Clinicians' Perspectives and Clinical Efficacy of a Health Information Technology Tool in Hospital Falls Risk Assessment and Prevention among Older Persons

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Higher Degree by Research Thesis Declaration

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Abstract

Background

The expanding ageing population has resulted in a focus on older persons within many healthcare systems. Falls present a growing problem with a significant impact on the community and healthcare system. Identifying falls risk factors and preventing falls have become priorities for many hospital and government policies, yet the evidence for the acceptability and efficacy of such interventions remains limited. Health technology has the potential to influence the field of falls prevention. Within research and clinical use, single and multi-component health technology strategies have been trialled to identify falls risk and prevent falls incidents. These have included sensor systems, video surveillance, and electronic health records. This thesis sought to evaluate the role of health technology in falls risk assessment and prevention, its perceptions by clinicians as end-users, and its effectiveness in reducing falls in hospital. More specifically, the thesis examined clinicians' perspectives and use of a health information technology tool. This tool incorporated an iPad™ device and automatically generated visual cues to highlight individual patients' falls risk. Its accuracy and efficacy in identifying and addressing falls risk scenarios, was evaluated compared to a standard screening tool. The aim of this study was to ultimately develop an acceptable and usable tool, in collaboration with clinicians, to deliver effective falls prevention in hospital.

Methods

Two methodologies and separate analyses were undertaken to complete this thesis: 1) An integrative review collated evidence for the effectiveness and clinicians' perspectives of health technology use in falls prevention; and 2) an action research study evaluated clinicians' perspectives on the health information technology tool, and informs its clinical use and efficacy in reducing hospital fall rates. Data was derived from focus group and survey research, with implementation of the health information technology tool occurring over consecutive 12-week periods on two medical wards at a single hospital setting. Both qualitative and quantitative analyses were applied to the data.

Results

Integrative review evidence, presented for the first time in this thesis, highlighted the lack of robust, consistent evidence for the acceptability and efficacy of health technology measures in falls prevention. The research conducted in this thesis addressed this gap in knowledge by evaluating staff's attitudes towards the health information technology tool. It evaluated its positive and negative aspects, barriers to use, and recommendations for improvement; alongside its accuracy and effectiveness in reducing fall rates. Overall, clinicians were supportive for incorporating the tool into clinical practice. They perceived it as a useful, timely means of alerting staff and patients to falls risk scenarios, and resulting in better quality of care and understanding of falls risk for patients. Clinicians identified issues with usability and lack of time for tool use, and highlighted potential improvements to tool design. As befitting action research methodology, the health information technology tool has undergone refinement based on clinicians' feedback. This has resulted in improved technology, clearer functioning of selection keys, colour coding of patients' falls risk, having an automated trigger for patient education on falls risk, and provision of more iPad™ devices for more efficient use. The falls risk scores for the health information technology tool and standard falls risk in older person screening tool were similar, and did not differentiate between falls-risk and non-risk situations. Both tools had high sensitivity and low specificity for identifying falls-risk scenarios. They had similar rates of completion by clinicians on the wards. Implementation of the intervention tool had mixed outcomes on hospital fall rates.

Conclusion

This thesis contributed new information to address the knowledge gap on health technology uptake and efficacy in addressing hospital falls risk. Clinicians were willing to use the health information technology tool, and identified benefits to using the tool for themselves and their patients. The intervention tool demonstrated similar acceptability and accuracy to the standard falls risk screening tool. Staff's concerns about usability are addressed in tool refinement, with active participation of end-users were considered key to improving intervention acceptance and usage, along with maximising useful feedback to further inform tool development. The effect of implementing the intervention tool on fall rates was mixed, highlighting the challenges of identifying and managing falls risk scenarios in hospital settings. The work arising from this thesis informed the development of a hand held android device used in the Ambience Intelligence Geriatric Management (AmbiGEM) system, incorporating printed visual cues with movement sensor alarms that alert clinicians to high-risk patient manoeuvres. Future research directions will involve evaluation of the acceptability and efficacy of the AmbiGEM system, which is currently undergoing clinical trial in two hospitals in South and Western Australia.

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List of Abbreviations

AHS	Australian health survey
AMU	Acute medical unit
AU	Australian
CALHN	Central Adelaide Local Health Network
c.f.	Compared to
CI	Confidence interval
CNC	Clinical nurse consultant
CPD	Continuous professional development
DNA	Deoxyribonucleic acid
EHR	Electronic health record
EMR	Electronic medical record
FRAT	Falls risk assessment tool
FROP	Falls risk in the older person
FROP-Com	Falls risk for older persons in the community
FTE	Full time equivalent
GEM	Geriatric evaluation and management
GEMU	Geriatric evaluation and management unit
HIT	Health information technology
HR	Hazard ratio
ICD-9-CM	International Classification of Diseases 9 Clinical Modifications
IQR	Interquartile ratio
IRR	Incident risk ratio
LOS	Length of stay
MFS	Morse falls scale
NPSA	National patient safety agency
NPV	Negative predictive value
OBD	Occupied bed days
OR	Odds ratio

