethical approval ensured that the data collection process was consistent with the 1975 Helsinki Declaration (World Medical Association, 2013). Human rights, which require protection within research, include the right to self-determination, privacy, anonymity and confidentiality, fair treatment and protection from discomfort and harm (Polit and Beck, 2017). The four ethical principles, respect of autonomy, beneficence / nonmaleficence and justice, encompass these rights (Snowden, 2015). In addition, Das and Sil, (2017) emphasis the principles of confidentiality and respect for privacy.

3.7.1 Autonomy

Researchers are obliged to maximise and respect participants sense of power and autonomy in the decision making process of deciding whether to participate in the research study (Campbell-Crofts et al., 2013). Fundamental to the principle of autonomy is the concept of informed consent and respecting ones decision not to participate in the study (Ellis, 2019). It is imperative that the researcher supplies adequate information on which to base a decision to participate in a study (Polit and Beck, 2010) including the purpose and nature of the research (Greaney et al., 2012). Four elements are vital to the decision-making process; understanding, appreciation, reasoning and choice (Campbell-Crofts et al., 2013).

Understanding necessitates a reciprocal relationship between the researcher and participating Community Hospitals/ Nursing Units, thus promoting their comprehension and analysis of the data provided (Flory and Emanuel, 2004). Appreciation relates to the Community Hospitals/ Nursing Units understanding of the information (Arraf et al., 2004). Reasoning refers to the Community Hospitals/

Nursing Units ability to weigh the risks and benefits of their participation in the study while choice involves their ability to communicate in a clear and unambiguous way (Ryan and Deci, 2000). In addition, for consent to be valid it must be free from coercion i.e. overemphasise/ unrealistic expectation of benefits or requested by a healthcare professional who provides treatment (Campbell-Crofts et al., 2013). In this study all obligations were upheld by the researcher as all participating Community Hospitals/ Nursing Units were provided with information outlining the nature of the study, including issues around confidentiality, data handling and storage and time effort to participate.

3.7.2 Beneficence/ Nonmaleficence

The rights, wellbeing and safety should take priority over the aim of the study (Parahoo, 2014). The principle of beneficence in research stipulates that the researcher will, to the best of their ability, do good; it is inextricably linked to the principle of nonmaleficence which stipulates that the researcher will, do no harm (Campbell-Crofts et al., 2013). Polit and Beck (2010) state research should benefit the participant or society. According to Grove et al. (2015) the benefits of the research should outweigh the risks. This research sought to determine the predictive accuracy of the FRASE risk assessment tool in identifying older adults at high risk of falls. Researchers have an obligation to present the risks versus the benefits, maximising the benefits and minimising the harms (Das and Sil, 2017). The greater the risk, the greater the ethical responsibility of the researcher to appropriately manage those risks providing information so a clear understanding is achieved (Campbell-Crofts et al., 2013). In this study the researcher upheld this obligation through the information provided to Community Hospitals/ Nursing Units. Minimal risk of harm was foreseen to the sample population as the research was a non-experimental, non-invasive study involving no interventions, thereby benefiting the body of nursing. The HSE Data Controller and Data Processors had access to the researcher both in person and via telephone throughout the research process. The HSE Data Controller and Data Processors were invited to contact the researcher whenever they felt the need to do so. The researcher also made herself available by visiting the research sites during the data collection phase.

3.7.3 Justice

The principle of justice seeks 'fair treatment'. Researchers are obliged to provide education on the expectation of the study (Das and Sil, 2017). In this study the researcher upheld this obligation through the information provided to Community Hospitals/ Nursing Units. Stakeholders should feel a partnership with the researcher (Campbell-Crofts et al., 2013). The researcher informed the HSE and the Community Hospitals/ Nursing Units on the progress of the research and the findings achieved.

3.7.4 Confidentiality

Nursing research must provide safety, dignity, respect and confidentiality to all participants (Meek Lange et al., 2013). Confidentiality is primarily to protect research participants from harm (Kaiser, 2009). Confidentiality is closely linked with the rights of beneficence and respect for human dignity. Anonymity is regarded as the mechanism through which privacy and confidentiality are maintained (Vainio, 2013). Anonymity is protected when the data cannot be linked to the older adults or the participating Community Hospitals/ Nursing Units. In this study the researcher upheld this obligation by ensuring the participating Community Hospitals/ Nursing Units that all data collected would undergo anonymisation. The study design stipulated that each Data Collection tool was anonymised at the point of collection by the Data Processors. The anonymised Data Collection tools were further reviewed by the HSE Data Controller to ensure no personal or identifiable details were shared with the researcher. In addition, no linkage tool is available to the researcher to map the data to the original older adults data or Community Hospital/ Nursing Unit. All raw Data Collection tools remain stored in a secure filing cabinet in the researchers office. All other sources of data remain stored in a secure and accessible manner for seven years as per University College Cork (2018) Data Protection Policy, after which the data will be destroyed. In addition, it was emphasised that anonymity would be upheld in any future presentations and publications arising from the research, thus assuring anonymity and confidentiality.

3.7.5 Respect for privacy

Privacy in research represents the freedom of participants to determine the time, extent, and general circumstances under which personal information will be shared with or withheld from others (Kelman, 1977). All research including human subjects should ensure that their research is not intrusive to any participant and their privacy is also guaranteed throughout the study. In this study the researcher upheld this obligation by enlisting the support of the HSE Data Controller and Data Processors. Through the anonymisation of data the Data Processors did not record the name, date of birth or any other personal identifiers on the Data Collection tool, thus anonymity was maintained. In addition, the HSE Data Controller reviewed each Data Collection toll to verify no personal identifiers were recorded prior to sharing the Data Collection tools with the researcher. To further enhance privacy all collected data is held securely in a locked filing cabinet in the researcher's office. Records will be maintained for a period of 7 years after publication in a secure location in the researchers' office and used only for entry of data onto data analysis software. Data will be held on a password protected computer known only to the researcher and academic supervisors. Through the anonymisation process undertaken by the Data Processors, and verified and approved by the HSE Data Controller, no record/ data stored on the researchers computer will be identifiable by name, person, or Community Hospital/ Nursing Units (Irish Universities Association, 2019).

3.8 Data Analysis

Polit and Beck (2018) describe data analysis as the systematic organisation and synthesis of research data. In research, the data analysis method required is directed by the research approach undertaken (Polit and Chaboyer, 2012). Descriptive statistics were used to analyse the data using the Stata version 15.0 (StataCorp, 2017). Through the application of descriptive statistics, the individual clinical variables measured by the FRASE risk assessment tool, the falls incident category information and overall FRASE risk category score in the research were described. Categorical data was described numerically using frequency and percentages (%) and graphically using bar charts. Continuous data was described using the mean and standard deviation (SD) as the data was normally distributed (Canova et al., 2017). The diagnostic accuracy of the FRASE risk assessment tool was assessed using the area under the ROC curve, sensitivity, specificity, positive likelihood ratio and negative likelihood ratio. Analysis also included Fisher's exact test, binary logistic regression and the calculation of the area under the ROC curve (McGee, 2002, Berrar and Flach, 2010, Wray et al., 2010; Canova et al., 2017). All statistical tests were two-sided and a p-value <0.05 considered as statistically significant (Cohen, 1992).

Receiver operating curves were established by applying the weighted risk scoring assigned within each independent fall risk variable in the FRASE risk assessment tool. The ROC reveals the relationship between sensitivity and specificity by exposing the point that best represents the trade-off between failing to detect the positives (sensitivity) against failure to detect the negative (specificity) (Berrar and Flach, 2012). ROCs demonstrate the clinical efficacy of a tool through the area under the curve (AUC) (McKechnie et al., 2016). The larger the area, the greater the overall predictive accuracy, therefore a tool commands good accuracy when the graph is closer to 1 (Scott et al., 2007). An AUC > 0.5 presents no discrimination is normally interpreted as an indicator for a useless test (Wray et al., 2010). An AUC of 0.5 is comparable to clinical judgement and random probability (Jester et al., 2005) while and AUC > 0.7 is considered to have decisive power (Wray et al., 2010).

Sensitivity and specificity are considered population measures providing a summary of the characteristics of a test over a population (Attia, 2003). Sensitivity is defined as the proportion of true positives that are correctly identified by the test, i.e. the proportion of fallers that are correctly identified as a 'high risk' of falls as per the FRASE. Specificity is defined as the proportion of true negatives that are correctly identified by the test; i.e. the total number of non-fallers correctly identified as 'low risk' of falls as per the FRASE (Yager, 1992). In contrast likelihood ratios are independent of disease prevalence, i.e. in this study a fall. Therefore, the larger the positive likelihood ratio, the greater the likelihood the older adult will experience a fall. Likewise, the smaller the negative likelihood ratio, the lesser the likelihood the older adult will experience a fall. Accordingly, a useful test provides a high positive likelihood ratio and a low negative likelihood ratio. In contrast to sensitivity and specificity which provide population characteristics, likelihood ratios express the power of diagnostic tests in increasing or decreasing the likelihood of disease at an individual level (Attia, 2003, Deeks and Altman, 2004).

Strupeit et al. (2016) advocate the use of a Fisher's exact test and t-tests to facilitate the analysis of association between assessment and fall event. A Fisher's exact test and chi-squared test analyse the level of independence between two independent and not correlated variables. The chi-squared test compares the distribution of a variable in a sample or group against the distribution in another sample or group (Kim, 2017). Thus, if there is an equal chance of falling among older adult male and older adult females, we will identify the chance of falling is the same regardless of gender and determine their relationship as independent. Assuming the sample is large, the chi-squared test applies an approximation to calculate an independency test under the null and alternative hypotheses, H0 and H1, respectively. Although valid for all sample sizes, the Fisher's exact test applies an exact test to calculate the null hypothesis of independence specifically for small-sized samples (Kim, 2017). Accordingly, the independent samples t-test was used to compare the FRASE risk assessment scores between non-fallers (n = 200) and fallers (n = 100). Fisher's exact test was used to compare the weighted categories catalogued within the FRASE risk assessment tool between non-fallers (n = 200) and fallers (n = 100). Univariate analysis was used to identify if the catalogued categories within the falls risk variables in the FRASE risk assessment tool were associated with faller status.

3.9 Conclusion

To conclude, this chapter provided an outline of the research approach and the procedures employed throughout the research process. The research design was consistent with the study's aims and objectives. The Data Processors ensured the anonymisation of all data collected within the Data Collection tools. The HSE Data Controller ensured the process of anonymisation was undertaken prior to submitting the Data Collection tools to the researcher for analysis. No identifiable personal information was shared. Chapter four presents the findings of the research study. Data is presented numerically using frequency and percentage (%) and graphically using bar charts.

Chapter 4: Research Findings

4.0 Introduction

This Chapter presents the research findings related to the predictive accuracy of the FRASE risk assessment tool in identifying older adults at high risk of falls. Data were collected and then processed in response to the research objectives outlined in Chapter 3. Initially in section 4.1, the profile and characteristics of the data captured in section one of the Data Collection Tool are presented. The data pertained to older adults at risk of falls in Community Hospitals/ Nursing Units in the South/ South West of Ireland. The data profile and characteristics are presented for the overall data sample (n = 300), data representative of older adults who did not experience a fall i.e. non-fallers (n = 200) and data representative of older adults who experienced a fall i.e. fallers (n = 100). In addition, all combinations of risk categories identified within the independent fall risk variables are presented according to the overall data sample (n = 300), non-fallers (n = 200) and fallers (n = 100). In section 4.2, the NIRF information captured in section two of the Data Collection Tool are presented. The information is representative of the group of older adults who experienced a fall i.e. fallers (n = 100). The information describes the type of falls experienced by the older adults whilst residing within the Community Hospitals/ Nursing Units in the South/ South West of Ireland. In section 4.3 the diagnostic accuracy of the FRASE risk assessment tool is presented. Finally in section 4.4 the research hypotheses are tested through the univariate analysis of the independent fall risk variables measured within the FRASE risk assessment tool. In addition, the predictive accuracy of each independent variable as a predictor of future falls among older adults is established.

The study hypotheses are tested using the area under the ROC curve, sensitivity (percentage of older adults who experienced a fall and correctly classified as high risk of falls), specificity (percentage of older adults who did not experience a fall and correctly not classified as a high risk of falls), positive likelihood ratio (LR+= sensitivity /(1-specificity)) and negative likelihood ratio (LR-=(1-sensitivity)/ specificity). The independent samples t-test facilitated the comparison of FRASE risk scores between the data representative of older adults who did not experience a fall (n

= 200) and the data representative of older adults who experienced a fall (n = 100). In addition, the Fisher's exact test was used for comparison of FRASE risk categories between the data representative of older adults who did not experience a fall (n = 200) and the data representative of older adults who experienced a fall (n = 100). Finally, the area under the ROC curve, univariate analysis, Fisher's exact test and binary logistic regression was used to identify the relationship between each independent fall risk variables within the FRASE and faller status. All statistical tests were two-sided and a p-value, 0.05 was considered to be statistically significant. Where possible the results are presented for the overall data sample (n = 300), data representative of older adults who did not experience a fall (n = 200) and data representative of older adults who experienced a fall (n = 100) during their admission. All results are presented in text and/ or with graphs and tables to assist in clarity.

4.1 Sample profile

The first research objective was to describe the data sample with reference to the independent variables within the FRASE risk assessment tool; gender, age, gait, sensory deficit, falls history, medication, medical history, and mobility. The sample consisted of data (n = 300) pertaining to older adults aged 65 years and older in Community Hospitals/ Nursing Units in the South/ South West of Ireland.

Approximately half of the data pertained to female older adults (54%, n = 161), and those aged 81 years and older (52%, n = 155) who had experienced a fall at home (51%, n = 153) in the 12 months prior to admission to the Community Hospital/ Nursing Unit. The data sample (n = 300) were primarily hesitant (32%, n = 96) and had no sensory deficit (23%, n = 69). Approximately half (53%, n = 158) required the use of aids to mobilise and a third (33%, n = 100) were at risk of fracture. The majority received anti-hypertensive medication (35%, n = 105) while 24.6% (n = 74) received no identified fall risk medication.

The overall sample is further divided into faller status: non-fallers (n = 200) and fallers (n = 100).

Gender

The gender fall risk variable was assessed under two categories, male gender (score=1) and female gender (score=2).

Over half of the non-fallers (n = 200) were female (58%, n = 116) and 42% were male (n = 84).

Over half of the fallers (n = 100) were male (55%, n = 55) and 45% were female.

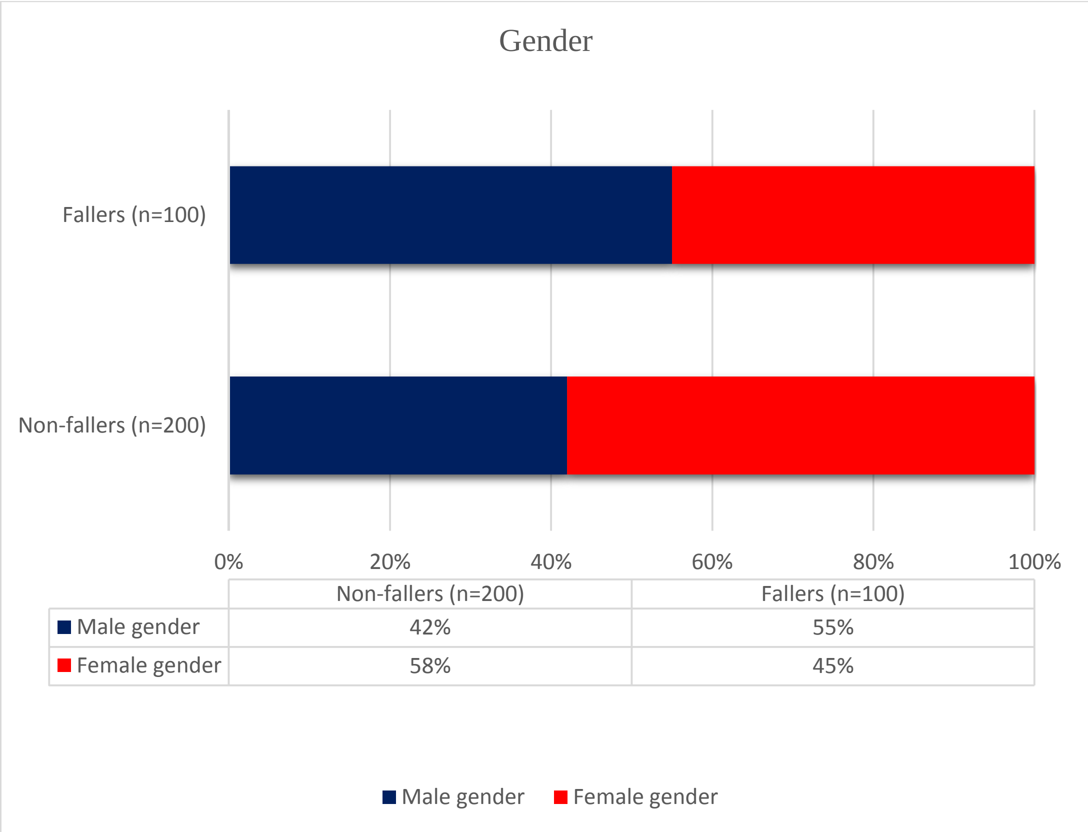


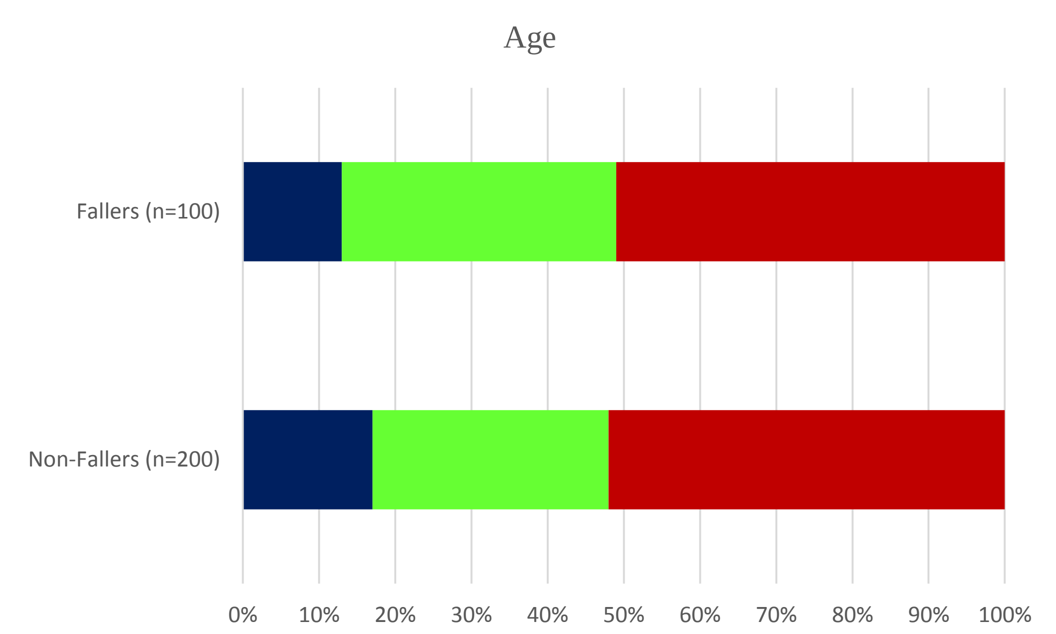
Figure 2: Gender non-fallers (n = 200) and fallers (n = 100)

Age

The research inclusion and exclusion criteria stipulated only data pertaining to older adults aged 65 years and older therefore, no data was obtained that represented adults aged below 65 years. Accordingly, the age fall risk variable was assessed under three categories, 60 – 70 years (score=1), 71- 80 years (score=2) and 81years and older (score=1).

Over half of the non-fallers (n = 200) were aged 81 years and older (52%, n = 104), followed by older adults aged between 71 and 80 years (31%, n = 62) and 60 – 70 years (17%, n = 34). Therefore, the majority of non-fallers (n = 200) were aged over 81 years (52%, n = 104).

half of the fallers (n = 100) were aged 81 years and older (51%, n = 51), followed by older adults aged between 71 and 80 years (36%, n = 36) and 60 and 70 years (13%, n = 13). Therefore, the majority of fallers (n = 100) were aged over 81 years (51%, n = 51).



	Non-Fallers (n=200)	Fallers (n=100)
60 - 70 years	17%	13%
71 - 80 years	31%	36%
81 years and older	52%	51%

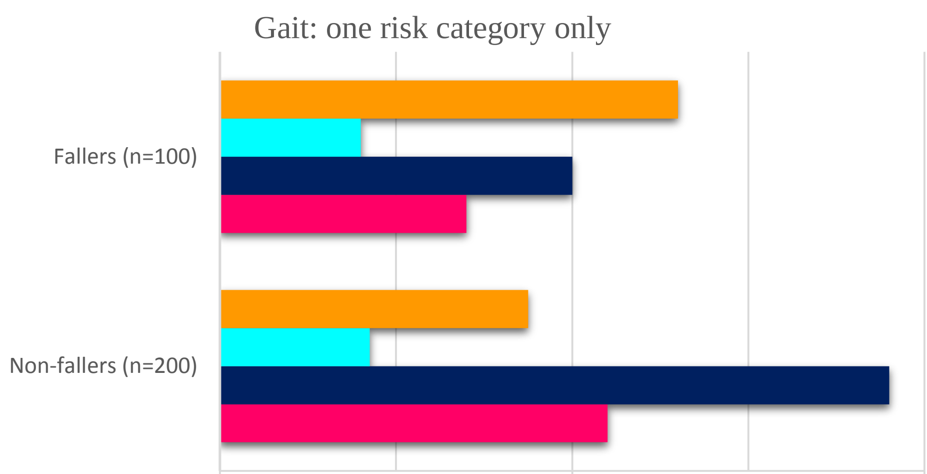
Figure 3: Age non-fallers (n = 200) and fallers (n = 100)

Gait

The gait fall risk variable was assessed under four categories, steady (score=0), hesitant (score=1), poor transfer (score=3) and unsteady (score=3).

Non-fallers (n = 200) were primarily hesitant gait only (38%, n = 76), followed by steady only (22%, n = 44) and unsteady (17.5%, n = 35). The least common category was poor transfer only (8.5%, n = 17).

Fallers (n = 100) were primarily unsteady only (26%, n = 26), followed by hesitant only (20%, n = 20) and steady only (14%, n = 14). The least common category was poor transfer (8%, n = 8).



	Non-fallers (n=200)	Fallers (n=100)
Unsteady only	17.50%	26%
Poor Transfer only	8.50%	8%
Hesitant only	38%	20%
Steady only	22%	14%

Figure 4: Gait one risk category only, non-fallers (n = 200) and fallers (n = 100)

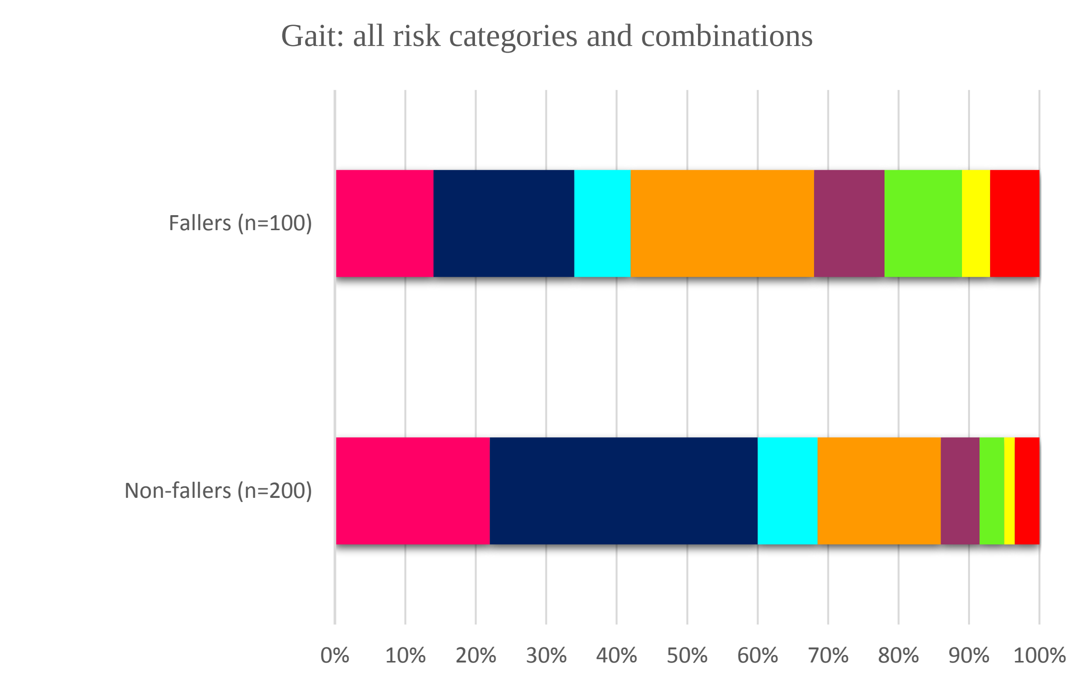
A combination of two gait categories would equate to a risk score of 4 or 6 within the gait fall risk variable.

5.5% (n = 11) of non-fallers were unsteady and poor transfer, 3.5 % (n = 7) were hesitant and unsteady, and 1.5% (n = 3) were hesitant and poor transfer.

11% (n = 11) of fallers (n = 100) were hesitant and unsteady, 10% (n = 10) were unsteady and poor transfer and 4% (n = 4) were hesitant and poor transfer.

A combination of three gait categories would equate to a risk score of 7 within the gait fall risk variable.

The maximum combined risk of hesitant, poor transfer and unsteady was identified in 3.5% (n = 7) of non-fallers (n = 200) and 7% (n = 7) of fallers (n = 100).