PPV	Positive predictive value
PROFET	Prevention of falls in the elderly trial
RN	Registered nurse
RR	Risk ratio
SALHN	South Adelaide local health network
s.d.	Standard deviation
STRATIFY	Saint Thomas risk assessment tool
TCP	Transitional care program
TQEH	The Queen Elizabeth Hospital
UK	United Kingdom
US	United States
USA	United States of America
WHO	World Health Organization

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Publications and presentations arising during this Masters candidature

First author publications related to this thesis

- Teh R, Mahajan N, Visvanathan R, Wilson A. “Clinical effectiveness of and attitudes and beliefs of health professionals towards the use of health technology in falls prevention among older adults”, International Journal of Evidence Based Healthcare, Dec 2015;13(4):213-223.
- Teh RC, Visvanathan R, Ranasinghe D, Wilson A. “Evaluation and refinement of a handheld health information technology tool to support the timely update of bedside visual cues to prevent falls in hospitals”, International Journal of Evidence Based Healthcare. Nov 2017. doi:10.1097/XEB.0000000000000129. [Epub ahead of print].
- Teh R, Wilson A, Ranasinghe D, Visvanathan R. “Use and clinical efficacy of standard and health information technology falls risk assessment tools”, Australasian Journal on Ageing. Dec 2017;36(4):327-331. doi:10.1111/ajag.12473.

First author paper presentations related to this thesis

- Oral presentation at Australia & New Zealand Falls Prevention Conference, Melbourne 2016 – “Developing a handheld health information technology tool to support timely update of bedside visual cues for falls prevention in hospital”.
- Oral presentation at Medical Nursing conference, Adelaide 2014 – “The problem with falls: a prevention strategy”.
- Oral presentation at Australian and New Zealand Falls Prevention conference, Sydney 2014 – “Health technology in falls detection and prevention: perspectives of healthcare staff”.
- Oral presentation at Australian and New Zealand Society of Geriatric Medicine conference, Melbourne 2014 - “The effectiveness and acceptability of health information technology in detecting or preventing falls”.

First author poster presentations related to this thesis

- Poster presentation at Western Health Research Week, Melbourne 2016 – “Development of a health information technology tool to support timely update of bedside visual cues for falls assessment and prevention”.
- Poster presentation at Australian Association of Gerontology conference, Adelaide 2014 – “Effectiveness of health technology for falls prevention and perspectives of health staff”.

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Chapter One: Introduction

Overview

This thesis is presented as a series of papers, with additional texts and analyses as necessary, exploring the perspectives and efficacy of a health information technology tool in hospital falls risk screening and prevention. This chapter provides a background to the research and rationale for investigation, introduces the research questions to be answered, and outlines the chapters and papers to follow.

Globally and locally, the older population is expanding, with consequences at an individual and systems level. Older age is associated with greater burden of chronic diseases, higher utilization of healthcare resources, and more adverse events during hospitalisation, including inpatient falls. The consequences of such unwanted falls can be devastating for older persons and their families, alongside the significant burden on health expenditure and resource utilisation. This has prompted many hospital and government policies to target falls prevention as a priority, and for interested parties to develop and implement falls risk screening and preventive tools. Health technology is emerging as a potential avenue to address falls risk, and evaluation of efficacy and acceptability is vital to wider implementation.

1.1 The ageing population

Population ageing, as defined by the expanding proportion of older persons within the local and worldwide community, is a major trend that will continue to grow [1]. The World Health Organization (WHO) has reported that the number of people aged 60 or older is projected to grow from an estimated 900 million in 2015 to 2 billion in 2050 (signifying from 12% to 22$% of the total global population) [2]. Within Australia, the population aged 65 years and above is projected to increase from 3.2 million at 30 June 2012, to between 5.7 and 5.8 million in 2031, to between 9.0 and 11.1 million in 2061, and between 1.5 to 18.1 million in 2101. This signifies a percentage increase in this older population from 14% (2012) to between 18.3% and 19.4% (2031), to between 22.4% and 24.5%

(2061), and between 24.6% and 27.1% (2101) [3]. Of note, the oldest old population aged 85 years and above is projected to have the greatest growth of all age groups, peaking at between 7% and 8% in 2032 [3].

Much of this shift to an increasingly older age distribution has been attributed to reduced fertility and mortality rates [1]. As the leading causes of death have moved increasingly from acute infections to chronic diseases [4], improved lifestyle conditions (e.g. food and water supply) and better medical care [5], especially among the older population, has led to a steady increase in life expectancy since the mid-nineteenth century [6].

Overall global life expectancy has been increasing, with an extra 5 years added between 2000 and 2015, representing the fastest increase in life expectancy since the 1960s [7]. Those aged 80 years and above are now the fastest growing age group globally [8]. Among Australians, those aged 65 years can now expect to live another 22 years (women) [9] and 19 years (men) [10]. This represents a seven year increase in life expectancy from the mid-1960s to 2013 [10]. However, this increased life expectancy is not uniform, with Aboriginal and Torres Strait Island persons born in 2010-2012 having a lower life expectancy (men 69.1 vs.79.7 years, women 73.7 vs. 83.1 years) compared to their non-Indigenous peers [11]. In the United States, the life expectancy among the lowest educated African Americans versus the highest educated Caucasians in 2008 was also shown to be reduced (men by 14.2 years, women by 10.3 years) [5].