	Non-fallers (n=200)	Fallers (n=100)
Steady only	22%	14%
Hesitant only	38%	20%
Poor Transfer only	8.50%	8%
Unsteady only	17.50%	26%
Poor Transfer and Unsteady	5.50%	10%
Hesitant and Unsteady	3.50%	11%
Hesitant and Poor Transfer	1.50%	4%
Hesitant, Poor Transfer and Unsteady	3.50%	7%

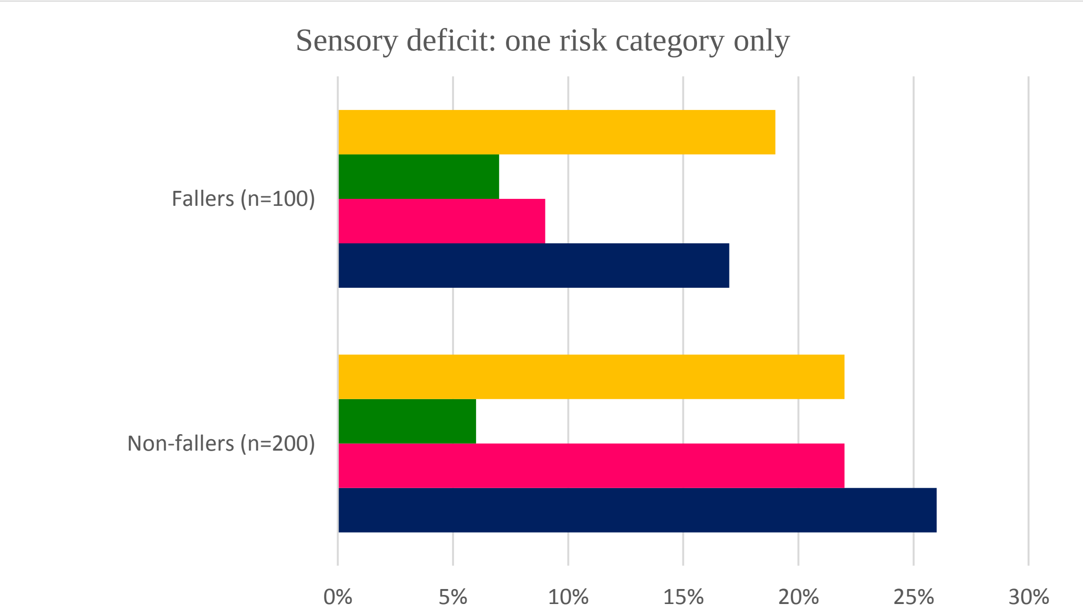
Figure 5: Gait all risk categories and combinations non-fallers (n = 200) and fallers (n = 100)

Sensory deficit

The sensory deficit fall risk variable was assessed under three categories, sight deficit (score=2), hearing deficit (score=1) and balance deficit (score=2).

26% (n = 52) of non-fallers (n = 200) presented no sensory deficit. The primary single weighted risk category was balance deficit (22%, n = 44) followed by sight deficit (22%, n = 44) and hearing deficit (6%, n = 12).

17% (n = 17) of fallers (n = 100) presented no sensory deficit. The primary single weighted risk category was balance (19%, n = 19), followed by sight deficit (9%, n = 9) and hearing deficit (7%, n = 7).



	Non-fallers (n=200)	Fallers (n=100)
Balance deficit only	22%	19%
Hearing deficit only	6%	7%
Sight deficit only	22%	9%
No sensory deficit	26%	17%

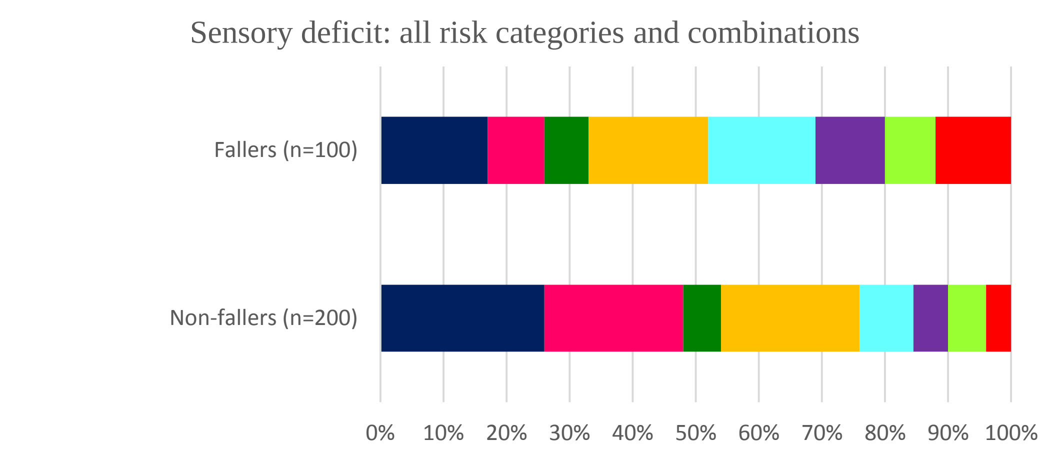
Figure 6: Sensory deficit one fall risk category non-fallers (n = 200) and fallers (n = 100)

A combination of two sensory deficit categories would equate to a risk score of 3 or 4 within the sensory deficit fall risk variable.

Among the non-fallers (n = 200) 8.5% (n = 17) presented with a combined sight and balance deficit, followed by 6% (n = 12) with a combined hearing and balance deficit, while 5.5% (n = 11) presented with a combined sight and hearing deficit.

Among the fallers (n = 100), 17% (n = 17) presented with a combined sight and balance deficit, followed by 11% (n = 11) with a combined sight and hearing deficit, while 8% (n = 8) presented with a combined hearing and balance deficit.

A combination of three sensory deficit categories would equate to the maximum weighted risk score of 5 within the sensory deficit fall risk variable. A hearing, sight and balance deficit was evident in 4% (n = 8) of non-fallers and 12% (n = 12) of fallers (n = 100).

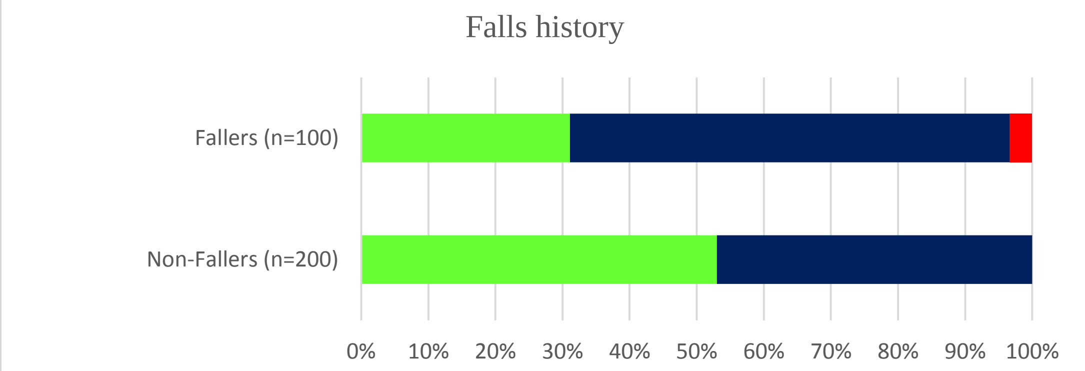


	Non-fallers (n=200)	Fallers (n=100)
No sensory deficit	26%	17%
Sight deficit only	22%	9%
Hearing deficit only	6%	7%
Balance deficit only	22%	19%
Sight and Balance deficit	8.50%	17%
Sight and Hearing deficit	5.50%	11%
Hearing and Balance deficit	6%	8%
Hearing, Sight and Balance deficit	4%	12%

Figure 7: Sensory deficit all risk categories and combinations non-fallers (n = 200) and fallers (n = 100)

Falls history

The falls history fall risk variable was assessed under four categories: none (score=0), at home (past 12 months) (score=2), in ward/ unit (score=2) and both (score=3). Over half (53%, n = 106) of the non-fallers (n = 200) had no previous falls history while less than half (47%, n = 94) had experienced a fall at home in the 12 months prior to their admission to the Community Hospital/ Nursing Unit. Over half (59%, n = 59) of the fallers (n = 100) experienced a fall at home in the 12 months prior to their admission to the Community Hospital/ Nursing Unit. Over one quarter (28%, n = 28) of fallers (n = 100) had no previous falls history while 3% (n = 3) had experienced a fall in the ward/ unit and 10% (n = 10) had experienced both a fall at home in the previous 12 months and a fall in the ward/ unit.



	Non-Fallers (n=200)	Fallers (n=100)
none	53%	28%
Fall at home (past 12 months)	47%	59%
Fall in the ward/ unit	0%	3%

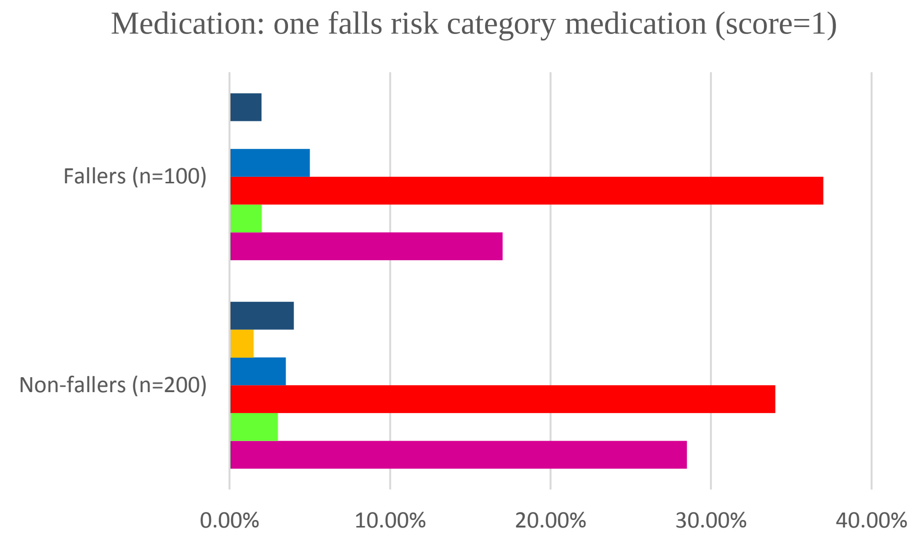
Figure 8: Falls history non-fallers (n = 200) and fallers (n = 100)

Medication

The medication fall risk variable was assessed under five categories hypnotics (score=1), neuroleptics (score=1), tranquillisers (score=1), anti-hypertensives (score=1) and diuretics (score=1).

Over a quarter (28.5%, n = 57) of non-fallers (n = 200) received no medication risk weighted towards a future fall. A total of 4% (n = 8) received hypnotic medication only while 21% (n = 10.5) were receiving hypnotic medication alone or in combination with medication(s) from one or more of the other medication categories. Neuroleptic medication only was received by 1.5% (n = 3) of non-fallers (n = 200) while 7.5% (n = 15) received neuroleptic medication alone or in combination with medication(s) from one or more of the other medication categories (score=1 or 1+). Tranquillisers only were received by 3.5% (n = 7) of non-fallers (n = 200) while 9.5% (n = 19) received tranquilliser medication alone or in combination with medication(s) from one or more of the other medication categories. Anti-hypertensive medication only was received by 34% (n = 68) of non-fallers (n = 200) while over half (57.5%, n = 115) were receiving anti-hypertensive medication alone or in combination with medication(s) from one or more of the other medication categories. A total of 3% (n = 6) of non-fallers (n = 200) received diuretic medication only while 17% (n = 34) received diuretic medication alone or in combination with medication(s) from one or more of the other medication categories.

17% (n = 17) of fallers (n = 100) received no medication risk weighted towards a future fall. 2% (n = 2) received hypnotic medication only while 14% (n = 14) received hypnotic medication alone or in combination with medication(s) from one or more of the other medication groups. Neuroleptic medication only was received by 0% (n = 0) of fallers (n = 100) however 8% (n = 8) received neuroleptic medication alone or in combination with medication(s) from one or more of the other medication groups. Tranquilliser medication only was received by 5% (n = 5) of fallers (n = 100) while 17% (n = 17) received tranquilliser medication alone or in combination with medication(s) from one or more of the other medication groups. A total of 37% (n = 37) received anti-hypertensive medication only while over half (68%, n = 68) received anti-hypertensive medication alone or in combination with medication(s) from one or more of the other medication groups. Diuretic medication only was received by 2% (n = 2) while 20% (n = 20) received diuretic medication alone or in combination with medication(s) from one or more of the other medication groups.



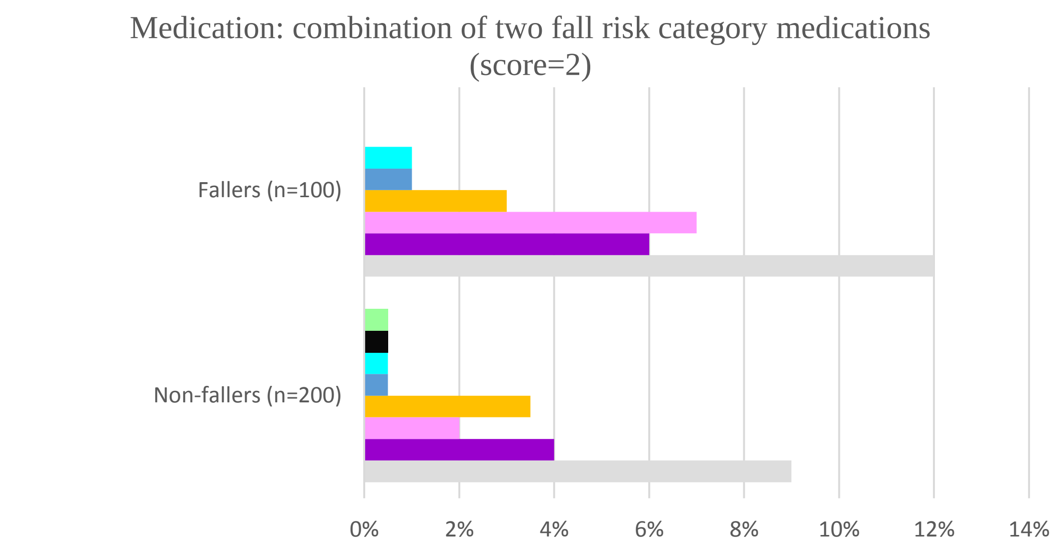
	Non-fallers (n=200)	Fallers (n=100)
Hypnotics only	4%	2%
Neuroleptics only	1.50%	0
Tranquillisers only	3.50%	5%
Anti-hypertensives only	34%	37%
Diuretics only	3%	2%
No medication	28.50%	17%

Figure 9: Medication (score 1) non-fallers (n = 200) and fallers (n = 100)

A combination of two medication categories would equate to a risk score of 2 within the medication fall risk variable.

The most common two medication combination among non-fallers (n = 200) was anti-hypertensives and diuretics (9%, n = 18), followed by tranquillisers and anti-hypertensives (4%, n = 18), neuroleptics and anti-hypertensives (3.5%, n = 7) and hypnotics and anti-hypertensives (2%, n = 4). The least common two medication combination among non-fallers (n = 200) was hypnotics and tranquillisers (0.5%, n = 1), hypnotics and diuretics (0.5%, n = 1), neuroleptics and diuretics (0.5%, n = 1) and tranquillisers and diuretics (0.5%, n = 1).

The most common two medication combination among fallers (n = 100) was anti-hypertensives and diuretics (12%, n = 12) followed by hypnotics and anti-hypertensives (7%, n = 7) and tranquillisers and anti-hypertensives (6%, n = 6). A total of 3% (n = 3) of fallers (n = 100) received neuroleptics and anti-hypertensives. The least common two medication combination among fallers (n = 100) were hypnotics and tranquillisers (1%, n = 1) and hypnotics and diuretics (1%, n = 1).



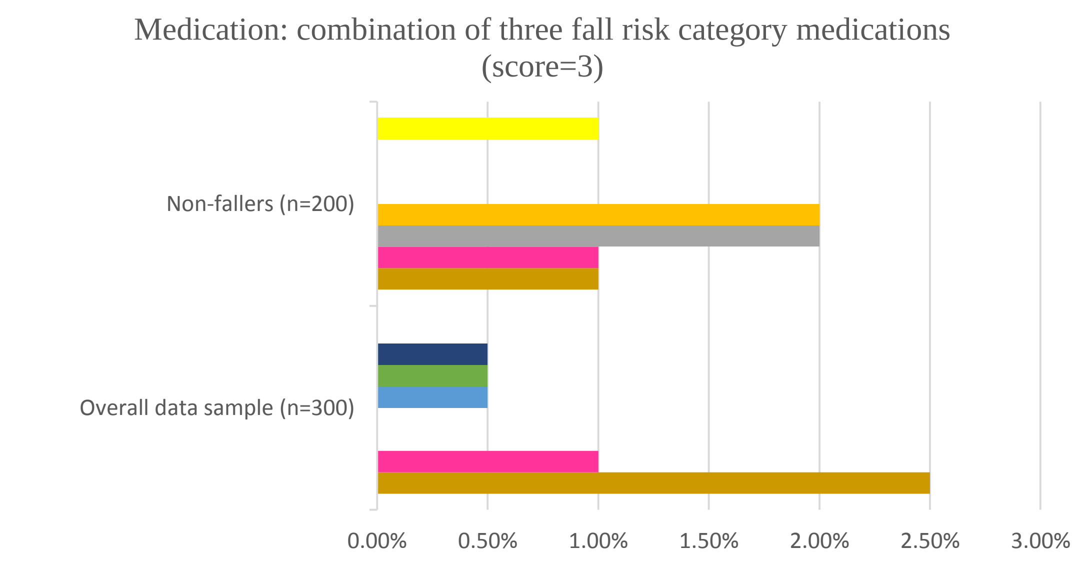
	Non-fallers (n=200)	Fallers (n=100)
Tranquillisers and diuretics	0.50%	0%
Neuroleptics and diuretics	0.50%	0%
Hypnotics and diuretics	0.50%	1%
Hypnotics and tranquillisers	0.50%	1%
Neuroleptics and anti-hypertensives	3.50%	3%
Hypnotics and anti-hypertensives	2%	7%
Tranquillisers and anti-hypertensives	4%	6%
Anti-hypertensives and diuretics	9%	12%

Figure 10: Medication (score 2) non-fallers (n = 200) and fallers (n = 100)

A combination of three risk category medications would equate to a risk score of 3 within the medication fall risk variable.

The most common three medication combination among non-fallers (n = 200) were hypnotics, anti-hypertensives, and diuretics (2.5%, n = 6) followed by neuroleptics, anti-hypertensives and diuretics (1%, n = 2). The least common three medication combination among non-fallers (n = 200) were neuroleptics, anti-hypertensives, and tranquillisers (0.5%, n = 1), hypnotics, tranquillisers and anti-hypertensives (0.5%, n = 1) and hypnotics, neuroleptics and anti-hypertensives (0.5%, n = 1). The three medication fall risk combinations of neuroleptics, tranquillisers and diuretics, hypnotics, neuroleptics and tranquillisers and tranquillisers anti-hypertensives and diuretics were not evident among non-fallers.

The most common three medication combination among fallers (n = 100) were neuroleptics, tranquillisers, and diuretics (2%, n = 2) and hypnotics, neuroleptics, and tranquillisers (2%, n = 2). The least common three medication combinations were, hypnotics, anti-hypertensives, and diuretics (1%, n = 1), neuroleptics, anti-hypertensives, and diuretics (1%, n = 1) and tranquillisers, anti-hypertensives and diuretics (1%, n = 1).



	Overall data sample (n=300)	Non-fallers (n=200)
Tranquillisers, anti-hypertensives and diuretics	0%	1%
Hypnotics, neuroleptics and anti-hypertensives	0.50%	0%
Hypnotics, tranquillisers and anti-hypertensives	0.50%	0%
Neuroleptics, anti-hypertensives and tranquillisers	0.50%	0%
Hypnotics, neuroleptics and tranquillisers	0%	2%
Neuroleptics, tranquillisers and diuretics	0%	2%
Neuroleptics, anti-hypertensives and diuretics	1%	1%
Hypnotics, anti-hypertensives and diuretics	2.50%	1%

Figure 11: Medication (score 3) non-fallers (n = 200) and fallers (n = 100)

Summary of medication

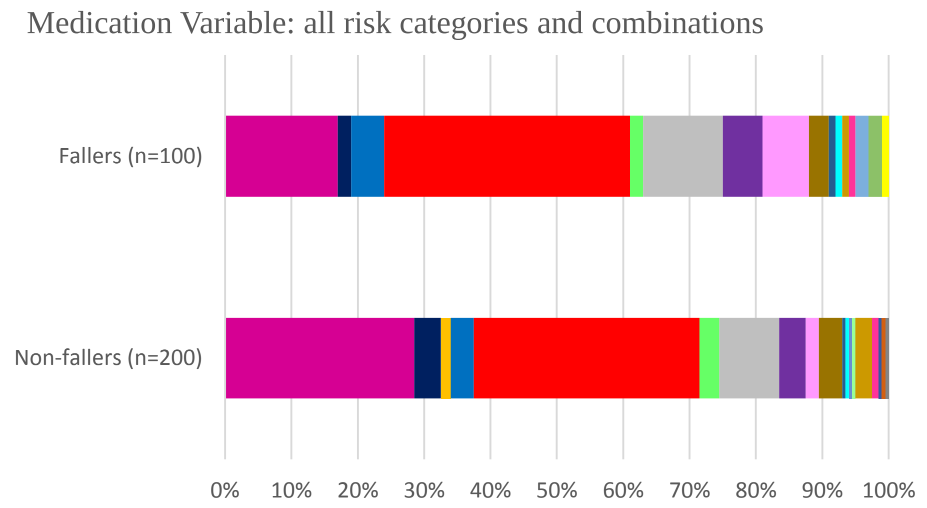
Over a quarter (28.5%, n = 57) of non-fallers (n = 200) received no medications, while 17% (n = 17) of fallers (n = 100) received no medications.

Anti-hypertensive medication (score=1) was the single most common risk category medication among non-fallers (n = 200) (34%, n = 68) and fallers (n = 100) (37%, n = 37).

Anti-hypertensives and diuretics were the most common two medication category combination (score=2) among non-fallers (n = 200) (9%, n = 18) and fallers (n = 100) (12%, n = 12).

The most common three medication category combination (score=3) among non-fallers (n = 200) was hypnotics, anti-hypertensives, and diuretics (2.5%, n = 6).

The most common three medication category combination among fallers (n = 100) was neuroleptics, tranquillisers, and diuretics (2%, n = 2).



	Non-fallers (n=200)	Fallers (n=100)
No medication	28.50%	17%
Hypnotics only	4%	2%
Neuroleptics only	1.50%	0%
Tranquillisers only	3.50%	5%
Anti-hypertensives only	34%	37%
Diuretics only	3%	2%
Anti-hypertensives and diuretics	9%	12%
Tranquillisers and anti-hypertensives	4%	6%
Hypnotics and anti-hypertensives	2%	7%
Neuroleptics and anti-hypertensives	3.50%	3%
Hypnotics and tranquillisers	0.50%	1%
Hypnotics and diuretics	0.50%	1%
Neuroleptics and diuretics	0.50%	0%
Tranquillisers and diuretics	0.50%	0%
Hypnotics, anti-hypertensives and diuretics	2.50%	1%
Neuroleptics, anti-hypertensives and diuretics	1%	1%
Neuroleptics, tranquillisers and diuretics	0%	2%
Hypnotics, neuroleptics and tranquillisers	0%	2%
Neuroleptics, anti-hypertensives and tranquillisers	0.50%	0%
Hypnotics, tranquillisers and anti-hypertensives	0.50%	0%
Hypnotics, neuroleptics and anti-hypertensives	0.50%	0%
Tranquillisers, anti-hypertensives and diuretics	0%	1%

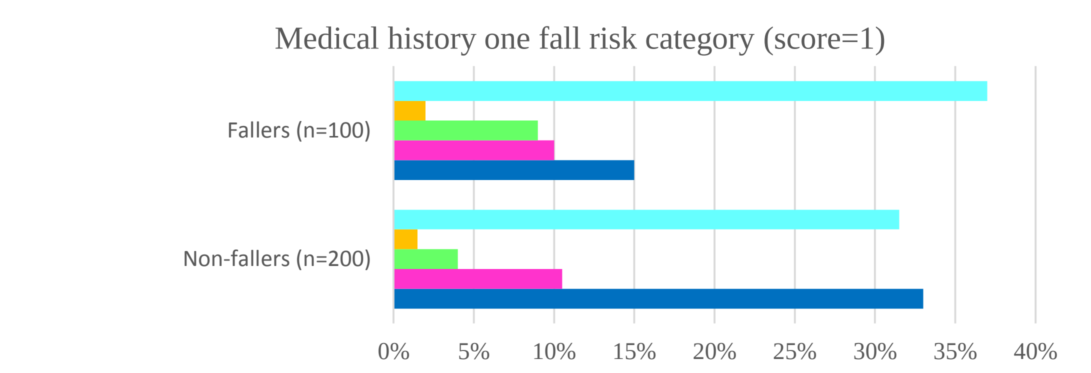
Figure 12: Medication all risk categories and combinations non-fallers (n = 200) and fallers (n = 100)

Medical history

The medical history fall risk variable is assessed under four categories, diabetes/ cardiovascular disease (score=1), organic brain disease/ confusion (mental test score <3) (score=1), seizure/ fits (score=1) and risk of fracture (score=1).

At 31.5% (n = 63) a risk of fracture was the most common medical history risk factor identified among non-fallers (n = 200) followed by diabetes/ cardiovascular disease (10.5%, n = 21), organic brain disease/ confusion (4%, n = 8), and seizure/fits (1.5%, n = 3). In total, 33% (n = 66) of non-fallers (n = 200) presented with no medical history fall risk factor identified within the medical history fall risk variable within the FRASE risk assessment tool.

At 37% (n = 37) a risk of fracture was the most common medical history risk factor identified among fallers (n = 100) followed by diabetes/ cardiovascular disease (10%, n = 10), organic brain disease/ confusion (9%, n = 9), seizure/fits (2%, n = 2). In total, 15% (n = 15) of fallers (n = 100) presented with no medical history fall risk factor identified within the medical history fall risk variable within the FRASE risk assessment tool.



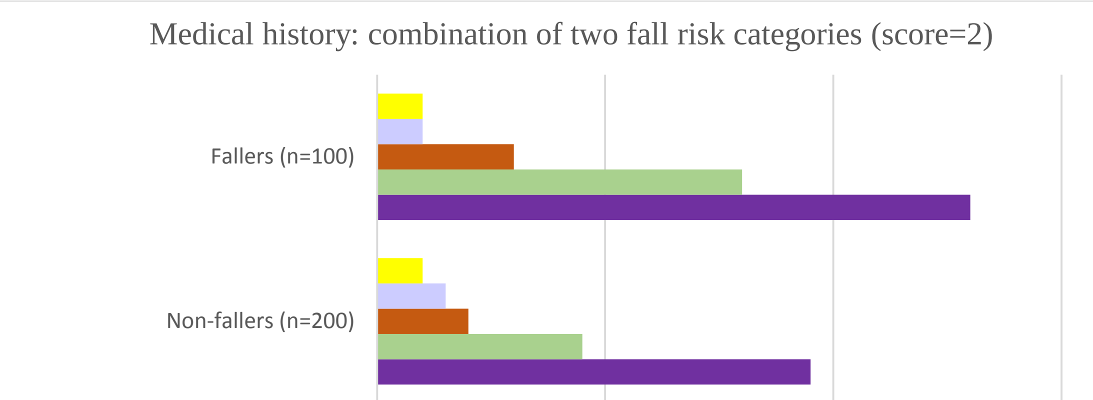
	Non-fallers (n=200)	Fallers (n=100)
Risk of Fracture	31.50%	37%
Seizures/ Fits	1.50%	2%
Organic brain disease/ Confusion	4%	9%
Diabetes/ CVD	10.50%	10%
None	33%	15%

Figure 13: Medical history (score=1) non-fallers (n = 200) and fallers (n = 100)

A combination of two medical history categories would equate to a risk score of 2 within the medical history fall risk variable within the FRASE risk assessment tool.

The most common two medical history combination among non-fallers (n = 200) were diabetes/cardiovascular disease and a risk of fracture (9.5%, n = 19) followed by organic brain disease/ confusion and a risk of fracture (4.5%, n = 9), seizures/ fits and a risk of fracture (2%, n = 4) and organic brain disease/ confusion and seizures/fits (1.5%, n = 3). The least common two medical history combination were diabetes/cardiovascular disease and organic brain disease / confusion (1%, n = 2).

The most common two medical history combination among fallers (n = 100) were diabetes/ cardiovascular disease and risk of fracture (13%, n = 13) followed by organic brain disease/ confusion and risk of fracture (8%, n = 8) and seizure/fits and risk of fracture (3%, n = 3). The least common two medical history combinations were organic brain disease/ confusion and seizures/fits (1%, n = 1) and diabetes/CVD and organic brain disease / confusion (1%, n = 1).



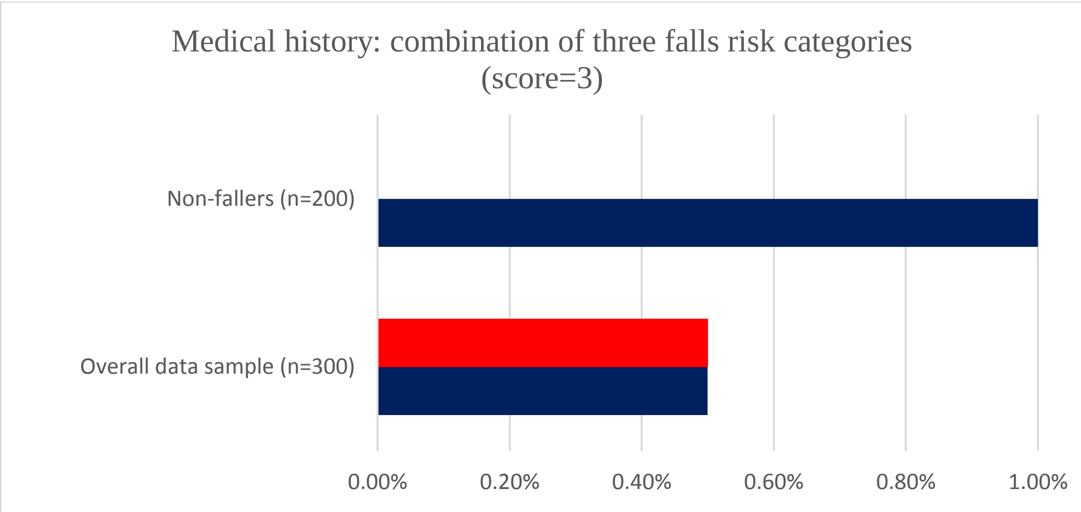
	Non-fallers (n=200)	Fallers (n=100)
Diabetes/ CVD and Organic brain disease/ Confusion	1%	1%
Organic brain disease/ Confusion and Seizures/ Fits	1.50%	1%
Seizures/ Fits and Risk of fracture	2%	3%
Organic brain disease/ Confusion and a Risk of fracture	4.50%	8%
Diabetes/ CVD and Risk of fracture	9.50%	13%

Figure 14: Medical history (score=2) non-fallers (n = 200) and fallers (n = 100)

A combination of three medical history categories would equate to a risk score of 3 within the medical history fall risk variable.

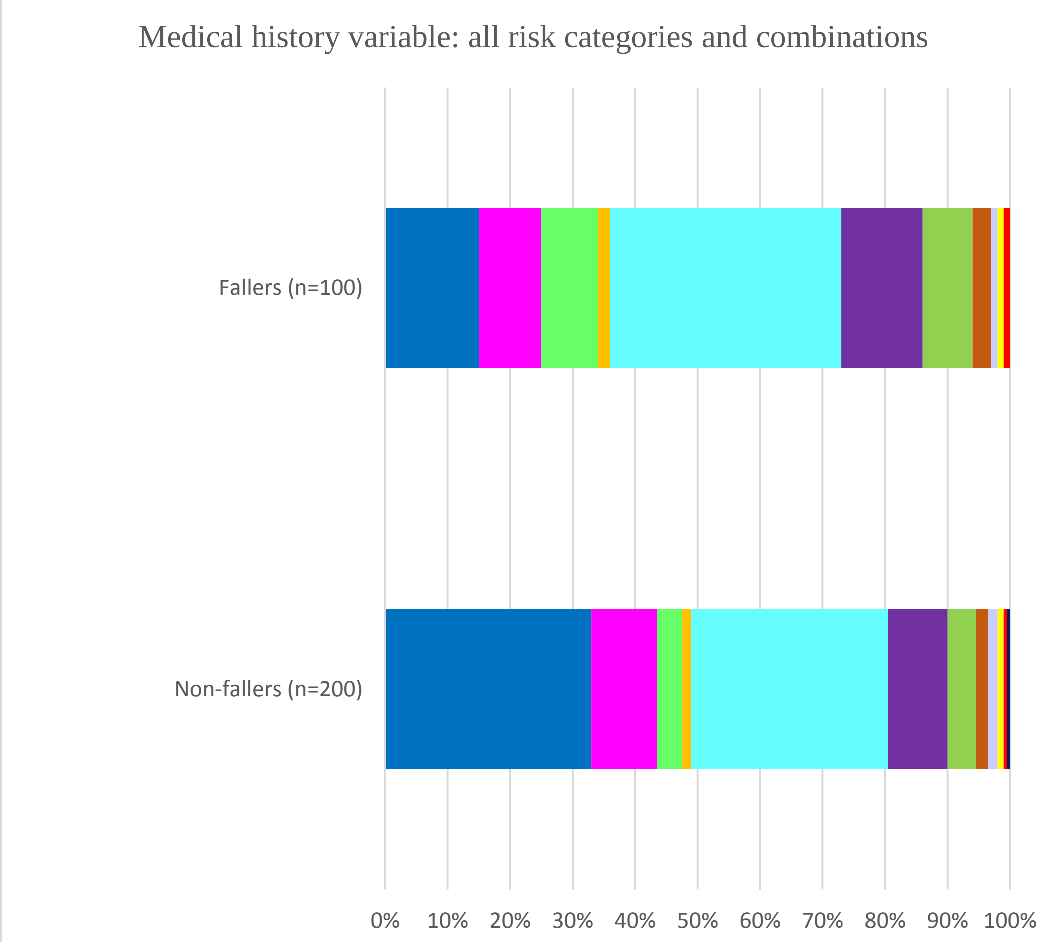
The most common three medical history combinations among non-fallers (n = 200) were organic brain disease/ confusion, seizures/fits, and risk of fracture (0.5%, n = 1) and diabetes/ cardiovascular disease, organic brain disease/ confusion and risk of fracture (0.5%, n = 1).

The only three medical history combination among non-fallers (n = 100) were organic brain disease/ confusion, seizures/fits, and a risk of fracture (1%, n = 1).



	Overall data sample (n=300)	Non-fallers (n=200)
Diabetes/ CVD, Organic brain disease/ Confusion and Risk of fracture	0.50%	0%
Organic brain disease/ Confusion, Seizures/ Fits and Risk of fracture	0.50%	1%

Figure 15: Medical history (score=3) non-fallers (n = 200) and fallers (n = 100)



	Non-fallers (n=200)	Fallers (n=100)
None	33%	15%
Diabetes/ CVD	10.50%	10%
Organic brain disease/ Confusion	4%	9%
Seizures/ Fits	1.50%	2%
Risk of Fracture	31.50%	37%
Diabetes/ CVD and Risk of fracture	9.50%	13%
Organic brain disease/ Confusion and a Risk of fracture	4.50%	8%
Seizures/ Fits and Risk of fracture	2%	3%
Organic brain disease/ Confusion and Seizures/ Fits	1.50%	1%
Diabetes/ Diabetes/ CVD and Organic brain disease/ Confusion	1%	1%
Organic brain disease/ Confusion, Seizures/ Fits and Risk of fracture	0.50%	1%
Diabetes/ CVD, Organic brain disease/ Confusion and Risk of fracture	0.50%	0%

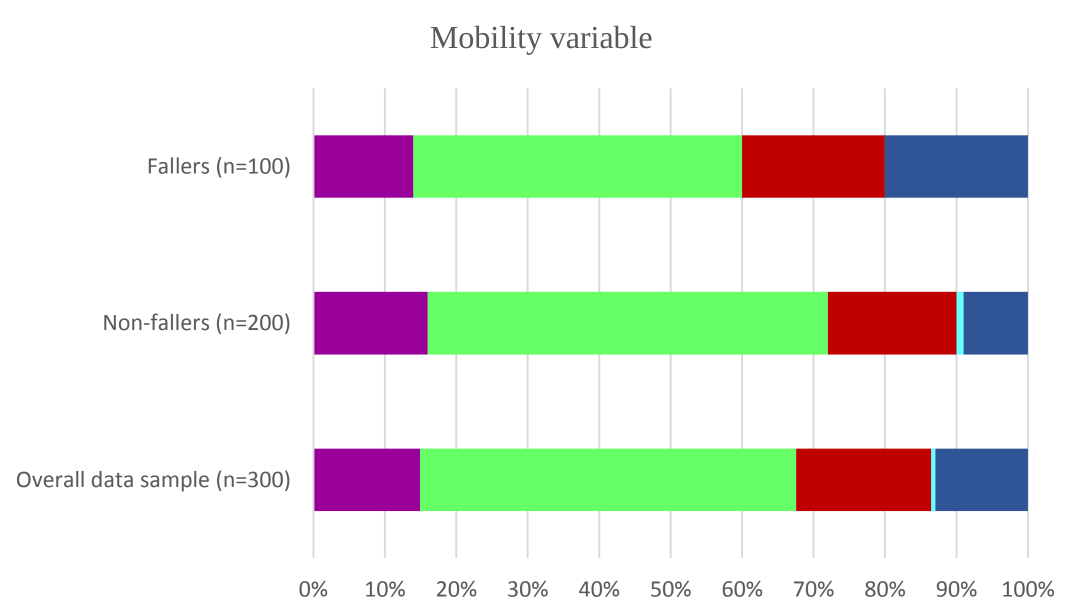
Figure 16: Medical history all risk categories and combinations non-fallers (n = 200) and fallers (n = 100)

Mobility

Within the mobility fall risk variable four mobility categories are itemised, full mobility (score=1), uses aids (score=2), restricted mobility (score=3) and bedbound (score=1).

Over half of the non-fallers were identified as uses aids only (56%, n = 112) followed by restricted (18%, n = 36), full mobility (16%, n = 32) and bedbound 1% (n = 2). A combined risk of uses aid and restricted was identified in 9% (n = 18) of non-fallers.

The majority of fallers (n = 100) were identified as uses aids (46%, n = 46) followed by restricted (20%, n = 20) and full mobility (14%, n = 14). 0% (n = 0) of fallers were identified as bedbound. A combined risk of uses aids and restricted was identified in 20% (n = 20) of fallers.



	Overall data sample (n=300)	Non-fallers (n=200)	Fallers (n=100)
Full mobility only	15%	16%	14%
Uses aids only	53%	56%	46%
Restricted only	19%	18%	20%
Bedbound only	0.60%	1%	0%
Uses aids and Restricted	13%	9%	20%

Figure 17: Mobility all risk categories and combinations non-fallers (n = 200) and fallers (n = 100)

Profile and characteristics summary of non-fallers (n = 200)

Over half (58%, n = 116) of the non-fallers (n = 200) were female, and those aged 81 years and older (52%, n = 104). Over half (53%, n = 106) had no previous falls history. Non-fallers were primarily hesitant (38%, n = 76), had no sensory deficit (26%, n = 52) and over half (56%, n = 112) required the use of aids to mobilise. A third of non-fallers (n = 200) had no medical history falls risks (33%, n = 66). Anti-hypertensives were the most commonly used medication (34%, n = 68) while 28.5% (n = 57) received no falls risk medication as per the FRASE risk assessment.

Profile and characteristics summary of fallers (n = 100)

Over half (55%, n = 55) of the fallers (n = 100) were male, and those aged 81 years and older (51%, n = 51). Over half the fallers (n = 100) (59%, n = 59) had experienced a fall in the 12 months prior to their admission. Fallers (n = 100) were primarily unsteady (26%, n = 26), had a balance deficit (19%, n = 19) and required the use of aids to mobilise (46%, n = 46). Over a third were at risk of fracture (37%, n = 37). Anti-hypertensives were the most commonly used medication (37%, n = 37) while 17% (n = 17) received no falls risk medication as per the FRASE risk assessment.

	Non-fallers (n=200)	Fallers (n=100)
	n (%)	n (%)
Gender		
Male (score=1)	84 (42.0)	55 (55.0)
Female (score=2)	116 (58.0)	45 (45.0)
Age group		
60-70 years (score=1)	34 (17.0)	13 (13.0)
71-80 years (score=2)	62 (31.0)	36 (36.0)
81+ years (score=1)	104 (52.0)	51 (51.0)
Falls history		
None (score=0)	106 (53.0)	28 (28.0)
At home (score=2)	94 (47.0)	59 (59.0)
In ward/unit (score=2)	0 (0.0)	3 (3.0)
Both (score=3)	0 (0.0)	10 (10.0)

Table 1: FRASE information on gender, age and falls history non-fallers (n = 200) and fallers (n = 100)

	Non-fallers (n=200)	Fallers (n=100)
	n (%)	n (%)
Gait		
Steady (score=0)	44 (22.0)	14 (14.0)
Hesitant (score=1)	76 (38.0)	20 (20.0)
Poor transfer (score=3)	17 (8.5)	8 (8.0)
Unsteady (score=3)	35 (17.5)	26 (26.0)
Hesitant and Poor transfer (score=4)	3 (1.5)	4 (4.0)
Hesistant and Unsteady (score=4)	7 (3.5)	11 (11.0)
Poor transfer and Unsteady (score=6)	11 (5.5)	10 (10.0)
Hesistant, Poor transfer and Unsteady (score=7)	7 (3.5)	7 (7.0)
Mobility		
Full (score=1)	32 (16.0)	14 (14.0)
Uses aid (score=2)	112 (56.0)	46 (46.0)
Restricted (score=3)	36 (18.0)	20 (20.0)
Bed bound (score=1)	2 (1.0)	0 (0.0)
Uses aid and restricted (score=5)	18 (9.0)	20 (20.0)
Sensory Deficit		
None (score=0)	52 (26.0)	17 (17.0)
Hearing (score=1)	12 (6.0)	7 (7.0)
Sight (score=2)	44 (22.0)	9 (9.0)
Balance (score=2)	44 (22.0)	19 (19.0)
Sight and Hearing (score=3)	11 (5.5)	11 (11.0)
Hearing and Balance (score=3)	12 (6.0)	8 (8.0)
Sight and Balance (score=4)	17 (8.5)	17 (17.0)
Sight, Hearing and Balance (score=5)	8 (4.0)	12 (12.0)

Table 2: FRASE information on gait, mobility, and sensory deficit non-fallers (n = 200) and fallers (n = 100)

	Non-fallers (n=200)	Fallers (n=100)
	n (%)	n (%)
Medical history		
None (score=0)	66 (33.0)	15 (15.0)
Risk of fracture (score=1)	63 (31.5)	37 (37.0)
Diabetes/CVD (score=1)	21 (10.5)	10 (10.0)
Organic brain disease/Confusion (score=1)	8 (4.0)	9 (9.0)
Seizures/Fits (score=1)	3 (1.5)	2 (2.0)
Diabetes/CVD and Risk of fracture (score=2)	19 (9.5)	13 (13.0)
Organic brain disease/Confusion and Risk of fracture (score=2)	9 (4.5)	8 (8.0)
Seizures/Fits and Risk of fracture (score=2)	4 (2.0)	3 (3.0)
Organic brain disease/Confusion and Seizures/Fits (score=2)	3 (1.5)	1 (1.0)
Diabetes/CVD and Organic brain disease/Confusion (score=2)	2 (1.0)	1 (1.0)
Organic brain disease/Confusion, Seizures/Fits and Risk of fracture (score=3)	1 (0.5)	1 (1.0)
Diabetes/CVD, Organic brain disease/Confusion and Risk of fracture (score=3)	1 (0.5)	0 (0.0)

Table 3: FRASE information on medical history non-fallers (n = 200) and fallers (n = 100)

	Non-fallers (n=200)	Fallers (n=100)
	n (%)	n (%)
Medication		
None (score=0)	57 (28.5)	17 (17.0)
Anti-hypertensives (score=1)	68 (34.0)	37 (37.0)
Hypnotics (score=1)	8 (4.0)	2 (2.0)
Tranquillisers (score=1)	7 (3.5)	5 (5.0)
Diuretics (score=1)	6 (3.0)	2 (2.0)
Neuroleptics (score=1)	3 (1.5)	0 (0.0)
Anti-hypertensives and Diuretics (score=2)	18 (9.0)	12 (12.0)
Tranquillisers and Anti-hypertensives (score=2)	8 (4.0)	6 (6.0)
Neuroleptics and Anti-hypertensives (score=2)	7 (3.5)	3 (3.0)
Hypnotics and Anti-hypertensives (score=2)	4 (2.0)	7 (7.0)
Hypnotics and Tranquillisers (score=2)	1 (0.5)	1 (1.0)
Hypnotics and Diuretics (score=2)	1 (0.5)	1 (1.0)
Neuroleptics and Diuretics (score=2)	1 (0.5)	0 (0.0)
Tranquillisers and Diuretics (score=2)	1 (0.5)	0 (0.0)
Hypnotics, Anti-hypertensives and Diuretics (score=3)	5 (2.5)	1 (1.0)
Neuroleptics, Anti-hypertensives and Diuretics (score=3)	2 (1.0)	1 (1.0)
Neuroleptics, Anti-hypertensives and Tranquillisers(score=3)	1 (0.5)	0 (0.0)
Neuroleptics, Tranquillisers and Diuretics (score=3)	0 (0.0)	2 (2.0)
Hypnotics, Transquillisers and Anti-hypertensives (score=3)	1 (0.5)	0 (0.0)
Hypnotics, Neuroleptics and Anti-hypertensives (score=3)	1 (0.5)	0 (0.0)
Hypnotics, Neuroleptics and Tranquillisers (score=3)	0 (0.0)	2 (2.0)
Tranquillisers, Anti-hypertensives and Diuretics (score=3)	0 (0.0)	1 (1.0)

Table 4: FRASE information on medication non-fallers (n = 200) and fallers (n = 100)

4.2 NIRF fall incident category information for fallers (n = 100)

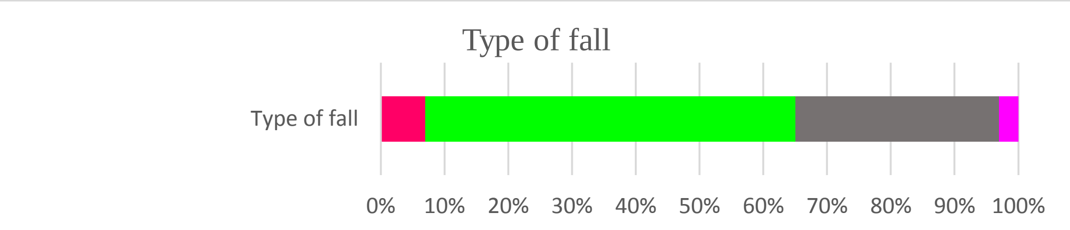
This section presents the fall incident category information related to the study sample. The information was extracted from Section 2 of the Data Collection tool. The information describes the type of falls experienced, the type of hazards the fall incidents were related to and the category of injury sustained by the older adults (n = 100) as a direct result of their fall. The falls incident category information pertaining to fallers (n = 100) is presented in Table 5.

	n (%)
Where fell	
From equipment/furniture	58 (58.0)
Same level/Ground	32 (32.0)
From height	7 (7.0)
Other	3 (3.0)
Type of hazard fall related to	
Unknown	42 (42.0)
Pre existing medical condition	23 (23.0)
Inappropriate equipment use	13 (13.0)
Rough terrain/ irregular surface	4 (4.0)
Surface contaminants	1 (1.0)
Failure/ malfunction of equipment	1 (1.0)
Other	16 (16.0)
Outcome at the time of the incident	
No injury	76 (76.0)
Injury not requiring first aid	15 (15.0)
Injury or illness requiring first aid	5 (5.0)
Injury requiring medical treatment	4 (4.0)

Table 5: NIRF information on fallers (n = 100)

Type of fall

Over half the data pertained to older adults who fell from equipment or furniture (58%, n = 58). The remaining falls were on the same level/ ground (32%, n = 32), from a height (7%, n = 7) or other (3%, n = 3).

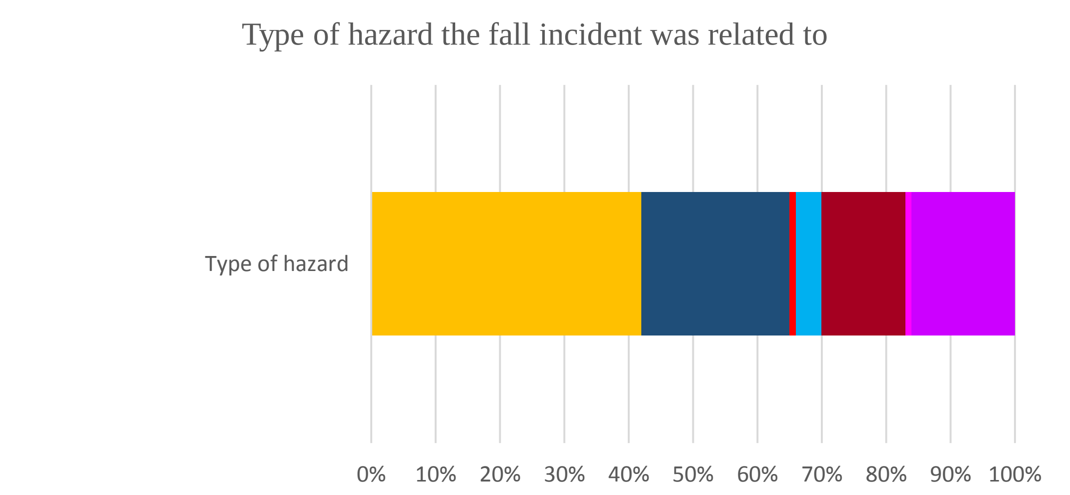


	Type of fall
Fall from height	7%
Fall from equipment or furniture	58%
Fall on same level/ ground	32%
Fall on stairs	0
Fall on steps	0
Other	3%

Figure 18: Type of fall experience of fallers (n = 100)

Type of hazard the fall incident was related to

The type of hazards the fall incidents were related to were primarily unknown (42%, n = 42). Where a hazard relating to a fall was identified the most common was a pre-existing medical condition (23%, n = 23). A total of 16% of fall incidents were attributed to other hazards. Thereafter, fall related incidents were associated with inappropriate use of equipment (13%, n = 13), rough terrain/ irregular surface (4%, n = 4), surface contaminants (1%, n = 1) and failure/ malfunction of equipment (1%, n = 1).

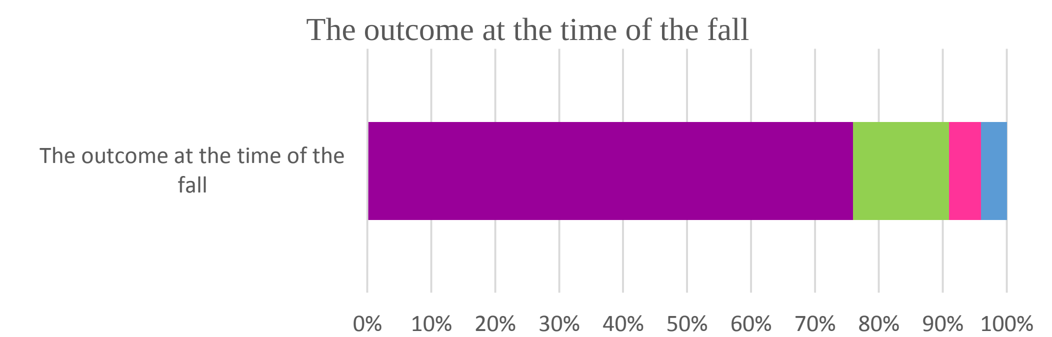


	Type of hazard
Unknown	42%
Pre-existing medical condition	23%
Inadequate supervision	0%
Obstruction/ protruding object	0%
Surface contaminants	1%
Rough terrain/ irregular surface	4%
Inappropriate equipment use	13%
Failure/ malfunction of equipment	1%
Horseplay	0%
Physical training/ sport	0%
Weather condition	0%
Inadequate lighting/ design	0%
Other	16%

Figure 19: Type of hazard the fall incident was related to among fallers (n = 100)

The outcome at the time of the fall

The majority of fall incidents were categorised as no injury (76%, n = 76). Thereafter, 15% (n = 15) were categorised as not requiring first aid while 5% (n = 5) were categorised as an injury or illness requiring first aid. A total of 4% (n = 4) of fall incidents (n = 100) resulted in an outcome that was categorised as an injury requiring medical treatment.



	The outcome at the time of the fall
Near miss	0
No injury	76%
Injury not requiring first aid	15%
Injury or illness requiring first aid	5%
Injury requiring medical treatment	4%
Longterm disability/ incapacity	0
Permanent incapacity	0
Death	0

Figure 20: The outcome at the time of the fall for fallers (n = 100)

4.3 Predictive accuracy of the FRASE risk assessment tool

The primary objective of this research was to determine the predictive accuracy of the FRASE risk assessment tool in identifying older adults at high risk of falls. The diagnostic accuracy of the FRASE was assessed using the area under the ROC curve. In addition, sensitivity (the percentage of older adults who experienced a fall correctly classified as 'high risk' of falls), specificity (the percentage of older adults who did not experience a fall correctly classified as 'not at high risk' of falls) was assessed. In addition, the positive likelihood ratio, and negative likelihood ratio was assessed. The positive likelihood ratio was the percentage of older adults in the FRASE 'high risk' category (score 13+) who experienced a fall divided by the percentage of older adults in the 'high risk' category (score 13+) who did not experience a fall (LR+ = sensitivity/ (1-specificity). The negative likelihood ratio was the percentage of older adults who experienced a fall that were not in the FRASE 'high risk' category (score 13+) divided by the percentage of older adults who did not experience a fall that were not in the FRASE 'high risk' category (score 13+) (LR- = (1- sensitivity)/ specificity).