One suggestion for this lower life expectancy among the socially disadvantaged is the combination of lifelong accumulated stressors and biological ageing, resulting in accelerated genetic damage [12]. Errors in protein translation and mutations in genes involved in deoxyribose nucleic acid (DNA) replication and repair [13], ultimately cause increased mutation load and death of the organism. This “allostatic load”, or lifetime physiologic load of adapting to stressors, is influenced by environmental exposures and individual differences in perceptions of what is “threatening” [14]. In a cyclical pattern, poor health can itself lead to social disadvantage, such as illness contributing to unemployment, which further adds to the reduced life expectancy [15].

1.2 The health of older persons

Among the older population, non-communicable or chronic diseases cause the majority of healthy life years lost [16]. The shifting age demographic has resulted in the increase in chronic diseases being felt worldwide [17]. Compared to previous generations, the current older population aged 65 years and above have a higher incidence of lifestyle-related diseases, such as type 2 diabetes mellitus and cancer [18]. The 2011-12 Australian Health Survey (AHS) found the self-report of diseases among those aged 65 years and above were 22% for heart, stroke and vascular diseases, 15% for diabetes, and 7% for cancer [19]. By comparison, those aged 85 years and above, had more age-related diseases. such as arthritis and dementia [18].

Advancing age is associated with increased prevalence of geriatric syndromes, meaning those “multifactorial health conditions that occur when the accumulated effects of impairments in multiple systems render (an older) person vulnerable to situational challenges” (e.g. urinary incontinence and functional dependence [20]. Older persons have a higher prevalence of frailty [21], meaning "a medical syndrome with multiple causes and contributors that is characterized by diminished strength, endurance, and reduced physiologic function that increases an individual's vulnerability for developing increased dependency and/or death" [22]. The presence and severity of functional limitation is linked to the risk of falling [23]. The risk of having two or more falls in the past 12 months is significantly increased among older persons aged 75 to 84 years with limitations in walking, transfer and balance abilities (10 times), compared to those without functional limitations [23]. This risk of multiple falls is also higher among those requiring assistance with personal activities of daily living (14 times) [23]. Frailty and functional limitations are also more prevalent among older persons residing in residential care facilities, who are more likely to fall compared to those living independently in the community [24]. Frailty has been shown to be independently associated with a higher risk of mortality and longer length of stay among older persons aged 75 years and above admitted to an acute care hospital [25].

1.3 The impact of an expanding older population

1.3.1 Health care systems

The expanding older population has placed increasing demands on the health care system. Health care policies in Australia, the United States (US), Canada, the United Kingdom (UK), and Europe, have recognized the health impact the expanding older population, and advocated for government leadership, healthcare policies, and research within the field of healthy or active ageing [26-30]. The WHO has defined healthy ageing has as "the process of optimizing opportunities for health, participation and security, to enhance quality of life as people age… (and) realize their potential for physical, social, and mental well-being" [31]. This has led to the development of their "Active Aging Policy Framework" (2002), targeting the prevention of chronic disease, excessive disability and premature mortality [16]. While in Australia, the "Promoting Healthy Ageing in Australia" document (2013) outlined recommendations for physical activity, nutrition, work, social environment and research for the older person [30].

This focus on older persons within health care systems is necessitated partly due to greater usage of health services by older persons compared to younger adults [19]. Data from the Australian Health Survey (2011-12) found adults aged 65 years and over were more likely to have seen a general practitioner (96% vs. 82%) or specialist (57% vs.28%), and been admitted to hospital (20% vs.11%), in the past 12 months, compared to those under 65 years [19]. Older Australians aged 84 years and above accounted for 7% of hospital admissions and 13% of days spent by patients in hospital, although they comprised just 2% of the population [32]. In the United States, one in three hospital admissions (1.3 million in 2003), were aged 65 years and above, despite accounting for just 12% of the population [33].

The number of hospitalizations among older persons has also been rising, with data from Western Australia (1993/4 to 2003/4) and Germany (2000-2009) showing a respective 22% and 6% increase in overall admissions [34, 35]. Data from both countries demonstrated greater than 40% rise for admissions for congestive cardiac failure [34, 35]. This finding is however not uniform, with other research demonstrating a decrease in hospitalizations for ischaemic heart disease, due to an improved management of cardiovascular risk factors [34, 36, 37].

Being older also influences hospital outcomes. Research from the Healthcare Cost and Utilization Project in the United States found older patients stayed 1.7 days longer in hospital, were 5 times more likely to die during their admission, and had 46% higher hospital costs, compared to younger patients [33]. Furthermore, the incidence of falls during inpatient admission rises with advancing age, and leads to an increased likelihood of prolonged hospital length of stay, extended period of ill health, and fatal complications among older persons, [38].

1.3.2 Health care expenditure

In the past, population ageing has played a relatively small role in increasing health expenditure in Australia, the UK, the US, and Canada [39-42]. This has changed in the current environment, with population ageing identified as the most reliable factor influencing future healthcare costs [39-42]. Indeed health expenditure in 13 countries, including Australia, the US, Canada, and parts of Europe, is already highest among 85-89 year olds, and higher among 65-69 year olds compared to 25-29 years olds [43-45].

In Australia, healthcare expenditure for those aged over 65 years was four times higher than for those aged under 65 years [46]. In 2002-03, the Australian Government Productivity Commission estimated one-third of government expenditure on health services was spent on those aged over 65 years, with this proportion projected to grow to over half (i.e. $211 billion) by the year 2044-45 [46]. This expenditure has mainly been funded by the Australian government (almost 70% vs. 17% by individuals, in 2011-12) [19]. In the US (2003), population ageing has been attributed to causing half the increase in healthcare expenditure, with those aged over 65 years accounting for 43.6% of national hospital costs (almost $US 329 billion) [47]. Moreover, these costs rise with increasing number of chronic conditions, with out-of-pocket health care costs among Australians aged 50-79 years rising from $353 to $882 per quarter, with none compared to more than four chronic conditions (2011) [48].

1.4 Falls in the older person

The reported falls incidence is rising, representing either improved reporting and/or a change in patient profile [49]. Moreover, true figures are likely to be higher due to well-documented under-reporting of falls incidents [50]. The rise in falls has had significant impact to the healthcare system with increased healthcare utilisation and expenditure; and costs associated with longer hospitalisations, long-term care at home or entry into residential care, workforce losses and insurance liabilities [51-57]. Falls are more common with advancing age [57], and often have greater significance for the older person in terms of morbidity and mortality [57].

Moreover, there are long-term consequences of falls with chronic pain, reduced quality of life, functional impairment, permanent disability, and increased discharge to permanent residential care [58-60].

Among the general older population, the proportion of recurrent fallers, meaning those with more than one fall in a given time period (usually 12 months), has been reported as 5% [61]. A prospective study of 325 community-dwelling persons aged 60 years or older found that the percentage of those with two or more falls in the past year increased with the number of falls risk factors, from 10% (none or one risk factor) to 69% (four or more risk factors) [62].

Thus, the problem of falls and ways to address this issue require special consideration, and will be further explored in the literature review presented in Chapter 2.

1.5 Thesis outline

1.5.1 Background and objectives

With the significant and growing burden of hospital falls and falls-related injuries, there is the urgency for research to evaluate the clinical efficacy and uptake of falls risk assessment and preventive tools. As a hospital clinician working with older persons, it was important to explore and evaluate methods to identify and address falls risk factors as they impacted patients, practice and the wider health sector. Therefore, the objectives of this thesis were to examine the problem of and risk factors for falls in hospital. Furthermore, the thesis objective was to explore methods of addressing and managing this falls risk, with a focus on health technology measures. The aim was to develop a strategy that was effective, acceptable and usable in preventing falls in hospital.

1.5.2 Research study aims and hypotheses

To this end, the research reported in this thesis focused on evaluating the clinical efficacy and clinicians' perspectives of a health information technology (HIT) tool. This tool incorporated an iPad™ device and automatically generated visual cues for bedside display, that was used in hospital falls risk assessment and prevention. The findings are presented in the form of three studies in Chapters 4, 5 and 6. The aims and hypotheses of these studies were:

1. To evaluate the effectiveness of health technology interventions in falls risk assessment and preventive strategies. The hypothesis of this study is that health technology methods are effective in reducing inpatient falls.
2. To examine clinicians' attitudes towards the use of health technology interventions in falls risk assessment and preventive strategies. The hypothesis of this study is that health technology methods are well accepted by healthcare staff.
3. To investigate and compare the perspectives of clinicians towards the HIT tool, before and after using the tool. The hypothesis of this study is that the HIT tool will be more positively perceived by clinicians after, compared to before, using the tool themselves.
4. To determine the acceptability, accuracy, and clinical efficacy in reducing hospital falls, of the HIT tool. The acceptability of the HIT tool is assessed by its completion rate on hospital wards. Its accuracy is assessed using the percentage of correctly assessed falls risk items on visual cues, using a standard risk assessment tool and clinical notes as gold standard. The clinical efficacy of the HIT tool is assessed by its correlation with standard falls risk assessment tool scores, and effect on hospital fall rates. The hypotheses of this study are that the HIT tool is consistently and accurately completed by staff, and lower falls rates among hospital inpatients.
5. To inform the further development and refinement of the HIT tool for translation into clinical practice.

1.5.3 Thesis organisation

The chapters of the thesis are ordered as follows:

Chapter 1 outlines an overview of the ageing population, its impact on individuals and the healthcare system, and consequences of falls in hospital, especially among the older population. It also reports the study aims and subsequent organization of this thesis

Chapter 2 presents a literature review on the problem of falls risk factors and current evidence for falls risk assessment tools and preventive strategies.