The boxplot in figure 21 presents the results of the independent samples t-test ($P<0.001$) which showed the mean score of the FRASE was significantly higher among fallers (n = 100) (mean (SD) 14.8 (4.5)) then non-fallers (n = 200) (mean (SD) 11.8 (4.11)) thus indicating a greater variation among non-fallers (n = 100).

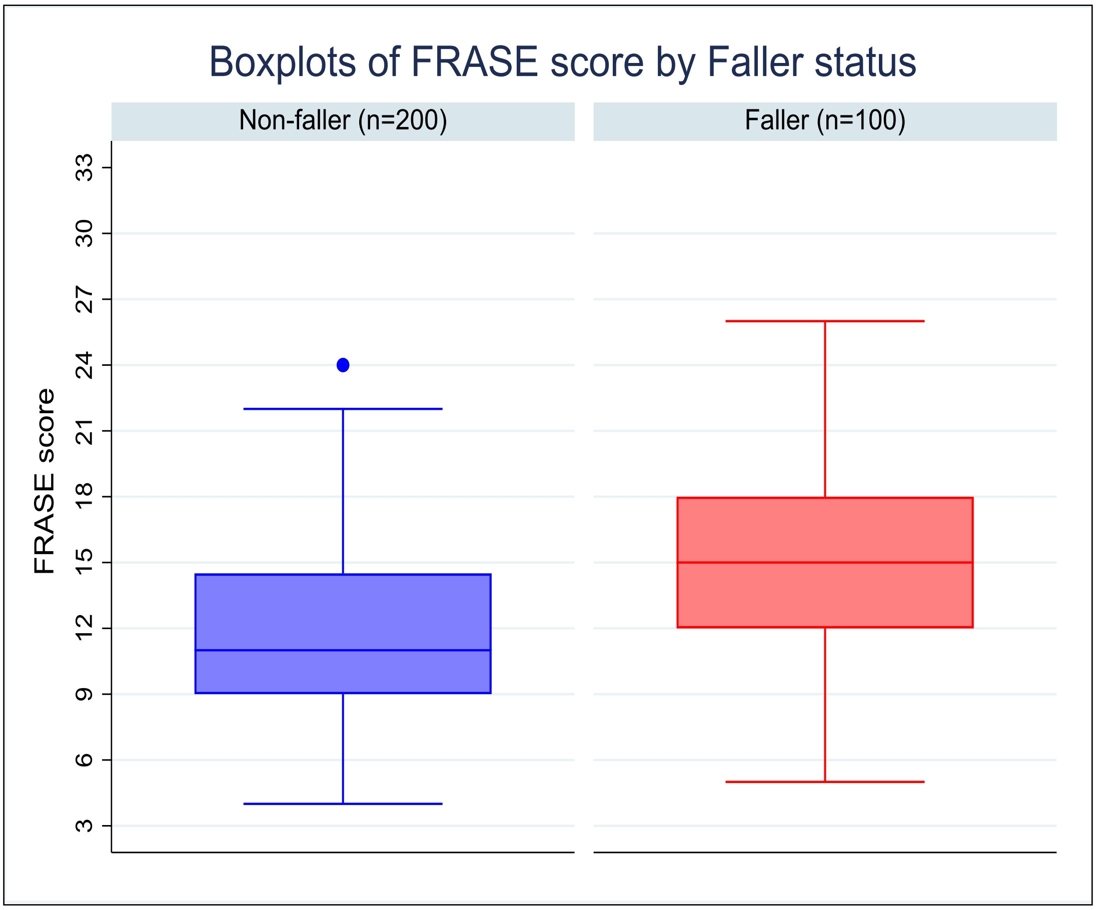
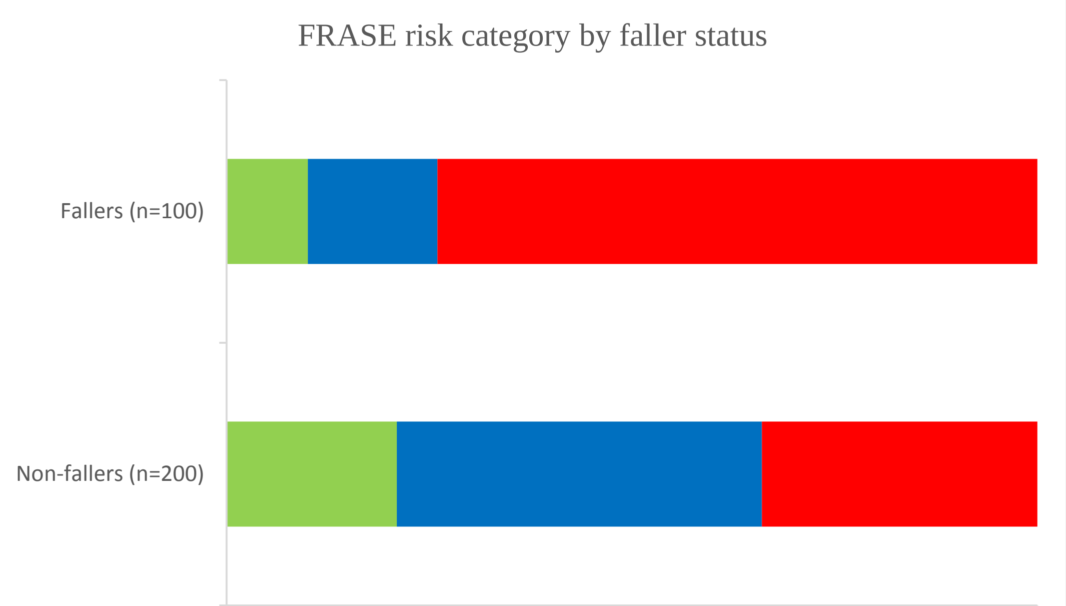


Figure 21: Boxplots of the FRASE score by faller status, non-fallers (n = 200) and fallers (n = 100)

The Fisher’s exact test (p<0.001) presented in figure 22 showed a significant relationship between faller status and FRASE risk category. Fallers (n = 100) were more likely to be in the high-risk category (74%) than non-fallers (n = 200) (34%).



	Non-fallers (n=200)	Fallers (n=100)
Low risk: 3-8	42%	10%
Medium risk: 9-12	90%	16%
High risk: 13+	68%	74%

Figure 22:FRASE risk category by faller status, non-fallers (n = 200) and fallers (n = 100)

The AUC for the FRASE risk assessment tool in this research was 0.698 (95% CI: 0.641, 0.748) demonstrating a predictive accuracy which is greater than clinical judgement and random probability (Figure 23).

Analysing the receiver operating characteristic (ROC) determines the relationship between sensitivity and specificity (Kim et al., 2011). Ideally, predictive values will present a low false negative rate at high sensitivity, AUC shows the possibility of the tool accurately distinguishing between PPV and NPV (Wray et al., 2010). A tool commands good accuracy when the AUC graph is closer to 1, successfully distinguishing between diseased or ‘at risk’ individuals and healthy or ‘not at risk’ individuals. A tool is considered to have decisive power if the AUC value is greater than 0.7 while AUC values below 0.5 hold no decisive power, demonstrating a predictive accuracy no greater than clinical judgment and comparable to random probability (Berrar and Flach, 2012).

An important method in investigating and diagnosing disease is the evaluation of biomarker levels. Disease diagnosis or for this research, the identification of older adults ‘at risk’ of falling, is dependent upon a correlation between biomarker levels and disease state (Ruopp et al., 2008). The cut-off point on the test is referred to as *c* (Smits, 2010). The biomarker levels for the diseased or ‘at risk’ population are usually higher than the corresponding non-diseased or ‘not at risk’ population (Ruopp et al., 2008). Accordingly, older adults with test scores greater than or equal to *c* are tested as positive i.e. ‘at risk’ of falling while older adults with test scores lower than *c* are tested as negative i.e. ‘not at risk’ of falling.

Sensitivity is the probability of an older adult who will experience a fall being tested as such while specificity is the probability of an older adult who will not experience a fall receiving a negative ‘not at risk’ test outcome (Smits, 2010). Consequently, the receiver operating characteristic (ROC) curve can be used to evaluate the effectiveness of a cut-off point/ biomarker in the determination of older adults ‘at risk’ of falling and older adults ‘not at risk’ of falling. Consequently, the ROC curve for the FRASE is presented in Figure 24 and was obtained by plotting the sensitivity against (1-sensitivity) at different cut-offs (*c*) of the FRASE score as per table 6.

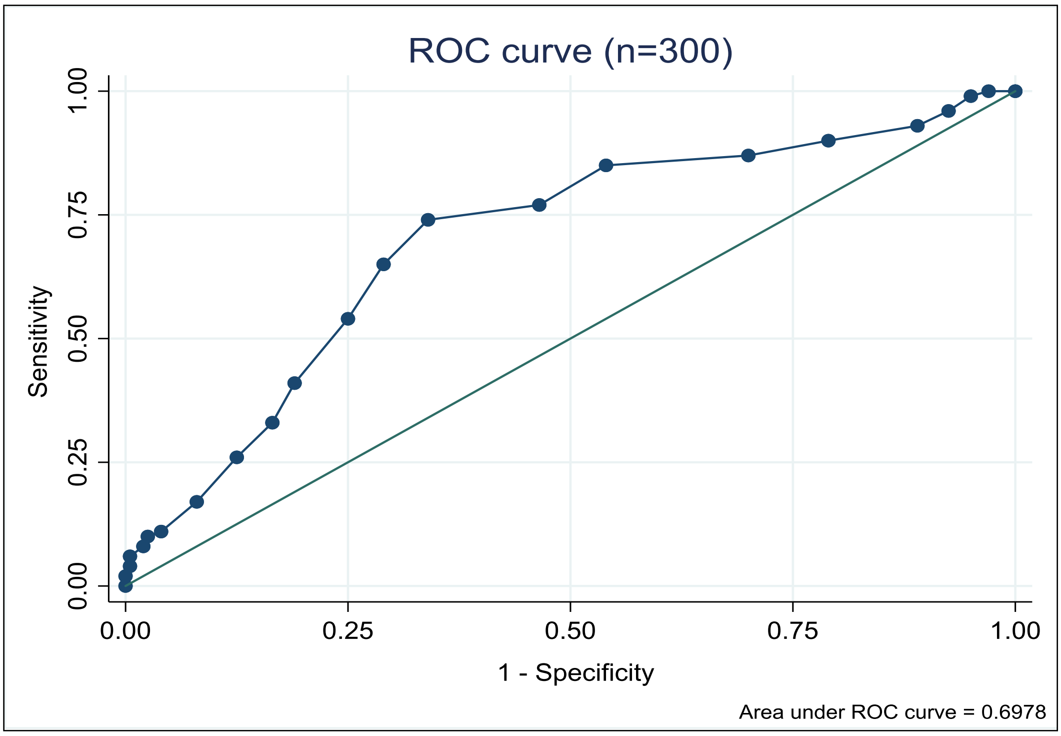


Figure 23: ROC curve for the FRASE

Cutpoint	Sensitivity	Specificity	Correctly Classified	LR+	LR-
(>= 4)	100.0	0.0	33.33	1.00	
(>= 5)	100.0	3.0	35.33	1.03	0.00
(>= 6)	99.0	5.0	36.33	1.04	0.20
(>= 7)	96.0	7.5	37.00	1.04	0.53
(>= 8)	93.0	11.0	38.33	1.04	0.64
(>= 9)	90.0	21.0	44.00	1.14	0.48
(>= 10)	87.0	30.0	49.00	1.24	0.43
(>= 11)	85.0	46.0	59.00	1.57	0.33
(>= 12)	77.0	53.5	61.33	1.66	0.43
(>= 13)	74.0	66.0	68.67	2.18	0.39
(>= 14)	65.0	71.0	69.00	2.24	0.49
(>= 15)	54.0	75.0	68.00	2.16	0.61
(>= 16)	41.0	81.0	67.67	2.16	0.73
(>= 17)	33.0	83.5	66.67	2.00	0.80
(>= 18)	26.0	87.5	67.00	2.08	0.85
(>= 19)	17.0	92.0	67.00	2.13	0.90
(>= 20)	11.0	96.0	67.67	2.75	0.93
(>= 21)	10.0	97.5	68.33	4.00	0.92
(>= 22)	8.0	98.0	68.00	4.00	0.94
(>= 23)	6.0	99.5	68.33	12.00	0.94
(>= 24)	4.0	99.5	67.67	8.00	0.96
(>= 26)	2.0	100.0	67.33		0.98
(> 26)	0.0	100.0	66.67		1.00

Table 6: Diagnostic accuracy across different cut-off of the FRASE score

Sensitivity and specificity are inversely related and fluctuate according to changes in the threshold therefore, applying a higher (lower) cut-off point value (c) will directly decrease (increase) the sensitivity and increase (decrease) the specificity (Smits, 2010).

Using the recommended ‘high-risk’ category cut-off point of 13+ as per the FRASE (i.e. a FRASE score greater than 12) sensitivity was 74.0% (95% CI: 64.3% to 82.3%) and specificity was 66.0% (95% CI: 59.0% to 72.5%). Therefore, using the recommended ‘high-risk’ category cut-off point of 13+ the FRASE presented good predictive accuracy in identifying fallers (n = 100) as ‘at risk’ of falls and moderate predictive accuracy in identifying non-fallers (n = 200) as ‘not at risk’ of falls.

When using the medium risk category cut off point of 9+ (i.e. a FRASE score greater than 9), sensitivity was 90% (95% CI: 82.4% to 95.1%) and specificity was 21% (95% CI: 15.6% to 27.3%). Therefore, using the medium risk category cut off point of 9+ the FRASE presented very good predictive accuracy in identifying fallers (n = 100) as ‘at risk’ of falls and low predictive accuracy in identifying non-fallers (n = 200) as ‘not at risk’ of falls.

The Yoden’s Index (J) sets thresholds on tests by interpreting the maximum potential effectiveness of a biomarker/ cut-off point value. The optimal cut-point (c*) is the cut-off point that optimises the biomarkers differentiation ability when equal weight is applied to sensitivity and specificity (Ruopp et al., 2008). Likelihood ratios provide the best measure of diagnostic accuracy, comparing tests for the same diagnosis (McGee, 2002)**.** Likelihood ratio in this research study is the probability of the weighted falls risk variables of fallers (n = 100) divided by the probability of the weighted falls risk variables of non-fallers (n = 200). A likelihood ratio > 1 contends with the diagnosis of interest (i.e. risk of falls). Thereafter, the greater the number the more convincingly the findings predict a risk of falls. A likelihood ratio between 0 and 1 argues against the diagnosis of interest (i.e. risk of falls). A likelihood ratio equal to 1 lacks diagnostic value (McGee, 2002).

In this research the recommended ‘high-risk’ category cut-off point of 13+ as per the FRASE was also Youden’s index best cut-off that maximised (sensitivity + specificity) resulting in a positive likelihood ratio of 2.18 (95% CI: 1.74 to 2.73) and a negative likelihood ratio of 0.39 (0.28 to 0.56). As a likelihood ratio > 1 contends with the diagnosis of interest (i.e. risk of falls) one can deduce that older adults who receive a risk score of 13+ in the FRASE risk assessment are likely to experience a fall. The medium risk category cut off point of 9+ was also Youden’s index best cut-off that maximised (sensitivity + specificity) resulting in a positive likelihood ratio of 1.14 (95% CI: 1.03 to 1.26) and a negative likelihood ratio of 0.48 (95% CI: 0.25 to 0.91). As a likelihood ratio > 1 contends with the diagnosis of interest (i.e. risk of falls) one can deduce that older adults who receive a risk score of 9+ (but less than 13) in the FRASE risk assessment are likely to experience a fall, but less likely than those who receive a risk score of 13+.

4.4 Relationship between faller status and the fall risk variables identified within the FRASE risk assessment tool

In this section univariate analysis investigating the relationship between faller status and each of the fall risk variables identified within the FRASE risk assessment are presented. A variable is any attribute that can be monitored or measured on a subject (Canova et al., 2017). In this research the eight fall risk variables identified within the FRASE falls risk assessment tool, gender, age, gait, sensory deficit, falls history, medication, medical history, and mobility are considered a variable of interest. Undertaking univariate descriptive analysis of each variable will describe the variable distribution in the data sample. All statistical tests were two-sided and a p-value <0.05 was considered to be statistically significant (Cohen, 1992).

Odds ratio is the probability of an older adult falling compared to the probability of an older adults not falling. It is a measure of association, which quantifies the strength of the correlation between an exposure and an outcome Ogumbanjo (2004)**.** Therefore, if non-fallers have lower odds, the OR will be above 1; if fallers have lower odds, the

OR will be less than 1; and if there is no difference between non-fallers and fallers, the OR will be exactly 1.

The AUC was selected to evaluate the independent fall risk variables within the FRASE risk assessment as this is the most common statistics to evaluate the discriminative ability of prediction models (Palumbo et al., 2016). Therefore, an AUC with a value of 1 or 0 will indicate that the predictive accuracy of the variable is always right or wrong, respectively. An AUC of 0.5 demonstrates the tests predictive accuracy is no better than random probability (Jester et al., 2005). The results of the univariate analysis are presented for each independent fall risk variable under the corresponding null hypothesis presented in section 3.6 of chapter 3.

Relationship between faller status and gender

H1: There is no relationship between faller status and gender as determined by the FRASE risk assessment tool

Univariate analysis in this research study showed a statistically significant relationship between faller status and gender (p=0.037) with males accounting for a higher percentage of fallers (55%) than non-fallers (42%).

To provide an estimate for the relationship between the two binary variables, faller status and gender, the odds ratio was measured. In the FRASE risk assessment female older adults were deemed a greater falls risk (score=2). Therefore, odds ratio equated to the odds in favour of an older adult experiencing a fall, and being of the female gender, to the odds in favour of an older adult experiencing a fall and not being of the female gender. The odds of a female older adult falling were 0.59 times (95% CI: 0.37 to 0.96, p=0.034) that of a male older adult falling. The odds of a male older adult falling were 1.69 times (95% CI: 1.04 to 2.74) the odds of a female older adult falling. Therefore, with an OR less than 1, female older adults showed a lower probability of falling in comparison to the male older adults and male older adults showed a great probability of falling in comparison to the female older adults. This result is opposite to the scoring of the FRASE where the higher weighted risk score is assigned to the female category within the gender fall risk variable.

Applying the higher weighted risk score for female (score=2) within the gender fall risk variable in the FRASE risk assessment tool, the area under the ROC curve was 0.435 (95% CI: 0.377 to 0.492). The accuracy of the test is dependent on the tests ability to distinguish between those who are ‘at risk’ of falls and those who are ‘not a risk’ of falls. Therefore, as the ROC curve is 0.435 (i.e. < 0.5), the gender fall risk variable demonstrates no discrimination and no predictive accuracy in predicting future falls among older adults.

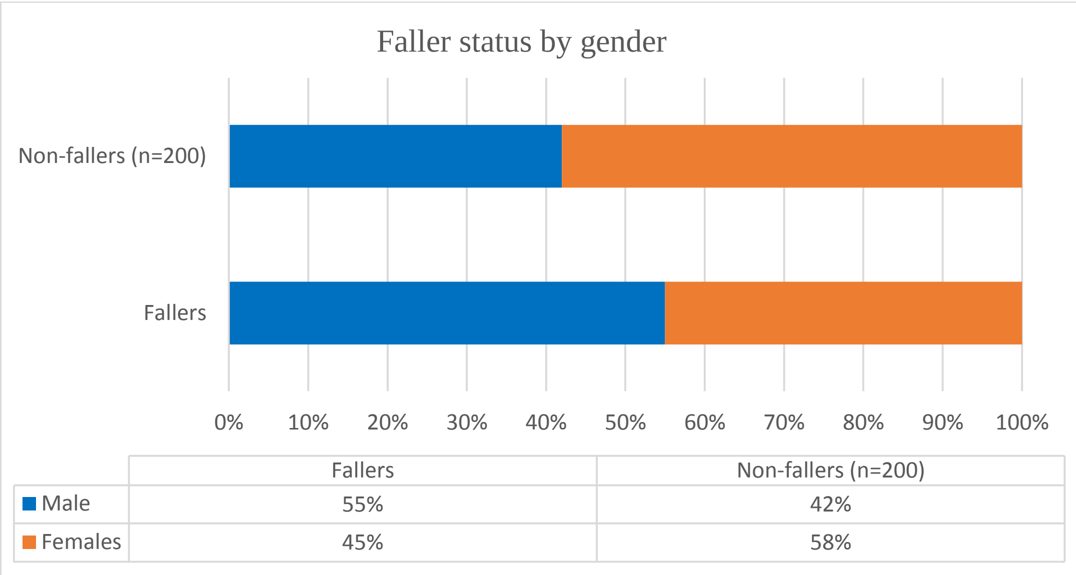


Figure 24: Faller status by gender

Relationship between faller status and age

H2: There is no relationship between faller status and age as determined by the FRASE risk assessment tool

Univariate analysis in this research study showed no statistically significant relationship between faller status and age p value <0.5 (p=0.434). Analysis of fallers status as per the three ages categories recorded, showed no statistically significant relationship between faller status and age (p=0.116). Statistically, 36% of fallers (n =

100) were within the 71-80 years age category, compared to 31% of non-fallers (n = 200).

To provide an estimate for the relationship between the two binary variables, faller status and age, the odds ratio was measured. In the age fall risk variable older adults aged between 71 – 80 years were deemed a greater risk of falls (score=2). Therefore, the odds ratio equated to the odds in favour of an older adult experiencing a fall, and being aged between 71 – 80 years, to the odds in favour of an older adult experiencing a fall and not being aged between 70 – 81 years. The odds of an older adult aged between 71 – 80 years experiencing a fall was 1.25 times (95% CI: 0.75 to 2.08, p=0.384) that of an older adult in the other combined age categories experiencing a fall. Therefore, with an OR greater than 1, older adults aged between 71 – 80 years showed a higher probability of falling in comparison to the older adults in the other combined age categories.

Applying the weighted risk scoring assigned to the three included age categories in the FRASE risk assessment tool, aged between 60 – 70 years (score=1), aged between 71 – 80 years (score=2) and aged 81 years and over (score=1), the area under the ROC curve was 0.525 (95% CI: 0.468 to 0.584). The accuracy of the test is dependent on the tests ability to distinguish between those who are ‘at risk’ of falls and those who are ‘not a risk’ of falls. Therefore, as the ROC curve is 0.525 (i.e. > 0.5) the age fall risk variable demonstrates low predictive accuracy in predicting future falls among older adults.

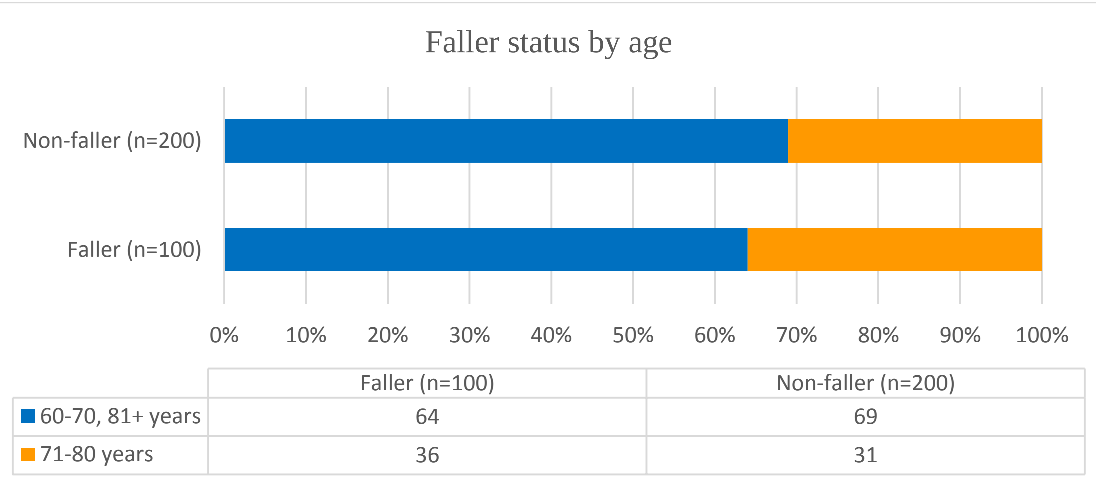


Figure 25: Faller status by age

Relationship between faller status and gait

H3: There is no relationship between faller status and gait as determined by the FRASE risk assessment tool

Univariate analysis identified a statistically significant relationship between faller status and gait ($p<0.001$). A higher percentage of fallers (n = 100) were hesitant (score=1) and had poor transfer (score=3) or were hesitant (score=1) and unsteady (score=3) compared to non-fallers (n = 200) (15% vs 5%, p=0.007). In addition, data pertaining to non-fallers (n = 200) showed a lower percentage of fallers (n = 100) were risk weighted as hesitant only (score=1) in the gait fall risk variable (20% vs 38%, p=0.002). There was no statistically significant difference in the data between non-fallers (n = 200) and fallers (n = 100) in the other itemised categories within the gait fall risk variable, steady (score=0), poor transfer (score=3) and unsteady (score=3).

Faller status was analysed against the individual fall risk categories within the gait fall risk variable, steady (score=0), hesitant (score=1), poor transfer (score=3) and unsteady (score=3). Analysis identified the unsteady (score=3) fall risk category was the only category to show a significant relationship with faller status ($p<0.001$). Comparing the data representative of older adults with an unsteady gait (score=3) and older adults who do not have an unsteady gait, those who have an unsteady gait are more likely to have fallen, (54% in the faller group vs 30% in the non-faller group). There was no significant relationship found between faller status and the steady category (p=0.121), hesitant category (p=0.538) or poor transfer category (p=0.057) within the gait fall risk variable.

To provide an estimate for the relationship between the two binary variables, faller status and gait fall risk variable, the odds ratio was measured. The odds ratio equates to the odds in favour of an older adult experiencing a fall and being steady/ hesitant/ having a poor transfer/ unsteady, to the odds in favour of an older adult experiencing a fall and not being steady/ hesitant/ having a poor transfer/ unsteady. The odds of an older adult with the maximum combined risk of poor transfer (score=3), unsteady gait

(score=3) and hesitant (score=1) falling was 3.80 times (95% CI: 1.19 to 12.09, p=0.024) that of an older adult who risk assessed as hesitant only (score=1).
Although a lower weighted risk, the odds of an older adult risk assessed as hesitant (score=1)/ poor transfer (score=3) or with the combined risk of hesitant (score=1) and unsteady (score=3) falling is 5.70 times (95% CI: 2.23 to 14.59), p<0.001) that of an older adult who was hesitant only (score=1).

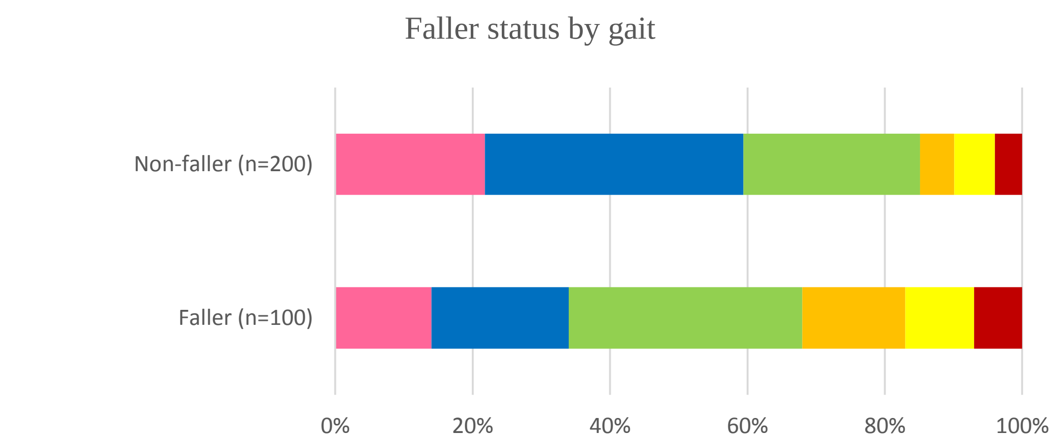
The odds of an older adult risk assessed as hesitant (score=1)/ poor transfer (score=3) or with the combined risk of hesitant (score=1) and unsteady (score=3) falling was 4.71 times (95% CI: 1.73 to 12.83, p=0.002) that of an older adult who had a steady gait (score=0).

The odds of an older adult with a combined risk of poor transfer (score=3) and unsteady gait (score=3) falling was 2.86 times (95% CI: 1.00 to 8.41, p=0.049) that of an older adult who had a steady gait only (score=0) and 3.45 times (95% CI: 1.29 to 9.28), p=0.014) that of an older adult who was hesitant only (score=1).

The odds of an older adult risk assessed as poor transfer (score=3) or unsteady gait (score=3) falling was 2.48 times (95% CI: 1.29 to 4.78, p=0.006) that of an older adult who was risk assessed as hesitant only (score=1).

The odds of an older adult categorised as hesitant only (score=1) falling was significantly lower than that of an older adult categorised as unsteady only (score=3), poor transfer only (score=3), or a combination of 2 gait issues or all three gait issues (score=4-7). In addition, the odds of an older adult who was categorised as steady (score=0) experiencing a fall was significantly lower than that of an older adult who had a combination of two gait issues (score=4-6). There were no statistically significant differences found between any of the other risk category combinations.

Applying the weighted risk scoring assigned to the four gait categories specified in the FRASE risk assessment tool, steady (score=0), hesitant (score=1), poor transfer (score=3) and unsteady (score=3), the area under the ROC curve was 0.641 (95% CI: 0.583 to 0.694). The accuracy of the test is dependent on the tests ability to distinguish between those ‘at risk’ and ‘not at risk’ of falling. Therefore, as the ROC curve is 0.641 (i.e. >0.5) the gait fall risk variable demonstrates significant predictive accuracy in predicting future falls among older adults.



	Faller (n=100)	Non-faller (n=200)
0 = Steady	14%	22%
1 = Hesitant	20%	38%
3= Poor transfer/ Unsteady	34%	26%
4 = Hesitant & Poor transfer/ Hesitant & Unsteady	15%	5%
6= Poor transfer & Unsteady	10%	6%
7 = Hesitant, Poor transfer & Unsteady	7%	4%

Figure 26: Faller status by gait

Relationship between faller status and sensory deficit

H4: There is no relationship between faller status and sensory deficit as determined by the FRASE risk assessment tool

Univariate analysis identified a statistically significant relationship between faller status and sensory deficit (p=0.001). Compared to non-fallers (n = 200), a higher percentage of fallers (n = 100) had both a sight deficit (score=2) and balance deficit (score=2) (total score=4) (17% vs 8.5%, p=0.034) or all three sensory deficits (total score=5) (12% vs 4%, p=0.013). A higher percentage of non-fallers (n = 200), had either a sight deficit (score=2) or balance deficit (score=2) (44% vs 28%, p=0.008). No statistically significant differences were found between non-fallers (n = 200) and fallers (n = 100) in terms of having no sensory deficit (26% vs 17% p=0.083), a hearing deficit (score=1) (6% vs 7%, p=0.803) or the risk weighted combinations of a sight deficit (score=2) and hearing deficit (score=1) or hearing deficit (score=1) and balance deficit (score=2) (11.5% vs 19% p=0.111).

Faller status was analysed against the individual categories within the sensory deficit fall risk variable, sight deficit (score=2), hearing deficit (score=1), and balance deficit (score=2). Analysis identified a statistically significant relationship between faller status and the hearing deficit category (p=0.004) and the balance deficit category (p=0.014). Comparing the data representative of older adults with a hearing deficit (score=1) with the data representative of older adults with no hearing deficit, the older adults with a hearing deficit (score=1) are more likely to have experienced a fall (38% in the faller group vs 21.5% in the non-faller group). In addition, comparing the data representative of older adults with a balance deficit (score=2) with the data representative of older adults with no balance deficit, the older adults with a balance deficit (score=2) are more likely to have experienced a fall (56% fallers vs 40.5% non-fallers). There was no statistically significant relationship found between faller status and the sight deficit category (p=0.140).

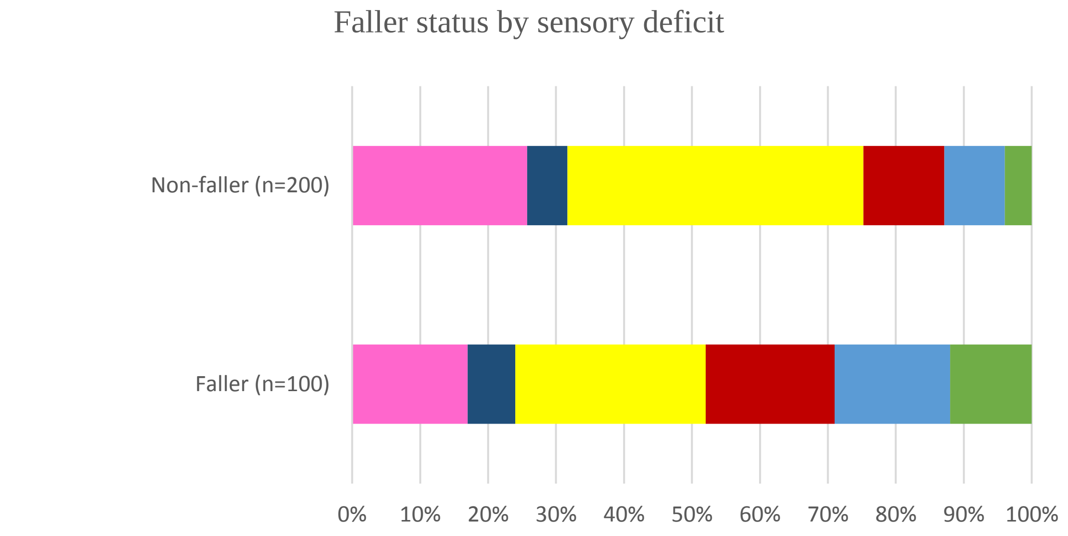
The odds of an older adult risk weighted for all three sensory deficits (score=5) experiencing a fall was 4.59 times (95% CI: 1.61 to 13.10, p=0.004) that of an older adult with no sensory deficits (score=0).The odds of an older adult risk weighted for all three sensory deficits (score=5) experiencing a fall was 4.71 times (95% CI: 1.75 to 12.69, p=0.002) that of an older adult with a sight deficit only (score=2) or balance deficit only (score=2).

The odds of an older adult with a combined sight (score=2) and balance deficit (score=2) (total score=4) falling was 3.06 times (95% CI: 1.29 to 7.28, p=0.011) that of an older adult with no sensory deficits (score=0). The odds of an older adult with a combined sight (score=2) and balance deficit (score=2) (total score=4) falling was and 3.14 times (95% CI: 1.42 to 6.96, p=0.005) that of an older adult with a sight deficit only (score=2) or balance deficit only (score=2).

The odds of an older adult with a combined risk of a sight (score=2) and hearing deficit (score=1) (total score=3) or a hearing (score=1) and balance deficit (score=2) (total score=3) falling was 2.53 times (95% CI: 1.12 to 5.73, p=0.026) that of an older adult with no sensory deficits (score=0). The odds of an older adult with a combined risk of a sight (score=2) and hearing deficit (score=1) (total score=3) or a hearing (score=1) and balance deficit (score=2) (total score=3) falling was 2.60 times (95% CI: 1.24 to 5.45, p=0.012) that of an older adult with a sight deficit only (score=2) or balance deficit only (score=2).

The odds ratios presented show an older adult with a combined risk of two sensory deficits (total score=3/4) or all three sensory deficits (total score=5) experiencing a fall is significantly higher than that of an older adult either no sensory deficits (score=0), a sight deficit only (score=2) or a balance deficit only(score=2). There were no statistically significant differences found between any of the other categories (e.g. no sensory deficit vs hearing deficit).

Applying the weighted risk scoring assigned to the three sensory risk categories within in the sensory deficit fall risk variable in the FRASE risk assessment tool, sight deficit (score=2), hearing deficit (score=1) and balance deficit (score=2), the area under the ROC curve was 0.623 (95% CI: 0.566 to 0.678).The accuracy of the test is dependent on the tests ability to distinguish between those ‘at risk’ and ‘not at risk’ of falling. Consequently, as the ROC curve is 0.623, the sensory deficit fall risk variable demonstrates significant predictive accuracy for predicting future falls among older adults.



	Faller (n=100)	Non-faller (n=200)
0= None	17%	26%
1 - Hearing	7%	6%
2 = Sight/ Balance	28%	44%
3 = Sight & Hearing/ Hearing & Balance	19%	12%
4 = Sight and Balance	17%	9%
5 = All three	12%	4%

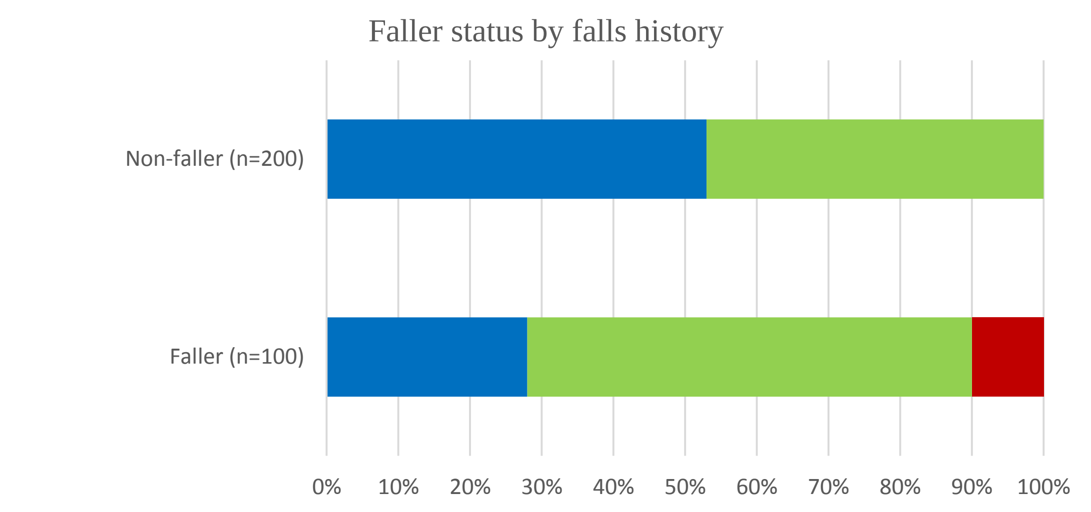
Figure 27: Faller status by sensory deficit

Relationship between faller status and falls history

H5: There is no relationship between fallers status and falls history as determined by the FRASE risk assessment tool

Univariate analysis showed a statistically significant relationship between faller status and falls history ($p<0.001$). Comparing non-fallers (n = 200) and fallers (n = 100), a higher percentage of fallers (n = 100) had experienced a previous fall both at home and in the ward/unit (score both=3) (10% vs 0%, $p<0.001$). In addition, a higher percentage of fallers (n = 100) had experienced a previous fall either at home (score=2) or in the ward/unit (score=2) (62% vs 47%, $p=0.015$). Non-fallers were more likely to have no previous history of falls in comparison to fallers (53% vs 28%, $p<0.001$). Logistic regression analysis could not be performed with the data representing the falls history fall risk variable as 0% (n = 0) of non-fallers (n = 200) experience a previous fall both at home (past 12 month) and in the ward/ unit (score=3).

Applying the weighted risk scoring assigned to the four falls history categories within in the falls history fall risk variable in the FRASE risk assessment tool, none (score=0), at home (past 12 month) (score=1), in ward/ unit (score=2), and both (score=3) the area under the ROC curve was 0.649 (95% CI: 0.593 to 0.704). The accuracy of the test is dependent on the tests ability to distinguish between those who 'at risk' and 'not a risk' of falling. Consequently, as the ROC curve is 0.649 (i.e. > 0.5) the falls history fall risk variable demonstrates significant predictive accuracy for predicting future falls among older adults.



	Faller (n=100)	Non-faller (n=200)
0 = None	28%	53%
2 = At home/ In ward or unit	62%	47%
3 = Both	10%	0%

Figure 28: Faller status by falls history

Relationship between faller status and medication

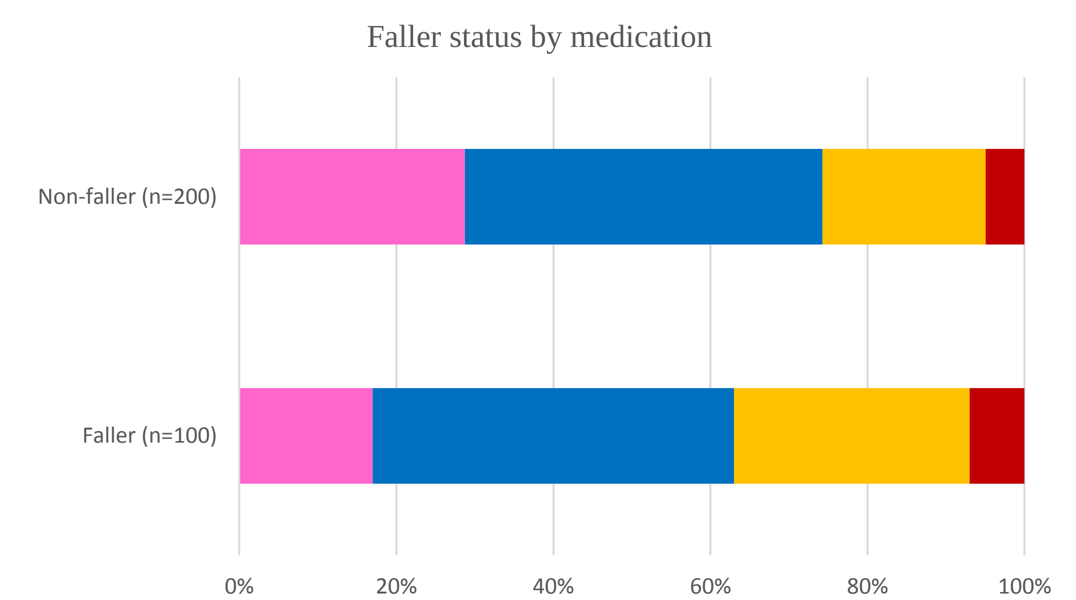
H6: There is no relationship between faller status and medication as determined by the FRASE risk assessment tool

Univariate analysis failed to show a statistically significant relationship between faller status and medication (p=0.081). The combined risk of 3 medications (score=3) and 2 medications (score=2) into one category showed a statistically significant relationship between faller status and the number of medications (p=0.037). Analysis of each medications separately showed no statistically significant relationships between faller status and hypnotics (p=0.446), neuroleptics (p=1.0), tranquillisers (p=0.088), anti-hypertensives (p=0.081) and diuretics (p=0.527). As the p-values for tranquilisers (score=1) (p=0.088) and anti-hypertensives (score=1) (p=0.081) were close to the p<0.05 cut-off, a multiple logistic regression model of both medications was undertaken. Data analysis identified both medications are statistically associated with faller status (Tranquillisers: p=0.038, Anti-hypertensives: p=0.049).

Comparing non-fallers (n = 200) and fallers (n = 100), a higher percentage of fallers (n = 100) were receiving two (score=2) or more (score=2+) medications within the 5 falls risk medication categories listed (37% vs 25.5%, p=0.044). In addition, a lower percentage of fallers (n = 100) were receiving no medication (score=0) which could be categorised within the 5 falls risk medication categories listed (17% vs 28.5%, p=0.033). In contrast, there was no statistically significant difference between fallers (n = 100) and non-fallers (n = 200) receiving medication from 1 falls risk medication category (score=1) (46% vs 46%, p=1).

The odds of an older adult receiving two (score=2) or more (score=2+) medications categorised within the 5 falls risk medication categories experiencing a fall was 2.43 times (95% CI: 1.22 to 4.84, p=0.011) that of an older adult receiving no fall risk medication category medication (score=0).

Applying the weighted risk scoring assigned to the five fall risk medication categories within in the medication fall risk variable in the FRASE risk assessment tool, hypnotics (score=1), neuroleptics (score=1), tranquillisers (score=1), anti-hypertensives (score=1) and diuretics (score=1) the the area under the ROC curve was 0.584 (95% CI: 0.525 to 0.640).The accuracy of the test is dependent on the tests ability to distinguish between those who are ‘at risk’ and ‘not at risk’ of falling. and those who are not diseased/ not a risk. Therefore, as the ROC curve is 0.584 (i.e.>0.5) the medication fall risk variable demonstrates predictive accuracy in predicting future falls among older adults.



	Faller (n=100)	Non-faller (n=200)
0 = 0 medications	17%	29%
1 = 1 medication	46%	46%
2 = 2 medications	30%	21%
3 = 3 medications	7%	5%

Figure 29: Faller status by medication

Relationship between faller status and medical history

H7: There is no relationship between faller status and medical history as determined by the FRASE risk assessment tool

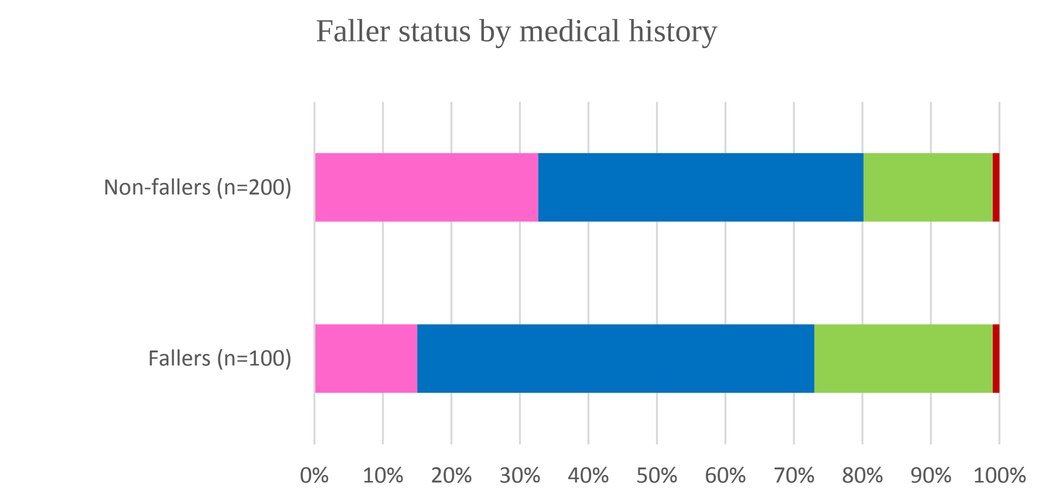
Univariate analysis showed a statistically significant relationship between faller status and medical history (p=0.005). Comparing the data representative of non-fallers (n = 200) and fallers (n = 100), a lower percentage of non-fallers (n = 100) had no medical condition categorised within the medical history fall risk variable (15% vs 33%, p=0.001). No statistically significant differences were found between fallers (n = 100) and non-fallers (n = 200) with one medical history risk category (score=1) (p=0.111) or two medical history risk categories (score=2) (p=0.136). No statistical comparison was undertaken of data representative of older adults (n = 3) with three medical history risk categories (score=3).

Independent analysis of each medical history falls risk category showed a statistically significant relationship between faller status and a risk of fracture (score=1) (p=0.028). Comparing the data representative of the older adults identified to be ‘at risk’ of fracture with older adults identified as ‘not at risk’ of fracture, those at risk were more likely to experience a fall (62% fallers vs 48.5% non-fallers). Showing p values greater than 0.05 no statistically significant relationship was identified between faller status and the medical history falls risk categories, diabetes/cardiovascular disease (p=0.660), organic brain disease/ confusion (p=0.083) or seizures/fits (p=0.613).

As the p-value for organic brain disease/ confusion (score=1) (p=0.083) is close to the cut-off (p<0.05), data pertaining to the medical history falls risk categories ‘risk of fracture’ (score=1) and ‘organic brain disease/confusion’ (score=1) were included in a multiple logistic regression model. Demonstrating p values < 0.05, both a ‘risk of fracture’ (score=1) (p=0.020) and ‘organic brain disease/ confusion’ (score=1) (p=0.046) showed a statistically significant relationship with faller status.

Logistic regression analysis was undertaken by combining data representative of two medical history fall risk categories (score=2) and three medical history fall risk categories (n = 3). The odds of an older adult with 1 medical history fall risk category (score=1) experiencing a fall was 2.69 times (95% CI: 1.40 to 5.14, p=0.003) that of an older adult with no categorised medical history fall risk (score=0). The odds of an older adult with 2 (score=2) or 3 (score=3) medical history falls risk categories experiencing a fall was 3.05 times (95% CI: 1.45 to 6.42, p=0.003) that of an older adult with no categorised medical history falls risk (score=0). No statistically significant difference was found between older adults with 1 (score=1) medical history falls risk category and older adults with 2 (score=2) or 3 (score=3) medical history fall risk categorise (p=0.676).

Applying the weighted risk scoring assigned to the medical history fall risk categories within the medical history fall risk variable in the FRASE risk assessment tool, ‘diabetes/ cardiovascular disease’ (score=1), ‘organic brain disease or confusion’ (score=1), ‘seizures/ fits’ (score=1), ‘risk of fracture’ (score=1) the area under the ROC curve was 0.597 (95% CI: 0.539 to 0.653).The accuracy of the test is dependent on the tests ability to distinguish between those who ‘at risk’ and ‘not at risk’ of falling. Therefore as the ROC curve is 0.597 (i.e. >0.5) the medical history fall risk variable demonstrates significant predictive accuracy in predicting future falls among older adults.



	Fallers (n=100)	Non-fallers (n=200)
0 = No medical conditions	15%	33%
1 = 1 medical condition	58%	48%
2 = 2 medical conditions	26%	19%
3 = 3 medical conditions	1%	1%

Figure 30: Faller status by medical history

Relationship between faller status and mobility

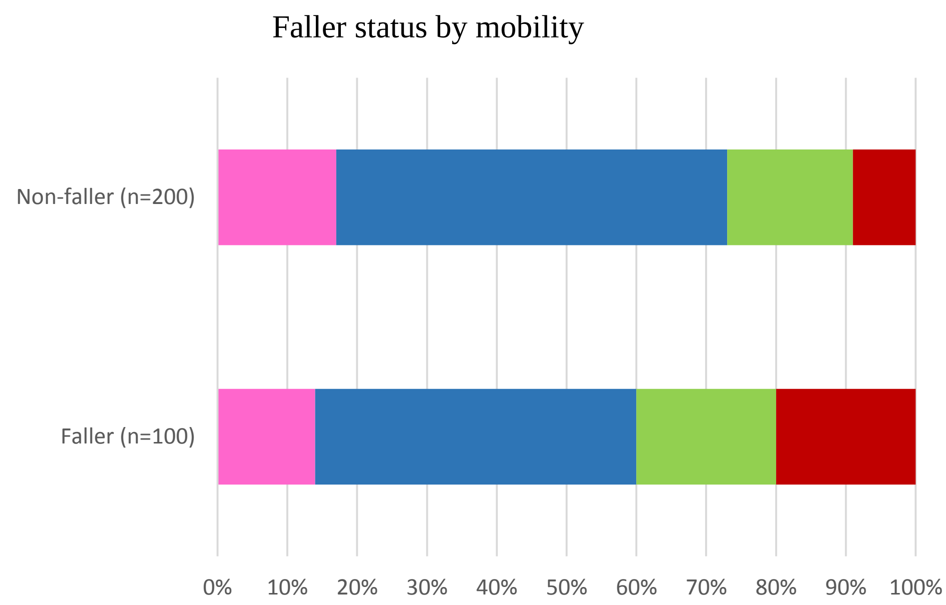
H8: There is no relationship between faller status and mobility as determined by the FRASE risk assessment tool

Univariate analysis showed a statistically significant relationship between faller status and mobility (p=0.049). Comparing fallers (n = 100) and non-fallers (n = 200), a higher percentage of fallers (n = 100) used an aid (score=2) and were restricted (score=3) (total score=5) (20% vs 9%, p=0.010). No statistically significant differences were found between fallers (n = 100) and non-fallers (n = 200) in terms of being restricted (score=3) (20% vs 18%, p=0.753), using aids (score=2) (46% vs 56%, p=0.112) or having full mobility (score=1)/being bedbound (score=1) (14% vs 17%, p=0.617).

The odds of an older adult with the combined risk of using aids (score=2) and having a restricted mobility (score=3) experiencing a fall was 2.70 times (95% CI: 1.11 to 6.57, p=0.029) that of an older adult who has full-mobility (score=1)/is bedbound (score=1). In addition, the odds of an older adult with the combined risk of using aids (score=2) and having a restricted mobility (score=3) experiencing a fall was 2.71 times (95% CI: 1.31 to 5.58, p=0.007) that of an older adult who only uses aids (score=2).

Independent analysis of the 4 categories within the mobility fall risk variable showed a statistically significant relationship between faller status and restricted mobility (score=3) (p=0.025). Comparing the data representative of older adults risk assessed as restricted (score=3) to older adults who are not restricted, those who are restricted (score=3) are more likely to have experienced a fall (40% fallers vs 27% non-fallers). No significant relationship was found between faller status and full mobility (score=1) (p=0.735) or uses aids (score=2) (p=0.898). The bedbound category (score=1) was not compared as the data represented too small a sample (n = 2). No statistically significant difference was found between older adults with the combined risk of uses aids (score=2) and restricted (score=3) (total score=5) and older adults with restricted mobility only (score=3). No statistically significant differences were found between any of the other groups (e.g. uses aids (score=2) vs restricted (score=3).