Chapter 3 describes research process, methodology and methods in relation to addressing research aims.

Chapter 4 presents a published integrative review evaluating the efficacy of and clinicians' perspectives towards the use of health technology in falls prevention.

Chapter 5 presents a published paper reporting on a mixed-methods study examining clinicians' perspectives of the HIT tool before and after tool trial.

Chapter 6 presents a published paper outlining the quantitative research undertaken to evaluate the acceptability, accuracy, and clinical efficacy of the HIT tool.

Chapter 7 summarises the total research findings of this Masters thesis; compares our significant findings to existing literature; outlines our contribution to current evidence, research, education, and practice; and presents possible future research directions.

Summary

The expanding ageing population presents special challenges with increased burden of disease, increased healthcare utilisation and expenditure, and poorer outcomes as an inpatient, including an increased risk of hospital falls. This has led to the older person being targeted as a key priority for many healthcare policies. Within this framework, the growing problem of falls requires attention and hence this thesis was designed to investigate health technology use within falls risk screening and prevention. The following Chapter 2 sets the framework for the research by presenting a literature review describing the problem of falls, risk factors, and evidence for effective risk assessment and management.

Chapter 2: Literature Review

Introduction

Following from the previous chapter which described the impact of the demographic shift in population ageing, this chapter offers a literature review describing the problem of falls in hospital and the consequences to patients and the healthcare system. It provides an understanding of the risk factors associated with falls, and reports on the evidence for falls risk screening tools and preventive strategies. Finally, it introduces the role of health technology within this field, which is further expanded on in the integrative review presented in Chapter 4.

2.1 The problem of falls in hospital

Thus there is a great variation in reported incidence of falls in hospital, ranging from 2-3% (acute setting) to 46% (rehabilitation setting) of patients falling at least once during their hospital admission [63, 64]. In 2014-15, Australian data found more than 33,000 inpatient episodes reporting a fall occurring within the health service area [65]. Falls are more prevalent in medical compared to surgical wards [66], in public compared to private hospitals (4.2 vs. 1.6 per 1,000 hospitalizations), and among patients living in major cities compared to very remote or remote areas (3.4 vs. 1.9 per 1,000 hospitalisations) [65]. Actual fall rates are likely to be even higher as falls incidents tend to be under-reported [50]. Moreover, there is considerable heterogeneity and no universal agreement in defining a fall. A fall has been defined as “any event resulting in the person coming to rest inadvertently on the floor or lower level, not as a result of a major intrinsic event (e.g. stroke) or overwhelming hazard” [67]. The International Classification of Diseases 9 Clinical Modifications (ICD-9-CM) provides several classifications for falls ranging from falls on the same level from slipping, tripping, stumbling or collision, pushing, shoving by another person; to falls from a height such as ladders or out of a building [68]. However the ICD-9-CM classification is not always applied and most institutions rely on incident reporting when counting fall events [68].

Taking these factors into account, it is more alarming that the reported falls rate in Australia has been rising, with an increase from 2.4 to 3.0 falls per 1,000 hospitalisations between 2009-10 to 2012-13 [49]. This increase in incidence may represent either improved reporting and/or a shift in patient profile [49]. The figures for hospital falls within Australia are comparable to international results. Data from the US reported an incidence of 3.3 to 11.5 inpatient falls per 1,000 patient days [69-73]. While in the UK, the National Audit of Inpatient Falls (2015) reported 6.63 inpatient falls per 1,000 occupied bed days (OBD) [74]. This OBD refers to a standard measure of hospital occupancy, meaning the proportion of beds either reserved for or with patients physically in them, divided by the total number of beds available for that time period [75].

2.2 The significance of hospital falls

2.2.1 Physical injury, functional decline and mortality

Falls-related morbidity and mortality pose a significant burden on society and health care systems. Hospital falls tend to cause serious complications, with 44% to 60% resulting in some form of harm [76, 77], especially among older persons [57]. These include minor injuries requiring simple intervention (12% to 82%), moderate injuries requiring sutures or splints (2.2% to 53.6%), major injuries requiring surgery, casting or further investigation (0.5% to 29%),or death from injuries sustained from the fall [57, 78]. The consequences of these falls may be long-lasting, leading to chronic pain, reduced quality of life, functional impairment, permanent disability, and higher rates of inpatient mortality [57-59].

A 10-year study of public hospitals in Victoria, Australia, found 17.6% of hospital falls resulted in fractures, 44.4% of which involved the hip [52]. There is systematic review evidence that fracture risk is 1.5 times higher among patients aged 80 years and above, who comprise 60% of all hospital falls-related fractures [57]. Moreover, older persons who sustain hip fractures in hospital had poorer outcomes compared to their peers who sustained hip fractures in the community [60]. These adverse consequences included longer length of stay (LOS) in hospital [52], reduced return to preadmission ambulation and functional status, increased rates of discharge to permanent residential care [60], and higher mortality rates [52].