Applying the weighted risk scoring assigned to the four categories in the mobility fall risk variable in the FRASE risk assessment tool, full (score=1), uses aids (score=2), restricted (score=3) and bedbound (score=1) the area under the ROC curve was 0.574 (95% CI: 0.515 to 0.630).The accuracy of the test is dependent on the tests ability to distinguish between those ‘at risk’ and those ‘not at risk’. Therefore, as the ROC curve is 0.574 (i.e. >0.5) the mobility fall risk variable demonstrates significant predictive accuracy in predicting future falls among older adults.



	Faller (n=100)	Non-faller (n=200)
1 = Full mobility/ Bedbound	14%	17%
2 = Uses aids	46%	56%
3 = Restricted	20%	18%
5 = Uses aids and restricted	20%	9%

Figure 31: Faller status by mobility

Summary of the relationship between faller status and the fall risk variables

To summarise, the analysis identified a significant relationship between faller status and gender (p=0.037). In disagreement with the weighted scoring in the FRASE, the odds of a male older adult falling were 1.69 times (95% CI: 1.04 to 2.74) the odds of a female older adult falling.

Analysis showed no significant relationship between faller status and age (p=0.434). However, in accordance with the FRASE weighted risk scoring, older adults aged between 71-80 years (score=2) were 1.25 times (95% CI: 0.75 to 2.08, p=0.384) more likely to experience a fall than older adults in the other combined age categories.

There was a statistically significant relationship between faller status and gait (p<0.001). An unsteady gait was identified in 54% of fallers (n = 100).

A significant relationship was also identified between faller status and sensory deficit (p=0.001). In comparison to non-fallers (n = 200), a higher percentage of fallers (n = 100) had both a sight and balance deficit (score=4) (17% vs 8.5%, p=0.034) or all three sensory deficits (score=5) (12% vs 4%, p=0.013). A significant relationship was identified between faller status and both a hearing deficit (score =1) (p=0.004) and balance deficit (score=2) (p=0.004). In disagreement with the FRASE weighted scoring no relationship was identified between faller status and a sight deficit (score=2) (p=0.140).

A significant relationship was identified between faller status and falls history (p<0.001). In comparison to non-fallers (n = 200) a higher percentage of fallers (n = 100) had experienced 'both' (score=3) a previous fall at home and in the ward/ unit (10% vs 0%, p<0.001). In comparison to non-fallers (n = 200) a higher percentage of fallers (n = 100) had experienced a fall a fall 'at home' (score=2) or 'in the ward/ unit' (score=2) (62% vs 47%, p=0.015). Non-fallers (n = 200) were more likely to have no previous falls history (score=0) (53% vs 28%, p<0.001).

A relationship between faller status and medication failed to reach statistical significance (p=0.081). Combined analysis identified a statistically significant relationship between faller status and a combination of three (score=3) or two medication (score=2) risk categories (p=0.037). Although, independent analysis identified no statistically significant relationship between faller status and the independent fall risk medication categories. A multiple logistic regression model identified a statistically significant relationship between faller status and tranquillisers (p=0.038) and faller status and anti-hypertensives (p=0.049. In comparison to non-fallers (n = 200) a higher percentage of fallers (n = 100) were receiving medications from two (score=2) or more (score=2+) fall risk medication categories (37% vs 25.5%). The odds of an older adult receiving medication from two or more falls risk medication categories (score=2/ 2+) experiencing a fall, was 2.43 times (95% CI: 1.22 to 4.84, p=0.011) that of an older adult who receives no medication from within the falls risk medication categories.

A significant relationship was identified between faller status and medical history (p=0.005) with a lower percentage of fallers (n = 100) having no medical history fall risks category (15% faller group vs 33% non-faller group). Independent analysis identified a statistically significant relationship between faller status and a 'risk of fracture' (score=1) (p=0.028). In addition, a multiple logistic regression model identified a statistically significant relationship between faller status and a 'risk of fracture' (p=0.020) and 'organic brain disease/ confusion' (p=0.046). Logistic regression analysis identified the odds of an older adult with one medical history fall risk category (score=1) experiencing a fall was 2.69 times (95% CI: 1.40 to 5.14, p=0.003) that of an older adult with no medical history falls risk category.

There was a significant relationship between faller status and mobility (p=0.049), with a higher percentage of fallers (n = 100) identified with the combined risk of 'uses aids' (score=2) and 'restricted' (score=3) (total score=5) (20% fallers vs 9% non-fallers). The odds of an older adult with the combined risk of 'uses aids' (score=2) and 'restricted' (score=3) (total score=5) experiencing a fall was 2.70 times (95% CI: 1.11 to 6.57, 0=0.029) that of an older adult with full mobility / bedbound (score=1). Independent analysis identified a statistically significant relationship between faller status and a identified a restricted mobility (score=3) (p=0.025). Older adults with a restricted mobility were more likely to have experienced a fall (40% fallers vs 27% non-fallers). No statistically significant difference was found between older adults with the combined risk of 'uses aids' (score=2) and 'restricted' (score=3) (total score=5), and older adults who had a restricted mobility only (score=3).

ROCs established the predictive accuracy of each independent fall risk variable differentiating between older adults 'at risk' and 'not at risk' of falls. The larger the area under the curve, the greater the overall predictive accuracy of the test. Gender achieved an AUC of 0.435 (95% CI: 0.377 to 0.492) showing no discrimination and no predictive accuracy in predicting future falls among older adults. Predicative accuracy was established for independent fall risk variable of age (AUC 0.525), gait (AUC 0.641), sensory deficit (AUC 0.623), falls history (AUC 0.649), medication (AUC 0.584) medical history (AUC 0.597) and mobility (AUC 0.574) as per the FRASE risk assessment. A summary of the results of univariate logistic regression investigating the relationship between faller status and the fall risk variables is presented in table 7. A summary of the ROC analysis of each fall risk variable is presented in table 8.

	Contribution to FRASE score	Non-fallers (n=200) n (%)	Fallers (n=100) n (%)	p-value[2]	OR (95% CI)[1]
Gender				0.037	
Male (Reference)	1	84 (42.0)	55 (55.0)		1
Female	2	116 (58.0)	45 (45.0)		0.59 (0.37 to 0.96)
Age group				0.434	
<60, 60-70 and 81+ years (Reference)	1	138 (69.0)	64 (64.0)		1
71-80 years	2	62 (31.0)	36 (36.0)		1.25 (0.75 to 2.08)
Falls history				<0.001	
None (Reference)	0	106 (53.0)	28 (28.0)		
At home or In ward/unit	2	94 (47.0)	62 (62.0)		
Both	3	0 (0.0)	10 (10.0)		
Gait				<0.001	
Steady (Reference)	0	44 (22.0)	14 (14.0)		1
Hesitant	1	76 (38.0)	20 (20.0)		0.83 (0.38 to 1.80)
Poor transfer/Unsteady	3	52 (26.0)	34 (34.0)		2.05 (0.98 to 4.31)
Hesitant and Poor transfer/ Hesitant and Unsteady	4	10 (5.0)	15 (15.0)		4.71 (1.73 to 12.83)
Poor transfer and Unsteady	6	11 (5.5)	10 (10.0)		2.86 (1.00 to 8.14)
Hesistant, Poor transfer and Unsteady (score=7)	7	7 (3.5)	7 (7.0)		3.14 (0.94 to 10.52)
Mobility				0.049	
Full/Bed bound (Reference)	1	34 (17.0)	14 (14.0)		1
Uses aid	2	112 (56.0)	46 (46.0)		1.00 (0.49 to 2.03)
Restricted	3	36 (18.0)	20 (20.0)		1.35 (0.59 to 3.09)
Uses aid and restricted	5	18 (9.0)	20 (20.0)		2.70 (1.11 to 6.57)
Sensory Deficit				0.001	
None (Reference)	0	52 (26.0)	17 (17.0)		1
Hearing	1	12 (6.0)	7 (7.0)		1.78 (0.61 to 5.26)
Sight/Balance	2	88 (44.0)	28 (28.0)		0.97 (0.49 to 1.95)
Sight and Hearing/Hearing and Balance	3	23 (11.5)	19 (19.0)		2.53 (1.12 to 5.73)
Sight and Balance	4	17 (8.5)	17 (17.0)		3.06 (1.29 to 7.28)
Sight, Hearing and Balance	5	8 (4.0)	12 (12.0)		4.59 (1.61 to 13.10)
Medical history				0.005	
No medical conditions (Reference)	0	66 (33.0)	15 (15.0)		1
1 medical condition	1	95 (47.5)	58 (58.0)		2.69 (1.40 to 5.14)
2 medical conditions	2	37 (18.5)	26 (26.0)		3.05[3] (1.45 to 6.42)
3 medical conditions	3	2 (1.0)	1 (1.0)		
Medication				0.081	
No medication (Reference)	0	57 (28.5)	17 (17.0)		1
1 medication	1	92 (46.0)	46 (46.0)		1.68 (0.88 to 3.20)
2 medications	2	41 (20.5)	30 (30.0)		2.45 (1.20 to 5.03)
3 medications	3	10 (5.0)	7 (7.0)		2.35 (0.78 to 7.10)

[1]Odds ratio and its corresponding 95% confidence interval

[2]From Fisher's exact test

[3]2 and 3 medical conditions combined for the analysis

Table 7: Summary of the results of univariate logistic regression investigating the relationship between risk factors and fall outcome

	area under ROC	(95% CI)
Gender	0.435	(0.377 to 0.492)
Age group	0.525	(0.468 to 0.584)
Falls history	0.649	(0.593 to 0.704)
Gait	0.641	(0.583 to 0.694)
Mobility	0.574	(0.515 to 0.630)
Sensory Deficit	0.623	(0.566 to 0.678)
Medical history	0.597	(0.539 to 0.653)
Medication	0.584	(0.525 to 0.640)

Table 8: Summary of the ROC analysis of each of the fall risk variables

4.5 Chapter Summary

To conclude, section 4.1 presented the profile and characteristics of the data captured in section 1 of the data collection tool. Approximately half the data (n = 300) pertained to female older adults (54%, n = 161) and those aged 81 years and older (52%, n = 155). Fewer non-fallers (n = 200) experienced a fall prior to admission in comparison to fallers (n = 100) (53% vs 59%). The most common category in the gait fall risk variable among non-fallers (n = 200) was hesitant (38%, n = 76) while an unsteady gait (26%, n = 26) was most common among fallers (n = 100). Approximately half (56%) of non-fallers (n = 200) used aids to mobilise in comparison to fallers (n = 100) (46%). In the sensory fall risk variable, non-fallers (n = 200) primarily had no sensory deficit (26%, n = 52) while fallers (n = 100) primarily had a balance deficit (19%, n = 19). A third of non-fallers (n = 200) presented with no medical history risk factor category (33%, n = 66) while 37% (n = 37) of fallers (n = 100) were identified as a 'risk of fracture'. Fewer non-fallers (n = 200) received anti-hypertensive medication in comparison to fallers (n = 100) (34% vs 37%). More non-fallers (n = 200) required no fall risk medication in comparison to fallers (n = 100) (28.5% vs 17%).

Section 4.2 presented the NIRF information captured in section 2 of the data collection tool. Approximately half of the falls were from equipment or furniture (58%, n = 58) and related to unknown hazards (42%, n = 42). The majority of falls were categorised with an outcome of no injury (76%, n = 76) at the time of the fall.

Section 4.3 presented the diagnostic accuracy of the FRASE risk assessment tool in identifying older adults at high risk of falls. The mean score of the FRASE was significantly higher among fallers (n =100) (mean (SD) 14.8 (4.5)) non-fallers (n = 200) (mean (SD) 11.8 (4.11)). The Fisher's exact test ($p<0.001$) presented in figure 22 also showed a significant relationship between faller status and FRASE risk category. Fallers (n = 100) were more likely to be in the 'high risk' category (74%) than non-fallers (n = 200) (34%). The FRASE AUC was 0.698 (95% CI: 0.641, 0.748) which demonstrates accuracy in predicting future falls among older adults.

In section 4.4, hypotheses were rejected or supported through univariate analysis of the independent fall risk variables measured within the FRASE risk assessment tool. A statistically significant relationship was identified between faller status and gender ($p=0.37$) however OR results disagreed with the weighted scoring of the FRASE. Age showed no statistically significant relationship with faller status ($p=0.434$). Falls history presented the greatest predictive accuracy with an AUC of 0.649 (95% CI: 0.593 to 0.704). A significant predictive accuracy was achieved by gait with an AUC of 0.641 (95% CI: 0.583 to 0.694) and sensory deficit with an AUC of 0.623 (95% CI: 0.566 to 0.678). Predictive accuracy was also established by the AUC value of medical history (AUC 0.597, 95% CI: 0.539 to 0.653), mobility (AUC 0.574, 95 % CI: 0.515 to 0.630), and medication (AUC 0.584, 95% CI: 0.525 to 0.640). Chapter 5 will discuss the findings presented with reference to previous published and relevant research.

Chapter 5: Discussion

5.1 Introduction

In this chapter the findings of the research are discussed with reference to previous published research and the wider literature. The aim of this research is to determine the predictive accuracy of the FRASE risk assessment tool in identifying older adults at high risk of falls in Community Hospitals/ Nursing Units. The secondary aim of the research is to determine the relationship between older adult's faller status and the risk factors; gender, age, gait, sensory deficit, falls history, medication, medical history and mobility as identified in the FRASE risk assessment tool. In Section 5.2 the profile and characteristics of the data captured in section 1 of the Data Collection tool are presented. In section 5.3 the diagnostic accuracy of the FRASE risk assessment tool is discussed. Finally, in section 5.4 in accordance with the null hypotheses the relationship between faller status and the risk factors; gender, age, gait, sensory deficit, falls history, medication, medical history, and mobility are discussed. The chapter concludes with a summary of the most significant findings.

5.2 Sample profile

A sample of 300 Data Collection tools (200 controls and 100 cases) were collected for inclusion in this study, which took place across a convenience sample of 12 Community Hospitals/ Nursing Units in the South/ South West of Ireland. The response rate was deemed sufficient to detect a small to medium effect size (Cohen, 1992) and is broadly comparable to the research by Harper et al. (2017). Over half of the data sample (n = 300) pertained to females (54%, n = 161), the remaining 46% (n = 139) pertained to males. This difference in gender distribution is not unexpected among the older adult population and similar to the gender distribution findings by (Wijnia et al., 2006, Chow et al. 2007, Higaonna 2015). Over half of the sample (n = 300) were aged 81 years and older (52%, n = 155) which corresponds with the global aging population (World Health Organisation, 2007). A number of studies (n = 3) identified similar age characteristics with mean ages ≥ 81 years (Vassallo et al., 2005; Sherrington et al., 2011; Strupeit et al., 2016). Different settings have different falls risk patient profiles (i.e. characteristics of non-fallers (n = 200) and fallers (n = 100), which determine the setting-specific nature of falls. A fall risk characteristic should offer utility value (clinical usefulness) to sustain value, motivation and completion compliance in clinical practice (McKechnie et al., 2016). The utility value of the characteristics of non-fallers (n = 200) and fallers (n = 100) are identified and discussed in accordance with the AUC value achieved.

Gender

The majority of non-fallers (n = 200) were female (58%, n = 116) while the majority of fallers (n = 100) were male (55%, n = 55). These characteristics were also identified in the retrospective study by Castellini et al. (2017). In contrast, the prospective observational study by Baran and Gunes (2018) identified the ratio of fallers to non-fallers among females was higher than that among males (40/95 and 11/64 respectively). In contrast to these findings the prospective descriptive study by Ivziku et al. (2011) reported an equal ratio of male and female fallers.

Age

Over half of the non-fallers (n = 200) were aged 81 years and older (52%, n = 104). This result is comparable to Harper et al. (2018) prospective cohort study which identified a mean age 80.9 (SD 7.4) for non-fallers (n = 118).

Over half of the fallers (n = 100) were aged 81 years and older (51%, n = 51). This finding is similar to the prospective descriptive study by Ivziku et al. (2011) which identified the mean age of fallers (n = 14) as 81 years (SD 8.5). In addition, the prospective observational study by Baran and Gunes (2018) identified the mean age of fallers (n = 51) as 81 years (SD 8.5).

Park (2018) acknowledges that a fall can occur at any age, but the frequency of falls increases with age. This increase is supported in the findings of Higaonna (2015) retrospective cohort design study were fallers (n = 67) were significantly older than non-fallers (n = 3199) (median 72 years, range 29 – 91 vs median of 60 years, range 15-97 p<0.001).

Gait

A hesitant gait was the most commonly identified gait category among the overall data sample (n = 300) and non-fallers (n = 200) (32% and 38% respectively). In contrast, an unsteady gait (26%) was the most common risk category among fallers (n = 100). Gait abnormalities were identified as a predictor of future falls in the systematic review by Power et al. (2014). In addition, Gates (2008) systematic review identified a slow gait speed (hesitant gait) and shuffling pattern (unsteady gait) as accurate predictors of a future fall among older adults.

Sensory deficit

A balance deficit (score=2) was the most common single weighted sensory deficit category among the overall data sample (n = 300) (21%), non-fallers (n = 200) (22%) and fallers (19%). These findings are similar to Castellini et al (2017) retrospective study which identified a balance disorder (28%) as the primary single sensory falls risk category among fallers (n = 365), patients deemed 'low risk' of falls (29%) (STRATIFY score < 2) and of patients deemed 'high risk of falls' (32.7%) (STRATIFY score ≥ 2).

A sight deficit (score=2) was the third most common single weighted sensory deficit among the overall data sample (n = 300) (18%), non-fallers (n = 200) (22%) and fallers (n = 100) (9%). These findings are similar to Castellini et al (2017) retrospective study which identified a visual impairment (6.9%) as the second most common single sensory falls risk category among fallers (n = 365), patients deemed low risk of falls (7.7%) (STRATIFY score < 2) and of patients deemed high risk of falls (8.9%) (STRATIFY score ≥ 2).

A hearing deficit (score=1) was the least common single weighted sensory deficit among the overall data sample (n = 300) (6.3%), non-fallers (n = 200) (6%) and fallers (n = 100) (7%). These findings are comparable to Castellini et al (2017) retrospective study which identified a hearing impairment (4.1%) as the least common single sensory falls risk category among fallers (n = 365), patients deemed 'low risk' of falls (3.3%) (STRATIFY score < 2) and of patients deemed 'high risk' of falls (5.9%) (STRATIFY score ≥ 2).

Falls history

Over half of the data sample (n = 300) had experienced a fall 'at home in the 12 months prior to their admission' (51%, n = 153) to the Community Hospitals/ Nursing Units. Among the non-fallers (n = 200) over half (53%, n = 106) had 'no previous falls history'. In contrast, among the fallers (n = 100) over half (59%, n = 59) had experienced 'a fall in the 12 months prior to their admission'. Sherrington et al. (2011) prospective cohort study presented opposing sample characteristics with over half (69% vs 82%) non-fallers (n = 288) and fallers (n = 150) experiencing a fall in the 12 months prior to admission.

Medication

The most common medication was anti-hypertensives among the overall data sample (n = 300) (35%, n = 105), non-fallers (n = 200) (34%, n = 68) and fallers (n = 100) (37%, n = 37). These results are comparable to the sample characteristics in Higaonna (2015) retrospective cohort design study where antihypertensives were the single most common medication among the overall sample (n = 3266) (30.4%, n = 994), non-fallers (n = 3217) (30.2%, n = 972) and fallers (n = 49) (44.9%, n = 22)..

Medical history

A third of the overall data sample (n = 300) were identified to be at risk of fracture (33%, n = 100). In contrast, a third of non-fallers (n = 200) had no categorised medical history fall risk (33%, n = 66). Similar to the overall data sample (n = 300) over a third of fallers (n = 100) were identified to be at risk of fracture (37%, n = 37). A risk of fracture was not identified in the studies presented however, Higaonna (2015) findings showed 6% of non-fallers (n = 3217) and 18.4% of fallers (n = 49) had bone / joint problems. In contrast, in the literature presented confusion/ cognitive impairment was the most common medical history associated with falls risk (Wijnia et al., 2006; Ivziku et al., 2011; Castellini et al., 2017). In addition, the prospective observational study by Baran and Gunes (2018) identified hypertension (62.89%), diabetes (40.88%) and heart failure (38.36) as the most common medical history diagnoses among the overall data sample (n = 159). All three medical conditions were more prevalent among fallers (n = 51) than non-fallers (n = 108), hypertension (72.54% vs 58.33%), diabetes (45.09% vs 38.88%) and heart failure (49.01% vs 33.33%).

Mobility

Over half of the overall data sample (n = 300) and non-fallers (n = 200) required the use of aids to mobilise (53% and 56% respectively). In contrast, less than half (46%) of fallers (n = 100) required the use of aids to mobilise. These characteristics are comparable to the sample characteristics in Latt et al. (2016) retrospective study were a greater percentage (52.3%) of non-fallers (n = 197) required assistance to mobilise in comparison to fallers (n = 20) (50%).

5.3 Predictive accuracy of the FRASE risk assessment tool

Baran and Gunes (2018) assert a FRAT should sufficiently distinguish between those ‘at risk’ and ‘not at risk’ of falls. Sensitivity and specificity values are obtained from a range of experimental cut-off points. The best cut-off value is the threshold of ‘high risk’, i.e. point at which a FRAT can miss the least number of fallers together with a low false positive (El Miedany et al. 2011).

In this study using the recommended ‘high risk’ category cut-off points of 13+ (i.e. a FRASE score greater than 12) the FRASE yielded a sensitivity of 74.0% (95% CI: 64.3% to 83.3%) and a specificity of 66.0% (95% CI: 59.0% to 72.5%). Oliver et al. (2004) advocate a 70% cut-off for sensitivity and specificity for ‘high’ predictive accuracy. Based on these predictive values the FRASE demonstrated ‘high’ predictive accuracy in correctly discriminating fallers as a high risk of falls and moderate predictive accuracy in correctly discriminating non-fallers as 'not at risk' of falls. However, El Miedany et al. (2011) assert a predictive accuracy value of 80% or over is paramount to deem a screening tool operationally useful. Based on these predictive values, the FRASE failed to demonstrate a predictive accuracy value to be deemed operationally useful.

Applying the medium risk category cut off point of 9+ (i.e. a FRASE score greater than 9) the FRASE in this study yielded a sensitivity of 90% (95% CI: 82.4% to 95.1%) and a specificity of 21% (95% CI: 15.6% to 27.3%). Based on these predictive values the FRASE demonstrated a very high predictive accuracy in correctly discriminating fallers as a 'high risk' of falls but a low predictive accuracy in correctly discriminating non-fallers as 'not at risk' of falls. This variation is expected as research has shown that the diagnostic accuracy of a FRAT fluctuates in terms of sensitivity and specificity when the cut-off point is modified (Aranda-Gallardo et al., 2015; Kim et al., 2011).

Vassallo et al. (2005) acknowledges that a FRAT with high sensitivity and specificity is challenging to develop and thus emphasises a high sensitivity as the most important measure. In addition, in the clinical environment where patients are instinctively prevented from falling a low sensitivity value should not be unexpected. Nevertheless, many studies caution that a low specificity will result in fewer patients correctly determined as 'not at risk', thereby prompting the application of unnecessary preventative interventions and misuse of scant clinical resources (Baran and Gunes, 2018; Kim et al., 2007; Vassallo et al., 2005).

The mean scores and standard deviation of the FRASE was significantly higher among the fallers (n = 100) (mean (SD) 14.8 (4.5)) than non-fallers (n = 200) (mean (SD) 11.8 (4.11)) indicating a greater variation among the data pertaining to fallers (n = 100). Similar findings were found in Chow et al. (2007) cross-sectional study where the total mean score for fallers was 32.12 (SD=26.2) while the mean score for non-fallers was 28.68 (SD = 19.13).

Findings indicate a significant relationship between faller status and FRASE risk category ($p<0.001$). Accordingly, fallers (n = 100) were more likely to be in the ‘high risk’ category (74%) than non-fallers (n = 200) (34%). This finding opposes the statistical analysis findings in Jester et al. (2005) quasi-experimental study which presented no statistical significance ($p=0.204$) in the falls rates between the retrospective (n = 30) and prospective groups (n = 60).

Sherrington et al. (2011) advocate using AUC values to quantify discrimination by distinguishing fallers operating characteristic from non-fallers. An area under the ROC curve with a value of 1 or 0 indicates the test is always right or wrong. A score of 0.5 demonstrates the tests predictive accuracy is no better than random probability and comparable to clinical judgement (Jester et al., 2005). The closer to 1 the AUC value is, the greater the predictive accuracy of the tool (Kim et al., 2011). An instrument is presents decisive power and is assumed to be reliable when the area under the curve (AUC) is > 0.7 (Wray et al., 2010; Aranda-Gallardo et al., 2017). In this study, the AUC for the FRASE risk assessment tool was 0.698 (95% CI: 0.641, 0.748). Therefore, the FRASE achieved a moderate predictive accuracy in discriminating non-fallers from fallers. Therefore, this finding opposes the results of Jester et al. (2005) quasi-experimental study where the FRASE risk assessment tool achieved a low predictive accuracy (AUC 0.560) in the prospective group (n = 60) and no discrimination (AUC 0.370) in the retrospective group (n = 30).

5.4 Relationship between faller status and risk variables within the FRASE risk assessment tool

Chow et al. (2007) asserts the usefulness of a FRAT should not be determined on the inter-item structure but rather that the items are significant, and representative of the risk being measured. Six of the eight falls risk variables in the FRASE risk assessment tool showed significant accuracy in predicting future falls among older adults, falls history (AUC 0.649), gait (AUC 0.641) sensory deficit (AUC 0.623), medical history (AUC 0.597), medication (0.584) and mobility (0.574). There was a statistically significant relationship between faller status and gender ($p=0.037$) indicating gender influenced faller status. In disagreement with the weighted scoring in the FRASE, male older adults were 1.69 times (95% CI: 1.04 to 2.74) more likely to fall than female older adults. No statistically significant relationship was established between faller status and age (p=0.434) supporting the null hypothesis. The findings of each independent variable will be discussed under each of the null hypotheses as presented in the Findings Chapter.

Relationship between faller status and gender

H1: There is no relationship between faller status and gender as determined by the FRASE risk assessment tool

There was a statistically significant relationship between faller status and gender (p=0.037) indicating the older adult faller status was influenced by gender. Nevertheless, gender achieved an AUC value of 0.435 demonstrating no discrimination. Therefore, gender presents no predictive accuracy in predicting future falls among older adults. Nonetheless, a higher percentage of fallers were males than non-fallers (55% vs 425). Castellini et al. (2017) also identified a greater percentage of fallers were male however the predictive accuracy of gender as a predictor of future falls was not analysed. Contrary findings were identified by Aranda-Gallardo et al. (2017), despite women experiencing more falls than men, no statistically significant relationship was identified between faller status and gender. Nevertheless, this finding must be interpreted with caution due to the limited statistical power derived from the low occurrence of falls (n = 24).

In disagreement with the weighted scoring in the FRASE, the odds of a male older adult falling were 1.69 times (95% CI: 1.04 to 2.74) the odds of a female older adult falling. A comparable finding was identified by Sherrington et al. (2011) were the odds ratio of a male older adult falling were 2.32 times (95% CI: 1.00 to 4.03) that of a female older adult falling.

Relationship between faller status and age

H2: There is no relationship between faller status and age as determined by the FRASE risk assessment tool

There was no statistically significant relationship between faller status and age ($p=0.434$) indicating older adult faller status was not influenced by age. Age achieved an AUC value of 0.525 demonstrating a predictive accuracy comparable to clinical judgement and random probability in predicting future falls among older adults. Although Matarese et al. (2014) advocate the National Institute for Health and Care Excellence (NICE) (2013) guidance to cease the routine application of FRATs and categorise all older adults aged 65 years and over 'at risk' of falls. This finding supports Wijnia et al. (2006) finding that age was not a predictor of falling.

In accordance with the FRASE weighted risk scoring, older adults aged between 71-80 years (score=2) were 1.25 times more likely to experience a fall than older adults in the other combined age categories. This finding supports Sherrington et al. (2011) prospective cohort study finding were the odds ratio of experiencing a fall aged 83 years and older was 1.01 times more likely among fallers than non-fallers, indicating age is not a predictor of falls among older adults. In contrast, by Aranda-Gallardo et al. (2017) identified increasing age was associated with the incidences of falls with the average age of the fallers (73.57 years, SD 14.19) significantly higher than for non-fallers (65.39 years, SD 17.58). Similarly, Higaonna (2015) identified fallers (median age 72) were older than non-fallers (median age 60 years). Statistical analysis relating to age however in the prospective inception cohort study by Sherrington et al. (2011) resulted in an OR of 1 between the group of fallers ($n = 150$) and non-fallers ($n = 288$). This finding implies age is not a predictor of future falls and suggests physiological functioning and comorbidity may be greater fall predictors than chronological age.

Relationship between faller status and gait

H3: There is no relationship between faller status and gait as determined by the FRASE risk assessment tools.

There was a significant associated between faller status and gait ($p<0.001$) indicating older adult faller status was influenced by gait. Gait achieved an AUC value of 0.641 demonstrating gait shows predicative accuracy in predicting future falls among older adults. This finding is supported by the findings of Gates et al. (2008) and Power et al. (2014) were gait abnormalities were strongly identified by as a predictor of future falls among older adults. The findings however are based on community-dwelling older adults rather than older adults within LTC settings. The use of the FRASE makes it difficult to draw direct comparison as gait was not assessed as an independent variable within the majority of FRATs but rather encompassed within the mobility and balance fall risk variables.

Relationship between faller status and sensory deficit

H4: There is no relationship between faller status and sensory deficit as determined by the FRASE risk assessment tool

There was a statistically significant relationship between faller status and sensory deficit ($p=0.001$) indicating older adult faller status is influenced by sensory deficits. Sensory deficit achieved an AUC value of 0.623 demonstrating significant predictive accuracy in predicting future falls among older adults. A significant relationship was established between faller status and a 'hearing deficit' (score=1) ($p=0.004$). This finding opposed the weighted scoring of the FRASE as a 'hearing deficit' was the lowest weight risk category within the sensory falls risk variable. This finding opposes the findings of Castellini et al. (2017) where a hearing deficit was significantly less common among fallers. Consistent with the literature (Castellini et al., 2017; Sherrington et al., 2011; Power et al., 2014; Gates et al., 2008) there was a significant relationship between faller status and 'balance' (score=2) ($p=0.014$).

Conflicting with the weighted scoring assigned by Cannard (1996) there was no significant relationship found between faller status and ‘sight deficit’ (score=2) (p=0.140) indicating older adults with a ‘sight deficit’ did not experience more falls. No statistically significant relationship was identified between faller status and sight by Castellini et al. (2017) however, Aranda-Gallardo et al. (2017) longitudinal prospective cohort study identified a strong relationship between visual impairment and future falls (HRR=3.00 1.92 to 4.69) (p=0.000).

The odds of an older adult risk weighted for all three sensory deficits (score=5) experiencing a fall was 4.59 times (95% CI: 1.61 to 13.10, p=0.004) that of an older adult with no sensory deficits (score=0). Although no study was comparable for all three sensory deficit categories, the odds ratio of increased postural sway was 1.93 times (95% CI: 1.00 to 3.26) more likely among fallers than non-fallers in Sherrington et al. (2011) prospective cohort study.

Relationship between faller status and falls history

H5: There is no relationship between faller status and falls history as determined by the FRASE risk assessment tool

There was a statistically significant relationship between faller status and falls history (p<0.001) indicating older adult faller status is influenced by previous falls history. Falls history achieved an AUC of 0.649 which demonstrated the greatest predictive accuracy in predicting future falls among older adults. This finding supports the literature that a previous falls history is a predictor of a future fall among older adults (Wijnia et al., 2006; Aranda-Gallardo et al., 2017; Latt et al., 2016; Gates et al., 2008). The significance of a previous falls history was also evident in the findings of the prospective cohort study by Harper et al. (2018). Despite the FROP Com Screen (SENS=39%) and Two-Item Screening Tool (SENS=48%) showing limited accuracy in identifying falls risk among the general population, both tools were more sensitive when applied in persons who had previously experienced a fall (45% and 79% respectively). Furthermore, although falling is multifactorial and highly individualised, the cross sectional data set study by Demura et al. (2011) established the 'symptoms of falling' was the most prominent predictor of a future fall among older adults (42.5%).

Relationship between faller status and medication

H6: There is no relationship between faller status and medication as determined by the FRASE risk assessment tool

There was no statistically significant relationship between faller status and medication (p=0.081) indicating older adult faller status was not influenced by medication. This finding opposes research by Baran and Gunes (2018) which identified a statistically significant relationship between fallers and medication. Medication as a falls risk is accepted within healthcare with the Agency for Healthcare Research and Quality (AHRQ) (2013) recommending a medication review in conjunction with FRATs to determine older adults at risk of falls (AHRQ, 2013). Further analysis identified a statistically significant relationship between faller status and a combination of three or two fall risk medication categories (p=0.037). This finding indicates older adult faller status is influenced by multiple medications. Accordingly, medication achieved an AUC value of 0.584 which demonstrates predictive accuracy in predicting future falls among older adults. A possible explanation for the poor relationship between faller status and one fall risk medication category may best be explained by the fact medication, in and of itself, does not equate to a fall risk. The risk is more associated with altered pharmacodynamics or pharmacokinetics and possible side effects such as altered balance, gait, cognition, mobility, continence, and mood. These possible side effects may occur for older adult in varying degrees increasing fall risk (Hendrich et al. 2003, McKay and Anderson, 2010).

No medication independently demonstrated a significant relationship with faller status. A multiple logistic regression model identified a statistically significant relationship between faller status and tranquillisers (p=0.038). This finding supports Latt et al. (2016) identification of a statistically significant association between faller status and psychotropic medication use (which includes tranquillisers). McKay and Anderson (2010) assert psychotropic medications cause confusion and thus increased falls risk.

Although Higaonna (2015) identified an association between faller status and hypnotics and/ or tranquilliser use, the strongest association was identified between anti-hypertensive use and faller status. The multiple logistic regression model in this study also identified a statistically significant relationship between faller status and anti-hypertensives (p=0.049). Anti-hypertensives reduce postural hypotension and thus increase falls risk (McKay and Anderson, 2010).

The odds of an older adult receiving two or more medications experiencing a fall was 2.43 times (95% CI: 1.22 to 4.84, p=0.011) that of older adults who were receiving no categorised fall risk medications. This finding supports Sherrington et al. (2011) prospective cohort study were the odds ratio of a central nervous system medication prescription was 2.04 times (95% CI: 1.00 to 3.30) more likely among fallers than non-fallers thus showing higher probability.

Relationship between faller status and medical history

H7: There is no relationship between faller status and medical history as determined by the FRASE risk assessment tool

There was a statistically significant relationship between faller status and medical history (p=0.005) indicating older adult faller status was influenced by physical health and co-morbid factors. Medical history achieved an AUC value of 0.587 which demonstrated predictive accuracy in predicting future falls among older adults. This finding supports the literature that medical history is a predictor of future falls among older adults (Wijnia et al., 2006; Demura et al., 2011; Ivziku et al., 2011; Castellini et al., 2017). The significance of the relationship between faller status and medical history is evident in Smith, et al. (2006) recommendation to develop disease specific FRATs.

The multiple logistic regression model identified a statistically significant association between faller status and 'risk of fracture' (p=0.020). The British Orthopaedic Association estimate 300,000 osteoporotic fractures occur yearly in England and expect figures to double by the year 2050 (McKay and Anderson, 2010). Although a ‘risk of fracture’ was not identified as a falls risk predictor within the literature presented, Castellini et al. (2017) identified neuromuscular and musculoskeletal disorders among the most common intrinsic falls risk factors.

The multiple logistic regression model also identified a statistically significant association between faller status and ‘organic brain disease/ confusion’ (p=0.046). The findings support Ivziku et al. (2011) identification of a statistically significant relationship between faller status and confusion. In addition, Castellini et al. (2017) identified cognitive impairment as the most common intrinsic fall risk factor among fallers. Cognitive impairment is often associated with poor safety awareness, gait and sensory impairments (McKay and Anderson, 2010) and agitation (Fernando et al., 2016; Kenny et al., 2016). Wijnia et al. (2006) identified a statistically significant relationship between faller status and agitation. This relationship was calculated from a sample of fallers (n = 36) were 25% (n = 9) resided in a psychogeriatric care unit and 23.04% (n = 8) had a dementia diagnosis.

In this study logistic regression analysis identified the odds of an older adult with two or three medical conditions experiencing a fall was 3.05 times that of an older adult with no medical history risk. This finding is comparable to Demura et al. (2011) where falls incidences increased as the risk factor score for “disease and physical symptoms” increased.

Relationship between faller status and mobility

H8: There is no relationship between faller status and mobility as determined by the FRASE risk assessment tool

There was a statistically significant relationship between faller status and mobility indicating older adult faller status was influenced by mobility. Of the four mobility fall risk categories, a statistically significant relationship was only established between faller status and ‘restricted’ mobility (p=0.49). Mobility achieved an AUC value of 0.574 demonstrating predictive accuracy in predicting future falls among older adults. Mobility as a predictor of future falls was only identified in one study within the literature presented. Demura et al. (2011) identified a distinctive distribution between faller status and physical function.

The odds of an older adult with the combined risk of using aids and restricted experiencing a fall was 2.70 times that of an older adult with full mobility / bedbound. Older adults assessed as bedbound would have no mobility and therefore require max assistance from the nursing team to move.

5.5 Chapter summary

The data sample (n = 300) provided allowed for the identification of non-faller (n = 200) and faller (n = 100) characteristics among older adults aged 65 years and older in Community Hospitals/ Nursing Units in the South/ South West of Ireland. In accordance with the FRASE (Cannard 1996) the best cut-off value and threshold of ‘high risk’ in this study space was the ‘high risk’ cut-off points of 13+ (i.e. a FRASE score greater than 12) yielding a good sensitivity of 74.0% (95% CI: 64.3% to 83.3%) and moderate specificity of 66.0% (95% CI: 59.0% to 72.5%). Nevertheless, with predictive accuracy values <80% the FRASE failed to demonstrate a predictive accuracy value to be deemed operationally useful. Utility value was identified by establishing each fall risk variables ability to discriminate non-fallers (n = 200) from fallers (n = 100). Six of the eight falls risk variables in the FRASE risk assessment tool showed significant accuracy in predicting future falls among older adults, falls history (AUC 0.649), gait (AUC 0.641) sensory deficit (AUC 0.623), medical history (AUC 0.597), medication (0.584) and mobility (0.574). Although a statistically significant relationship was established between faller status and gender (p=0.037) the findings opposed the weighted scoring of the FRASE. Therefore, gender demonstrated no discrimination in predicting future falls among older adults (AUC 0.435). No statistically significant relationship was identified between faller status and age (p=0.434). Age presented a predictive accuracy comparable to clinical judgement and random probability (AUC 0.525) thus refuting recommendation by the NICE guidance (2013) and Matarese et al. (2014) to unanimously categorise all older adult aged 65 years and older a ‘high risk’ of falls. Chapter 6 concludes this research study, summarising the study findings and the implications of the FRASE tool for practice.

The chapter will also present recommendations for clinical practice, policy development and future research. In addition, the limitations of the findings are presented.

Chapter 6 Conclusion and Recommendations

6.1 Introduction

This chapter summarises the research study and explores the contribution of the study's findings to the existing literature. The overarching contribution of the study lies in its ability to determine the predictive accuracy of the FRASE risk assessment tool in identifying older adults at high risk of falls in Community Hospitals/ Nursing Units. Section 6.2 summarises the research study. This is followed by the study conclusion in section 6.3. The recommendations for clinical practice, policy development and future research are outlined in section 6.4. Section 6.5 presents the methodological limitations of the study. The research study concludes in section 6.6.

6.2 Study summary

The primary aim of this study was to determine the predictive accuracy of the FRASE risk assessment tool in identifying older adults at high risk of falls in Community Hospitals/ Nursing Units. The secondary aim was to determine the relationship between older adult faller status and the risk factors, gender, age, gait, sensory deficit, falls history, medication, medical history and mobility as identified in the FRASE risk assessment tool.

In attempting this, the researcher used a quantitative approach which utilised deductive reasoning to test theories (Polit and Beck, 2017). In addition, a correlation design was employed to establish whether or not relationships exist between variables (Grant and Giddings, 2002). Deductive reasoning allows for the generalisation of findings within quantitative research due to strict adherence to the experimental method employed (Nicholls, 2009b). The conclusion, recommendations and limitations of the research are presented in this chapter.

6.3 Study conclusions

The findings from this research study demonstrated that using the recommended cut of point of 13+ the FRASE demonstrated a good sensitivity 74.0% (95% CI: 64.3% to 82.3%) and a moderate specificity 66.0% (95% CI: 59.0% to 72.5%). Therefore, the FRASE demonstrated good accuracy in identifying fallers as 'at risk' of falls, and moderate accuracy in identifying non-fallers as 'not at risk' of falls. El Miedany et al. (2011) stipulate that a FRAT must achieve a predictive accuracy value of ≥ 80% to be deemed operationally useful in clinical practice. As the FRASE did not achieve a predictive accuracy values ≥ 80% it therefore cannot be deemed operationally useful in identifying fall risk among the older adult population in Community Hospitals/ Nursing Units. Nevertheless, the FRASE was a sensitive and specific predictor of future falls among older adults. Therefore, the FRASE may assist nurses in the appropriate application of fall prevention intervention to minimising the negative impact of falling on older adults

It is of paramount importance that the falls risk assessment tool utilised in clinical practice assesses appropriate predictive factors for the population of interest (Callis, 2016)). Six of the eight falls risk variables in the FRASE risk assessment tool showed utility value through demonstrating predictive accuracy in predicting future falls among older adults, falls history (AUC 0.649), gait (AUC 0.641) sensory deficit (AUC 0.623), medical history (AUC 0.597), medication (0.584) and mobility (0.574).

Callisaya et al. (2012) assert the greater the number of risks identified, the greater the risk of falling. Nonetheless, numerous studies identified a previous falls history as the single most significant predictor of a future fall (Wijnia et al., 2006; Aranda-Gallardo et al., 2017; Latt et al., 2016; Gates et al., 2008). Similarly, it emerged from this study that the falls history falls risk variable demonstrated the greatest predictive accuracy for predicting future falls among older adults (AUC 0.649). Gait achieved the second highest predictive accuracy value (AUC 0.641) thus indicating that similar to community dwelling older adults (Gates, 2008; Power et al., 2014) gait is predictor of future falls among older adults in LTC settings (AUC 0.641).

This research endeavours to offer the suggestion that despite the weighted scoring of the FRASE, male older adults (score=1) are a greater risk of falls than females (score=2) (p=0.037, AUC 0.435). Similarly, within the sensory deficit fall risk variable, a statistical relationship was identified between faller status and older adults with a hearing deficit (score=1) (p=0.004). In contrast, no significant relationship was identified between faller status and the higher weighted sight deficit risk category (score=2) (p=0.140). Medication was predictive of future falls among older adults (AUC 0.584). Furthermore, in accordance with the literature, a statistically significant relationship was identified between older adult faller status and the use of tranquillisers (p=0.038) and anti-hypertensives (p=0.049).

The findings highlighted the statistical relationship between older adult faller status and medical history (p=0.005) specifically ‘risk of fracture’ (p=0.020) and organic brain disease/ confusion (p=0.46). In contrast, age demonstrated an AUC value comparable to random probability (AUC 5.25) thus indicating medical history is more significant than chronological age in predicting future falls among older adults. Finally, a statistically significant relationship was identified between older adult faller status and mobility (p=0.49) with mobility demonstrating predictive accuracy in predicting future falls among older adults (AUC 0.574).

6.4 Recommendations

This research explored the predictive accuracy of the FRASE risk assessment tool in identifying older adults at high risk of falls and the relationship between older adult faller status and the risk factors; gender, age, gait, sensory deficit, falls history, medication, medical history, and mobility. During the course of this research a number of recommendations were established. These recommendations pertain to clinical practice, policy development and future research.

6.4.1 Implication for clinical practice

The findings in this study recommend clinicians within LTC settings review current fall prevention practices and apply increased emphasis on the fall risk variables that established predictive accuracy among older adults aged 65 years and older. Ongoing assessment of older adults falls history (AUC 0.649), gait (AUC 0.641) sensory deficit (AUC 0.623), medical history (AUC 0.597), medication (0.584) and mobility (0.574) would assist nurses in the development of individualised care plans with targeted falls prevention interventions. Echoing El Miedany et al. (2011) falls prevention is an ongoing process of which screening is just the beginning.

The findings of this study established no statistically significant relationship between faller status and age (p=0.434). Accordingly, to avoid overestimating risk and the application of unnecessary falls prevention restrictions this study concurs with Sherrington et al. (2011) and recommends nurses disregard older adults chronological age and place greater emphasis on older adults physiological functioning and comorbidity. Furthermore, in agreement with the literature, older adult with a previous falls history present the greatest risk of a future fall.

6.4.2 Implication for policy development

Several studies have acknowledged the importance of FRATs in minimising clinical expenditure through accurate deployment of falls prevention interventions (Healy et al., 2004; Thomas et al., 2010; El Miedany et al., 2011; Latt et al., 2016; McGarrigle et al., 2017). Higaonna (2014) suggested the similarities between the falls risk variable within the Japanese Nursing Association Fall Risk Assessment and the NICE (2013) guidelines may explain the tools predictive accuracy values. Therefore, continued use of FRATs revised and validated in accordance with the NICE (2013) guidelines may increase predictive accuracy, reduce falls and ensure cost containment of overstretched healthcare budgets.

The NICE (2013) guidance recommends a multifactorial fall risk assessment with tailored multifactorial falls reduction interventions. Therefore, stakeholders and policy makers must strive to revise falls policy and assessments in keeping with these recommendations. In accordance with McKechnie et al. (2016) the analysis of non-fallers and faller in this study provides means for developing a local falls risk patient profile. This patient profile can guide the revision of local policy and practice to increase accuracy in discriminating non-fallers from fallers. Therefore, this research study recommends the introduction of simplified fall-related documentation that identifies older adults previous falls history, gait and sensory deficit deficits, cognitive impairment, risk of fracture, anti-hypertensive and tranquilliser use and restricted mobility. Combined with intervention strategies these fall risk predictors may enhance targeted fall prevention strategies and reduce fall risk among older adults in Community Hospitals/ Nursing Units.

6.4.3 Implications for further research in the research area

Although many studies suggest FRATs may have little incremental value over the clinical judgement of nursing staff (Myers, 2003; Haines et al., 2007; Healey et al., 2008; Oliver, 2008; Oliver et al., 2008; Wagner et al. 2011; McKechnie et al., 2016; Aranda-Gallardo et al., 2017; Castellini et al., 2017) the FRASE was a sensitive and specific predictor of future falls among older adults in Community Hospitals/ Nursing Units. In relation to diagnostic accuracy calculations, two confounders can have impact: treatment paradox and ward prevention measures (Ivziku et al., 2011). As the withholding of fall prevention measures would be unethical, future research designs that include the collection of information on compounding variables pertaining to falls prevention measures is warranted. The possible value of qualitative research to explore treatment paradox and ‘clinical judgement’ must be considered. In addition, the weighted risk scores assigned to gender and sight deficit within the FRASE risk assessment tool could be further explored, Finally, the male gender as a predictor of future falls among older adults aged 65 years and older warrants further research.

6.5 Methodological limitations of the study

A correlational design achieved the aim and objectives of the study however, some limitations within the study merit consideration. Despite the overall suitability of the non-experimental correlational study design, several weaknesses must be acknowledged. Selection bias must be declared as correlational studies are undertaken on pre-existing groups rather than random selection (Pannucci and Edwin, 2010; Harper et al., 2018). In addition the researcher was subjective and bias inviting a convenience sample of 12 Community Hospitals/ Nursing Units to participate in the study. Accordingly, convenience sampling limits the generalisation of findings as the researcher cannot determine how well the convenience sample represented the population regarding the traits or mechanism analysed. Consequently, the possibility of hidden biases cannot be overruled.

Similarities between non-fallers and fallers cannot be assumed before the occurrence of the independent variable (i.e. the predictive accuracy of the FRASE risk assessment tool) (Scotland, 2012). Consequently, findings must be interpreted tentatively as pre-existing differences among the older adults may present a reasonable alternative explanation for variation among faller status. Therefore, one must consider that a third variable may influence the relationship between any of the older adult faller status and any of the risk factors identified within the FRASE risk assessment tool, gender, age, gait, sensory deficit, falls history, medication, medical history and mobility.

The possibility of measurement errors must be considered as multiple Data Processors were used to access data. As the Data Processors transcribed the FRASE data onto the anonymised Data Collection tools, therefore the accuracy of completion of the FRASE risk assessment by the assessing nurse and the accuracy of transcription by the Data Processors must be taken into consideration. In addition, the accuracy of compliance in reporting fall incidents on the National Incident Management system via a NIRF-01 Person form must also be considered. Theoretically, a falls incident may not have been recorded and thus not captured during the data gathering phase.

Latt et al. (2016) acknowledged the limitation that the risk score assigned on admission may not be reflective of the person's risk at the time of experiencing or not experiencing a fall. Although the Data Processors collected the most recent FRASE data, the Data Collection tool did not capture the timeframe between FRASE risk score assignment and falls incident. In addition, the Data Collection tool did not capture the post fall FRASE data among fallers (n = 100) which may have shown changes to the older adults weighted risk scoring. Irrespective of the risk score achieved by the older adult, the sensitivity of the FRASE may have been reduced by nurse clinical expertise and the intuitive implementation of unconscious fall prevention measures.

McKechnie et al. (2016) highlighted how the unit of analysis impacts the predictive accuracy of the instrument. In accordance with Article 6 of GDPR (Government of Ireland, 2018) the data did not identify individuals therefore the unit of analysis was the older adult and not the fall. Consequently, older adults with repeated falls may have been included numerous times in the data sample which may have inflated the predictive accuracy achieved by the FRASE.

Regardless of the weaknesses identified, experimentation is not appropriate for many clinical problems, thus maintaining the role of correlational research in nursing research. While the interpretation of causal relationships is not the focus of correlational research, casual inferences may be identified if the study examines a causal hypothesis deduced from an established theory Furthermore, in contrast to experimental research, correlational research facilitates the collection of a large amount of data and numerous interrelationships in a relatively short timeframe. In addition, artificiality is often linked to experimental studies however correlational research demonstrates strong realism and therefore rarely criticised for artificiality (Polit and Beck, 2017).

6.6 Concluding Statement

This research study has determined the predictive accuracy of the FRASE risk assessment tool in identifying older adults at high risk of falls in Community Hospitals/ Nursing Units. In addition this research study determined the relationship between older adult faller status and the risk factors gender, age, gait, sensory deficit, falls history, medication, medical history, and mobility as identified in the FRASE risk assessment tool. The conclusions and recommendations illustrate that this research study has helped inform nursing practice on the accurate assessment of falls risk among older adults aged 65 years and older in Community Hospitals/ Nursing Units and will add to the body of nursing knowledge. The conclusion and recommendations are transferable to current day clinical practice.