Less than 1% of falls in hospital result in death, yet this figure translates to more than 11,000 falls-related deaths per year in the US alone [69]. American data have also demonstrated that inpatient falls increased mortality rates from 20.9 to 26.6 deaths per 1,000 persons, with an even greater increase for those aged 95 years and above (odds ration [OR] = 2.93; confidence interval [CI] = [2.50-3.43]) [79]. In addition, the mortality burden from falls was even higher among males (OR = 1.64, CI = [1.54-1.75]), non-Caucasians (OR = 1.09; CI = [1.01-1.19]), and those with other comorbidities (OR = 3.41, CI = 3.05-3.82), dehydration (OR = 1.14; CI = 1.05-1.25) and intracranial fractures (OR =4.46; CI = 4.02-4.95) [79].

2.2.2 Emotional consequences

Hospital falls not only lead to physical injury, they can also have psychosocial repercussions. Fear of falling is one of the more common consequences [58]. It is present in 27% to 50% of older persons, being more prevalent where there is a previous history of previous falls, and refers to "a lasting concern about falling that leads to an individual avoiding activities that s/he remains capable of performing" [80]. [80, 81]. Fear of falling may relate to gait, vision and mobility disturbances [82], and has strong associations with poor postural performance [83], reduced walking speed, muscle weakness [84], loss of mobility, and functional decline [85]. It may contribute to restriction of activity [86], further falls [87, 88] lower self-rated health and quality of life [89], increasing dependence on others, social isolation, anxiety, and depression [85, 90].

2.2.3 Healthcare service utilization and costs

Those hospital admissions associated with inpatient falls tend to have a longer LOS compared to those admissions without inpatient falls [52]. A ten-year cohort study of hospitals in Australia found inpatient falls increased median LOS from five to nineteen days (p<0.001) [52], with data from the Australian Institute of Health and Welfare (2009-10) reporting this LOS was longer compared to admissions for falls sustained within the community [91]. The 6-PACK trial (2011-13) within six hospitals in Australia demonstrated that hospital falls increased LOS by 8 days (95% CI 5.8-10.4, p<0.001), and hospital costs by AU$6669 (95% CI $3888-$9450, p<0.001), after adjusting for age, sex, cognitive impairment, comorbidities and admission type [92]. The 6-PACK trial reported that hip fractures added an extra 4 days (95% C1.8-6.6, p<0.001) to hospital LOS, along with additional hospital costs of AU$4727 (95% CI -$568 to $10,022, p=0.080) per patient [92]. Osteoporosis Australia (2012) found this LOS (6.9 ± 2.7 vs. 11.5 ± 5.7 days) and hospital costs (AU$17123 ± $9306 vs. AU$22532 ± $12002) were higher among those aged 70 years and above, compared to those aged 50-69 years [93].

Within the United States, direct medical costs of falls within the emergency, hospital and outpatient setting were $US616.5 million for fatal and $US 30.3 billion for non-fatal injuries in 2012. This rose to $US 637.5 million and $US 31.3 billion, respectively, in 2015 [94]. Patients who sustained an injurious fall were estimated to have hospital charges of greater than $US 4,200 compared to those who did not fall [95]. Data from the National Health Service in the United Kingdom (July 2017) estimated that inpatient falls costs the country £630 million [96]. An estimated 87% of these costs were attributed to older patients, who accounted for just 77% of total hospital falls [96]. While a prospective study in four institutions in Finland in 2002 found that the average cost of an inpatient fall was Euro 944 [53].

Most of the hospital expenditure around inpatient falls has been attributed to increased LOS on subacute or rehabilitation wards, as opposed to acute care [97]. Impaired rehabilitation may further increase healthcare expenditure and risk of entering permanent residential care [53-55]. Requiring either permanent residential care or long-term care at home account for the majority (54%) of expenditure from falls sustained in hospital by older persons [98]. In New South Wales, Australia (2006/07), 23% of the total AU$558.5 million expenditure associated with falls injuries among older persons were related to costs around residential care [99]. Moreover, there is the additional economic burden of subsequent workforce losses, insurance liabilities [51], and potential medicolegal disputes around hospital falls [100, 101].

2.3 Risk factors for falls in hospital

Hospital admissions are often associated with decline in physical health, cognition, function and mobility, which together with unfamiliar staff and surroundings, may contribute to heightened falls risk [58, 102, 103]. Over 400 falls risk factors have been identified in the literature [67]. An integrative review

(2015) of 23 studies highlighted twenty-eight intrinsic (patient-related) and extrinsic (environment-related) risk factors for falls [57]. The risk of falls has been shown to rise exponentially with the number of falls risk factors [62, 67, 104, 105], with research implicated intrinsic factors as being more crucial for those aged 80 years and over [106], and extrinsic factors for older persons aged under 75 years [107].

2.3.1 Intrinsic falls risk factors

Non-medical factors

Literature has demonstrated the foremost intrinsic risk factor for falls is advancing age [57]. Research has found between 40% to more than 50% of inpatient falls occur among older persons aged 65 years and above [52, 55, 69, 108]. There were mixed findings around gender prevalence, with some studies citing male [108-111] and female gender [108, 112] as falls risk factors, and others that gender itself was not associated with falls risk [57]. Two studies have found older women were more likely fall and to sustain falls-related fractures, compared to older men, and that this risk increased with advancing age [105, 113]. Racial disparities have also been documented, with Caucasians falling more often compared to Afro-Caribbeans, Hispanics, and South-East Asians ethnicities [62, 88].

The relationship between activity and falls may be U-shaped, with falls occurring most often among the most inactive and most active [114, 115]. Those who are sedentary tend to fall more often compared to those who are moderately or very active [114]. While exercises of higher intensity or duration may confer added falls risk during that activity, especially among those who have already fallen [116]. Footwear may also play a role, with high heeled shoes shown to impair balance and thereby contribute to falls risk [117]. A history of previous falls [62, 118] and fear of falling present additional risk factors for falling [88].

Medical factors

Chronic health conditions can increase falls risk. These include stroke, Parkinson's disease, cardiac disease [119], hypertension [57], and chronic obstructive pulmonary disease [120]. Additionally, diabetes, hyperthyroidism [121], arthritis [62], peripheral sensory loss [122], carotid sinus hypersensitivity, orthostatic hypotension [123], and depression [120], have all been shown to increase falls risk. Among older adults with cancer, there is increased falls risk if brain metastases are present [124]. The incidence of falls also rises with increasing burden of chronic disease [120, 125]. There is case-control evidence for Charlson comorbidity index, meaning the impact of comorbidity burden on ten-year mortality [126], of greater than three, increasing the risk of falls among hospital patients [95].

Cognition also influences falls risk. Altered mental states such as delirium (risk ratio [RR] 1.7, CI 1.6-1.8), dementia (RR 1.8, CI 1.6-2.0) [52], and mild cognitive impairment [127], can all increase the risk of falls among older adults. Scores of less than 26 [125] or 24 [115] on the Mini-Mental State Examination [128], or greater than four errors on a short mental status questionnaire [67], have been shown to be associated with increased falls risk. The Longitudinal Aging Study in Amsterdam demonstrated that immediate memory was an independent risk factor for falls among persons aged 75 years and above [129]. There is case-control evidence that Confusion and Mobility assessment scores of greater than one among hospital patients, and the presence of impaired decision-making among stroke inpatients [130], are associated with a higher risk of inpatient falls [95]. While older adults with deficits in executive function [131], dual-tasking [132], verbal reasoning [133], processing speed [134], and visuospatial abilities [135] have also been noted to fall more often.

A number of case-control studies have reported that generalized weakness, easy fatigability [101, 130], lower limb weakness [136], abnormal or unsteady gait [100, 137], and use of a walking aid [100], are all risk factors for falls in hospital. The role of frailty and sarcopenia in falls and serious falls injuries is increasingly being recognized [138], with reduced grip strength [139], difficulty rising from a chair [62, 140], and low body mass index, all linked with increased falls risk [125]. Vitamin D deficiency, contributing to abnormal gait and muscle weakness, increases the risk of falls, while osteomalacia and osteoporosis increase the risk of falls-related fractures [141, 142]. Additionally, foot problems (bunions, toe and nail deformities), lower limb ulcers, and pain on walking, may also contribute to balance difficulties and hence predispose to falling [67].

Within literature, there have been mixed outcomes for visual impairment and the risk of falls [109-111, 143]. Specific visual disturbances such as problems with visual acuity, contrast sensitivity, and visual fields;

the presence of cataracts, glaucoma, macular degeneration, strabismus, amblyopia, diplopia, nystagmus, and self-reported poor vision (regardless of visual acuity), have also been linked to increased falls risk [144-147]. Wearing bifocal or multifocal lenses may further contribute to the risk of falls [148].

The presence of urinary incontinence has been identified as a risk factor for falls in some studies [109, 110, 149], but not in others [143, 150, 151]. There is case-control evidence for needing assistance with toileting being a risk factor for falls among older hospital patients [152]. While night-time sleep disturbances have also been linked with increased falls risk among older persons [153].

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Polypharmacy and medications

Polypharmacy and the presence of specific medications have been shown to increase the risk for falls among older adults [119]. While there is no consensus on the definition of polypharmacy, it has been variably defined as taking two or five or more medications simultaneously [154, 155]; consuming unnecessary or extraneously using medications, regardless of number [156]; and taking two or more medications of the same pharmacological class and mechanism, in order to target the same or different condition(s) [157]. The risk of falls increases with the presence and number of medications taken, with those taking four or more medications at highest risk of falling [154, 155, 158-160].

However, there is literature review evidence that addressing “inappropriate prescribing” may be more beneficial than reducing number of medications when addressing falls risk [161]. Inappropriate prescribing describes the use of any medication that confers a significant risk of an adverse drug-related event, where there is a lower-risk and equally or more effective alternative for treating the same condition [162]. Inappropriate prescribing also refers to using medications at a higher frequency or for a longer duration than clinically indicated, using multiple medications with known drug–drug interactions and drug–disease interactions, and under-utilising beneficial medications that are clinically indicated but not prescribed due to flawed reasoning [162]. Poor adherence to medications has been associated with increased falls risk (OR 1.5, 95% CI 1.2–1.9; $p<0.001$), even after adjusting for age, sex, race, education, alcohol use, cognition, functional status, depression, and number of medications[163].