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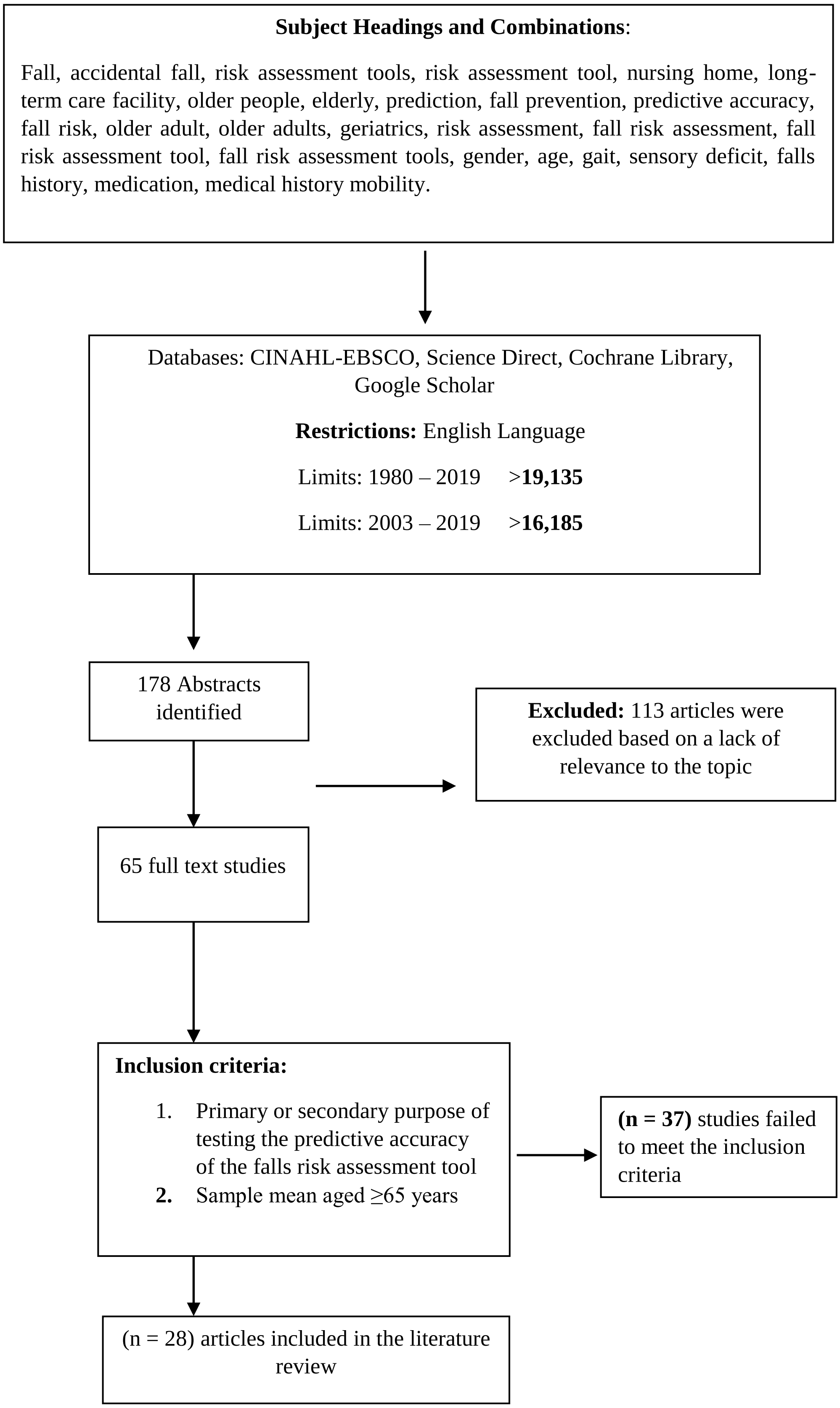
Appendices

Appendix A: Search Strategy Results

	Electronic database search (key words in search in bold)	View Results	Published since 2003
S1	Search results for “accidental fall” AND “risk assessment tools” AND (“nursing home or long-term care facility”)	0	
S2	Search results for “accidental fall” AND “risk assessment tools” AND “nursing home”	6	
S3	Search results for “accidental fall” AND “risk assessment tool” AND “older people”	12	
S4	Search results for “accidental fall” AND “risk assessment tool” AND “prediction”	11	
S5	Search results for “accidental fall” AND “risk assessment tool” AND “predictive accuracy”	4	
S6	Search results for “fall prevention” AND “risk assessment tool” AND “predictive accuracy”	1	
S7	Search results for “fall prevention” AND “risk assessment tool” AND “elderly”	2	
S8	Search results for “fall” AND “risk assessment tool” AND “older adults”	5	
S9	Search results for “fall” AND “risk assessment tool” AND “geriatrics”	0	
S10	Search results for “fall risk assessment” AND “older adults” OR “elderly”	19,135	16,188
S11	Search results for “fall risk assessment” AND “elderly”	76	16
S12	Search results for “fall risk assessment” AND “older adults”	12	
S13	Search results for “fall risk assessment tools” AND “older adults”	2	
S14	Search results for “fall risk assessment tool” AND “older adults”	4	
S15	Search results for “accidental fall” AND “risk assessment” AND “nursing home”	120	9
S16	Search results for “fall risk” AND “older adults” AND “gender”	21	
S17	Search results for “fall risk” AND “older adults” AND “age”	121	72
S18	Search results for “fall risk” AND “older adults” AND “gait”	92	15
S19	Search results for “fall risk” AND “older adults” AND “sensory deficit”	0	
S20	Search results for “fall risk” AND “older adults” AND “falls history”	10	
S21	Search results for “fall risk” AND “older adults” AND “medication”	15	
S22	Search results for “fall risk” AND “older adults” AND “medical history”	6	
S23	Search results for “fall risk” AND “older adults” AND “mobility”	96	46

Appendix B: Search Strategy: Inclusion and Exclusion Criteria



Appendix C: Data Collection Tool

<table>
<tr><th colspan="3">DATA COLLECTION SHEET</th></tr>
<tr><td colspan="3">SECTION 1: Falls Risk Assessment Scale for the Elderly: insert the FRASE Risk Assessment Scores of the person prior to experiencing the Slip/ Trip/ Fall</td></tr>
<tr><td>GENDER</td><td>Male = 1 Female = 2</td><td></td></tr>
<tr><td>AGE</td><td>BELOW 60 = 1 60-70 =1 71-80 =2 81+ = 1</td><td></td></tr>
<tr><td rowspan="4">GAIT</td><td>Steady = 0</td><td></td></tr>
<tr><td>Hesitant = 1</td><td></td></tr>
<tr><td>Poor Transfer = 3</td><td></td></tr>
<tr><td>Unsteady = 3</td><td></td></tr>
<tr><td rowspan="3">SENSORY DEFICIT</td><td>Sight = 2</td><td></td></tr>
<tr><td>Hearing = 1</td><td></td></tr>
<tr><td>Balance = 2</td><td></td></tr>
<tr><td>FALLS HISTORY</td><td>None = 0 At Home (past 12 months) = 2 In Ward/ Unit = 2 Both = 3</td><td></td></tr>
<tr><td rowspan="5">MEDICATION</td><td>Hypnotics = 1</td><td></td></tr>
<tr><td>Neuroleptics = 1</td><td></td></tr>
<tr><td>Tranquillisers = 1</td><td></td></tr>
<tr><td>Anti – hypertensives = 1</td><td></td></tr>
<tr><td>Diuretics = 1</td><td></td></tr>
<tr><td rowspan="4">MEDICAL HISTORY</td><td>Diabetes/ CVD = 1</td><td></td></tr>
<tr><td>Organic Brain Disease / Confusion (MTS < 3) = 1</td><td></td></tr>
<tr><td>Seizures/ Fits = 1</td><td></td></tr>
<tr><td>Risk of Fracture = 1</td><td></td></tr>
<tr><td rowspan="4">Mobility</td><td>Full = 1</td><td></td></tr>
<tr><td>Uses Aid = 2</td><td></td></tr>
<tr><td>Restricted = 3</td><td></td></tr>
<tr><td>Bed bound = 1</td><td></td></tr>
<tr><td rowspan="3">Total Score</td><td>3-8 = Low Risk</td><td></td></tr>
<tr><td>9-12 = Medium Risk</td><td></td></tr>
<tr><td>13+ = High Risk</td><td></td></tr>
<tr><td colspan="3"></td></tr>
<tr><td colspan="3">SECTION 2: Falls incident category information (NIRF-01 Person)</td></tr>
<tr><td colspan="3">How did the person fall (tick appropriate category)</td></tr>
<tr><td rowspan="6">Sub section 1</td><td>From height</td><td></td></tr>
<tr><td>From equipment/ furniture</td><td></td></tr>
<tr><td>Same level/ Ground</td><td></td></tr>
<tr><td>On stairs</td><td></td></tr>
<tr><td>On steps</td><td></td></tr>
<tr><td>Other</td><td></td></tr>
<tr><td colspan="3">What type of hazard did this incident relate to (tick appropriate category)</td></tr>
<tr><td rowspan="13">Sub section 2</td><td>Unknown</td><td></td></tr>
<tr><td>Pre-existing medical condition</td><td></td></tr>
<tr><td>Inadequate supervision gen health/ post op</td><td></td></tr>
<tr><td>Obstruction / protruding object</td><td></td></tr>
<tr><td>Surface contaminants</td><td></td></tr>
<tr><td>Rough terrain/ irregular surface</td><td></td></tr>
<tr><td>Inappropriate equipment use</td><td></td></tr>
<tr><td>Failure/ malfunction of equipment</td><td></td></tr>
<tr><td>Horseplay</td><td></td></tr>
<tr><td>Physical training/ sport</td><td></td></tr>
<tr><td>Weather condition</td><td></td></tr>
<tr><td>Inadequate lighting/ design</td><td></td></tr>
<tr><td>Other</td><td></td></tr>
<tr><td colspan="3">What was the outcome at the time of the incident (tick appropriate category)</td></tr>
<tr><td rowspan="8">Sub section 3</td><td>Near miss</td><td></td></tr>
<tr><td>No injury</td><td></td></tr>
<tr><td>Injury not requiring first aid</td><td></td></tr>
<tr><td>Injury or illness, requiring first aid</td><td></td></tr>
<tr><td>Injury requiring medical treatment</td><td></td></tr>
<tr><td>Long term disability/ incapacity (incl. Psychosocial)</td><td></td></tr>
<tr><td>Permanent incapacity (incl. Psychosocial)</td><td></td></tr>
<tr><td>Death</td><td></td></tr>
</table>

Appendix D: Ethical Approval from the Research Ethics Committee in Institute of Technology, Tralee

Institiúid Teicneolaíochta Trá Lí

INSTITUTE OF TECHNOLOGY TRALEE

Institute Research Ethics Committee (IREC)

MINIMAL RISK REVIEW

15/06/2018

Dr. Catrina Heffernan
Department of Nursing and Healthcare Sciences
Solas Building, North Campus

Dr. Heffernan,

Re: *The predictive accuracy of the FRASE Risk Assessment Tool in identifying older people at risk of falls.*

Thank you for your application and additional correspondence. The Minimal Risk application was discussed at a recent IREC meeting with input from the wider committee.

It was agreed to approve the application at minimal risk level to proceed to the point of, but not including, data collection, subject to a number of conditions being met prior to data collection. As the study involves significant Data Protection issues, in a very new regulatory context (General Data Protection Regulations, operative from the 25th May 2018), the following conditions are attached:

1. Approval by a clinical ethics committee and adherence to subsequent recommendations/conditions in respect of consent to access patients' records
2. Permissions to collect data, as specified in research protocol, from the relevant Data Controller within HSE sites
3. Controlling and processing of data in accordance with the up to date Data Protection regime including the General Data Protection Regulation 2018
4. Compliance with General Data Protection Regulations (2018) and Data Protection legislation throughout the duration of the study
5. The development of a data management strategy to support the project

While the Data Protection Commissioner previously noted that anonymized data did not require patient consent (*Data Protection Guidelines on research in the Health Sector,* 2007) as the new GDPR regulations are now in place, the Data Commissioner's Office is currently reviewing all existing guidance. In this respect, it is essential, for the protection of participants and researchers, and to ensure compliance with GDPR, that researchers ensure appropriate permissions are granted from authorized individuals within HSE sites.

Ms. Miriam McGillycuddy is available to address any further data protection queries the research team may have.

The general conditions of approval also apply;

a. The research is undertaken in accordance with Institute's Research Ethics Policy
b. If there is any planned substantive change in the research protocol, this detail is submitted to the Research Ethics Committee for review in advance.
c. If any ethical difficulties arise in the course of your project these are reported to the Chair of the Research Ethics Committee.

I wish you well with your research.

Sincerely,

Anna-Marie Greaney

Dr Anna-Marie Greaney
Chair, Institute Research Ethics Committee (IREC)
c/o Office of Vice President Academic Affairs and Registrar
Institute of Technology Tralee
North Campus
V92 HD4V
Phone: 0667191960 E-Mail: irec@ittralee.ie

From: Institute Ethics Committee <irec@ittralee.ie>
To: Catrina Heffernan <Catrina.Heffernan@staff.ittralee.ie>
Cc: Elizabeth Heffernan <Elizabeth.Heffernan@staff.ittralee.ie>
Sent: Tue, 09 Apr 2019 20:44:36 +0100 (IST)
Subject: Re: CREC approval for the Predictive accuracy of the FRASE risk assessment tool in identifying older people at risk of falls

Dear Catrina, Elizabeth,

Thank you for your confirmation of adherence to all conditions outlined by the research ethics committee in letter dated 15/06/2018.
The conditions required for data collection to commence have now been met. Please also note general conditions of approval noted within the letter.

If you require additional correspondence for your records please let me know.

Kind regards,
Anna-Marie

Dr Anna-Marie Greaney
Chair, Institute Research Ethics Committee (IREC)
c/o Office of Vice President Academic Affairs and Registrar
Institute of Technology Tralee
North Campus
V92 HD4V
Phone: 0667191960
E-Mail: irec@ittralee.ie

Appendix E: Ethical approval from Cork University Teaching Hospitals Clinical Research Ethics Committee

COISTE EITICE UM THAIGHDE CLINICIÚIL

Clinical Research Ethics Committee of the Cork Teaching Hospitals

Tel: +353-21-4901901
Email: crec@ucc.ie

University College Cork
Lancaster Hall
6 Little Hanover Street
Cork
Ireland

CREC Review Reference Number: ECM 4 (dd) 12/02/19 & ECM 3 (r) 05/03/19

Date: 7th March 2019

Dr Catrina Heffernan
Lecturer
Department of Nursing and Health Care Sciences
Institute of Technology
Tralee
Co Kerry

Study Title: The predictive accuracy of the FRASE Risk Assessment tool in identifying older people at risk of falls.

The Chairman approved the following:

- Confirmation that the study will be carried out in accordance with GDPR
- Confirmation that the data will be anonymised prior to data collection by the investigators involved in this study
- Addition of Dr Elizabeth Heffernan as a co-investigator in the study.

Yours sincerely

Professor Michael G Molloy
Chairman
Clinical Research Ethics Committee
of the Cork Teaching Hospitals

The Clinical Research Ethics Committee of the Cork Teaching Hospitals, UCC, is a recognised Ethics Committee under Regulation 7 of the European Communities (Clinical Trials on Medicinal Products for Human Use) Regulations 2004, and is authorised by the Department of Health and Children to carry out the ethical review of clinical trials of investigational medicinal products. The Committee is fully compliant with the Regulations as they relate to Ethics Committees and the conditions and principles of Good Clinical Practice.

Appendix F: Letter for Permission to Data Controller

[redacted]

20th September 2018

Re: Permission for assistance to access FRASE data and fall incident category data (NIRF-01 Person form) for the purpose of research data collection

Study Title: To determine the predictive accuracy of the FRASE risk assessment tool in identifying older adults at high risk of falls in Community Hospitals/ Nursing Units

Dear [redacted],

I am currently undertaking a MSc by research at the Institute of Technology Tralee and I am seeking your assistance with my research study.

The aim of my study is to determine the predictive accuracy of the FRASE risk assessment tool in identifying older adults at high risk of falls. The secondary aim of the research study is to determine the relationship between older adult faller status and the risk factors; gender, age, gait, sensory deficit, falls history, medication, medical history and mobility as identified in the FRASE risk assessment tool.

I am therefore seeking your assistance to act as a **Data Controller** to oversee data management compliance. As Data Controller/ Researcher I will access FRASE data and fall incident category data pertaining to older adults aged 65 years and older in Community Hospitals/ Nursing Units in the South/ South West of Ireland to fulfil the objectives of my research.

The processing of personal data from the two forms (FRASE and NIRF-01 Person) must be undertaken in accordance with Article 6 of GDPR. Therefore, I am seeking your assistance to fulfil the role of a Data Controller to oversee data management. The role of Data Controller necessitates your oversight in the application to gather data, the process of data collection and the outcome anticipated. Your name and number will be made available to each of the Community Hospitals

I am in the process of gaining Ethical approval from **The Clinical Research Ethics Committee of the Cork Teaching Hospitals (CREC)** and I will forward a copy of this for your perusal.

Data Processors (Clinical Nurse Managers) will collect the data by means of a Data Collection tool (Appendix C) which I will distribute should all persons accept to support the data collection process. All data must be anonymised at the point of collection by the Data Processors. The definition of a fall for the purpose of this study and the role and responsibility of a Data Processor as per Data Protection (2018) are outlined in the attached information leaflet (Appendix J). I would like to place a collection box in each ward area for the completed Data Collection Tools for your collection. Thereafter, the data collection process necessitates your review and verification of the Data Collection tools to ensure that no personal data is included in the data set. On your approval the Data Collection tools may be shared with me for statistical analysis.

All anonymised data will be held securely in a locked filing cabinet in my office. Records will be maintained for a period of 7 years after publication in a secure location in my office and used only for entry of data onto data analysis software. Data will be held on a password protected computer known only to me and my academic supervisors. Through the anonymisation of data, no record/ data stored on my computer will be identifiable by name, person or Community Hospital/ Nursing Units.

I do not envisage that this research will impact on service delivery and I do hope that you are in a position to approve and support this study within the Community Hospitals/ Nursing Units. If you require further information, please do not hesitate to contact me.

I look forward to your reply.

Yours sincerely,

[redacted]

Appendix G: Access Approval/ Data Controller letter from the HSE

General Manager Residential Services
Older People Cork/Kerry & NHSO,
Social Care Division
Cork & Kerry Community Healthcare Org,
[redacted]

Cúram Sláinte Pobail Corcaigh Ciarraí
Feidhmeannacht na Seirbhíse Sláinte
Ospidéal Naomh Columbanus,
[redacted]

4th October 2018

Re: Permission for Susan Daly to access data on the National Incident Management System and the FRASE scoring of older adults who experience or have experienced a fall

To whom it may concern

I wish to acknowledge that the applicant named above has the permission and approval of Cork Kerry Community Healthcare to analyse data pertaining to the NIMs system and the FRASE score of older adults who experience or have experienced a fall whilst residing within the below named Community Hospitals / Nursing Units [redacted].

[redacted]

[redacted]

The forms/ data for analysis will be provided to the applicant named above already matched with both anonymised.

I can also confirm that the applicant will also be provided with access to all relevant activity data /trend reports in relation to falls data held on NIMS pertaining to the older persons residential services in Cork Kerry Community Healthcare.

Yours sincerely,

[redacted]

[redacted]
General Manager
Residential Services for Older Persons (Cork/Kerry) & NHSO

Appendix H: Letter for Permission to the Directors of Nursing

[redacted]

10th October 2018

Re: Permission to Access FRASE data and fall incident category data (NIRF-01 Person form) for the purpose of research data collection

Study Title: To determine the predictive accuracy of the FRASE risk assessment tool in identifying older adults at high risk of falls in Community Hospitals/ Nursing Units

Dear [redacted],

I am currently undertaking an MSc by research at the Institute of Technology Tralee and I am seeking your assistance with my research study.

The aim of my study is to determine the predictive accuracy of the FRASE risk assessment tool in identifying older adults at high risk of falls. The secondary aim of the research study is to determine the relationship between older adult faller status and the risk factors; gender, age, gait, sensory deficit, falls history, medication, medical history, and mobility as identified in the FRASE risk assessment tool.

I am therefore seeking permission to access FRASE data and fall incident category data pertaining to older adults aged 65 years and older in your hospital for the purpose of gathering data to fulfil the objectives of my research.

The processing of personal data from the two forms (FRASE and NIRF-01 Person) must be undertaken in accordance with Article 6 of GDPR. Therefore, I am also seeking permission to access the Clinical Nurse Manager(s) in your Community Hospital/ Nursing Unit to fulfil the role of Data Processors, to collect and anonymise the data on behalf of the HSE Data Controller.

The HSE Data Controller is a nominated person within the Health Service Executive to oversee the application to gather data, the process of data collection and the outcome anticipated.

I am in the process of gaining Ethical approval from **The Clinical Research Ethics Committee of the Cork Teaching Hospitals (CREC)** and I will forward a copy of this for your perusal.

The data will be collected by means of a Data Collection tool (Appendix C) distributed to the Data Processors. The definition of a fall for the purpose of this study and the role and responsibility of a Data Processor as per Data Protection (2018) are outlined in the attached information leaflet (Appendix J) which will also be distributed to each Data Processor. I would like to place a collection box in each ward area for the completed Data Collection Tools, for collection by the HSE Data Controller. Thereafter, the data collection process necessitates all Data Collection tools are reviewed by the HSE Data Controller to verify that no personal data is included in the data set. Only on the approval of the HSE Data Controller will the Data Collection tools be shared for statistical analysis.

All anonymised data will be held securely in a locked filing cabinet in my office. Records will be maintained for a period of 7 years after publication in a secure location in my office and used only for entry of data onto data analysis software. Data will be held on a password protected computer known only to me and my academic supervisors. Through the anonymisation of data, no record/ data stored on my computer will be identifiable by name, person, or Community Hospital/ Nursing Units.

I do not envisage that this research will impact on service delivery and I do hope that you are in a position to grant me permission to conduct the study at your hospital. If you require further information, please do not hesitate to contact me.

I look forward to your reply.

Yours sincerely,

[redacted]

Appendix I: Letter seeking Data Collector Assistance

[redacted]

5th February 2019

Re: Permission for assistance to access FRASE data and fall incident category data (NIRF-01 Person form) for the purpose of research data collection

Study Title: To determine the predictive accuracy of the FRASE risk assessment tool in identifying older adults at high risk of falls in Community Hospitals/ Nursing Units

Dear [redacted],

I am currently undertaking an MSc by research at the Institute of Technology Tralee and I am seeking your assistance with my research study.

The aim of my study is to determine the predictive accuracy of the FRASE risk assessment tool in identifying older adults at high risk of falls. The secondary aim of the research study is to determine the relationship between older adult faller status and the risk factors; gender, age, gait, sensory deficit, falls history, medication, medical history and mobility as identified in the FRASE risk assessment tool.

I am therefore seeking your assistance to act as a **Data Processor** to access FRASE data and fall incident category data pertaining to older adults aged 65 years and older in Community Hospitals/ Nursing Units in the South/ South West of Ireland to fulfil the objectives of my research.

The processing of personal data from the two forms (FRASE and NIRF-01 Person) must be undertaken in accordance with Article 6 of GDPR. Therefore, I am seeking your assistance to fulfil the role of a Data Processor to provide the data. The role of Data Processor necessitates the collection and anonymisation of data on behalf of the HSE Data Controller.

The HSE Data Controller is a nominated person within the Health Service Executive to oversee the application to gather data, the process of data collection and the outcome anticipated.

I am in the process of gaining Ethical approval from **The Clinical Research Ethics Committee of the Cork Teaching Hospitals (CREC)** and I will forward a copy of this for your perusal.

The data will be collected by means of a Data Collection tool (Appendix C) which I will distribute should you accept to support the data collection process. The definition of a fall for the purpose of this study and the role and responsibility of a Data Processor as per Data Protection (2018) are outlined in the attached information leaflet (Appendix J). I would like to place a collection box in each ward area for the completed Data Collection Tools, for collection by the HSE Data Controller. Thereafter, the data collection process necessitates all Data Collection tools are reviewed by the HSE Data Controller to verify that no personal data is included in the data set. Only on the approval of the HSE Data Controller will the Data Collection tools be shared for statistical analysis.

I do not envisage that this research will impact on service delivery and I do hope that you are in a position to fulfil the role of Data Processor and support the study at your hospital. If you require further information, please do not hesitate to contact me.

I look forward to your reply.

Yours sincerely,

[redacted]

Appendix J: Research Information Leaflet

Research study information leaflet

Study Title: To determine the predictive accuracy of the FRASE risk assessment tool in identifying older adults at high risk of falls in Community Hospitals/ Nursing Units

Researchers name: [redacted] Contact number: [redacted]

Background: Numerous studies indicate the predictive accuracy of various numerical risk prediction tools is often not replicated when explored in different settings, and among different populations (Myers, 2003; Gates et al., 2008; Latt et al., 2016). Discrepancies in predictive accuracy values question the operational usefulness of FRATs in clinical practice, and the benefits to be achieved when compared against clinical judgement alone (Myers, 2003; Haines et al., 2007; Healey et al., 2008; Oliver, 2008; Oliver et al., 2008; Wagner et al. 2011; McKechnie et al., 2016; Aranda-Gallardo et al., 2017; Castellini et al., 2017).

Study Aim: The aim of my study is to determine the predictive accuracy of the FRASE risk assessment tool in identifying older adults at high risk of falls. The secondary aim of the research study is to determine the relationship between older adult faller status and the risk factors; gender, age, gait, sensory deficit, falls history, medication, medical history, and mobility as identified in the FRASE risk assessment tool.

Definition of a fall: For the purpose of this study a fall is defined as "an event which results in a person coming to rest inadvertently on the ground or floor or other lower level" World Health Organisation (2018, p.1)

Definition of an older adult: The World Health Organisation (WHO) (2002) define an older adult as any person with a chronological age of 65 years or more

Method: Random sample of FRASE data and NIRF data pertaining to older adults aged 65 years and older in Community Hospitals/ Nursing Units in the South/ South West of Ireland. Data collection will entail the use of a Data Collection tool.

Inclusion criteria:
FRASE data pertaining to older adult aged 65 years and older
NIRF falls incident category data pertaining to older adults aged 65 years and older

Exclusion criteria:
FRASE data pertaining to older adult aged less than 65 years
NIRF falls incident category data pertaining to older adults aged less than 65 years

Role and responsibility of a Data Processor: Personal data is defined as any information relating to an identified or identifiable individual (Government of Ireland, 2018). This individual is also known as a 'data subject' (DPC, 2019a). An identifiable individual is one who can be identified, directly or indirectly, in particular by reference to an identifier such as a name, an identification number, location data, an online identifier or to one or more factors specific to the physical, physiological, genetic, mental, economic, cultural or social identity of that individual (GDPR 2018, Government of Ireland, 2018). Accordingly, data about living individuals which has been anonymised such that it is not possible to identify the data subject from the data or from the data together with certain other information, is not governed by the GDPR or the Data Protection Act 2018, and is not subject to the same restrictions on processing as personal data. Therefore, it was important that the data collected for this research study is anonymised (European Commission, 2018).

Anonymisation: Anonymisation of data means processing it with the aim of irreversibly preventing the identification of the individual to whom it relates. Data can be considered effectively and sufficiently anonymised if it does not relate to an identified or identifiable natural person or where it has been rendered anonymous in such a manner that the data subject is not or no longer identifiable (DPC, 2019b).

Data Processors are required to collect the data by means of a Data Collection tool. All data must be anonymised at the point of collection by the Data Processors. All completed data collection tools must be placed in the collection box at ward level for collection by the HSE Data Controller. Thereafter, the data collection process necessitates the HSE Data Controller to review Data Collection tools and verify that no personal data is included in the data set. On the HSE Data Controller approval the Data Collection tools will be shared with the researcher for statistical analysis.

All anonymised data will be held securely in a locked filing cabinet in the researchers office. Records will be maintained for a period of 7 years after publication in a secure location in the researchers office and use only for entry of data onto data analysis software. Data will be held on a password protected computer known only to the researcher and supervisors. Through the anonymisation of data, no record/ data stored on the researchers computer will be identifiable by name, person, or Community Hospital/ Nursing Units.

Please note the nominated HSE Data Controller to oversee this research study data management compliance is [redacted] and the contact details are [redacted]

If you require further information, please do not hesitate to contact me.

Yours sincerely,

[redacted]