Inappropriate prescribing may contribute to falls risk by its effects of sedation, altered sleep patterns, confusion, dizziness, orthostatic hypotension, and other central nervous system disturbances [164]. Medication type can influence fall risk [165]. Sedatives have been shown to increase the risk of falls among older adults in the community, residential, acute care, and rehabilitation setting [166-168]. Moreover, this age group has a unique “dose-response” relationship between sedative use and falls incidence [169]. In terms of mechanism of increased falls risk, benzodiazepine use contributes to increased postural sway, loss of balance, and loss of position-sense in the toes [170, 171]. A case-control study of benzodiazepine use in hospital found these medications more than doubled the odds of falling among older inpatients (OR 2.26, 95% CI 1.21-4.23), with an even greater risk of hospital falls when narcotic drugs were added [172]. This falls risk was highest in the first two weeks of commencing the benzodiazepine [173], but remained elevated after 30 days of use [174]

Overall, antidepressants and anxiolytics are the most commonly prescribed medication classes that raise the risk of falls [175]. Tricyclic antidepressants (OR 1.51, 95% CI 1.14-2.00) and selective serotonin reuptake inhibitors (OR 1.72, 95% CI 1.40-2.11) are particular culprits due to their significant anticholinergic, sedative, and extrapyramidal side-effects [166, 167]. Older persons taking one or more anticholinergic or sedative medications nearly double their risk of falling each year, compared to those taking less than one of either medication [165]. Antipsychotic medications also increase the risk of falls (OR 1.59, 95% CI 1.37-1.83) [167], in particular for olanzapine (hazard ratio [HR] 1.74, 95% CI 1.04-2.90) and risperidone (HR 5.05, 95% CI 1.4-17.75) [176].

Other drug classes that have been implicated in increasing falls risk include diuretics, anti-arrhythmic medications, and digoxin [166]. The use of nonsteroidal anti-inflammatories has also been associated with a tenfold increase in likelihood of sustaining in inpatient fall for older hospital patients (OR 10.2, 95% CI 2.6-38.6, p=0.001) [26].

2.3.2 Extrinsic falls risk factors

Care setting and staffing availability

Most hospital falls occur in patients' rooms (62% to 77.1%), followed by in the bathroom (11.4% to 68%) and hallway (4.9% to 13%) [55, 70, 108, 110, 112, 143, 177]. Aged care units have the highest incidence of inpatient falls, followed by internal medicine and neurological units [69, 70, 151, 178]. Longer lengths of stay in hospital further increase the risk of inpatient falls [57]. Systematic review evidence has shown that most hospital falls are unwitnessed, occur at bed transfers, and are associated with attending to basic physical needs [179]. Between 25% to 70.3% of inpatient falls occur while walking or transferring [109, 112, 180], 12% to 69% are linked to urinating and defecating [55, 69, 110, 180, 181], and 15.9% to 51% occur when getting out of bed [108, 112, 143].

There is increased incidence of falls during staff shift changes [110], evening and night shifts [69, 112, 182], and between 7am and 11am in the morning [55]. Reported fall rates are generally higher where there are increased patient to nursing staff ratios [69]. It may be that patient-related factors, such as greater illness severity or higher prevalence of impaired balance and weakness, rather than staffing factors may have contributed to increased fall rates [69]. Thus, further research is required into the role of staffing availability to falls risk.

Environment

Environmental factors in hospital can contribute to increased falls risk. The presence of bed rails and attachments to equipment (e.g. catheter, intravenous leads); improper bed height; poor lighting; slippery/wet floors; uneven flooring; obstacles on the ground; doorway and furniture design; badly fitting footwear and clothing; and inappropriate or lack of walking aids, assistive or safety equipment all significantly increase the risk of hospital falls [61, 183 57, 183-185]. The risk of serious injury related to a fall was increased if it involved a bedside commode (OR 3.7, 95% CI 1.1 to 12.1) or occurred on the oncology ward (11% moderate/severe injury) [69]. Falls-related injuries may also be increased with the use of bed rails [186].

2.4 Falls risk assessment tools in hospital

2.4.1 Role and current use

In order to identify and address these risk factors, several falls risk assessment has been developed and used, especially for older adults [187]. These falls risk screening tools evaluate the physiological condition, sensory deficits, mobility, function and self-reported deficits of hospital inpatients. The tools often incorporate risk factor checklists and numerical risk prediction instruments to estimate the risk of future falls and target prevention to those deemed at 'high risk' [188]. To be clinically useful, such prognostic models need to demonstrate usability; staff adherence; inter-rater reliability; objective calculation of risk scores; predictive validity [encompassing sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and total predictive accuracy]; external validity (i.e. substantiated in more than one patient cohort); and greater accuracy compared to "best guess" clinical judgement [189].

In Australia, the "Preventing Falls and Harm From Falls in Older People: Best Practice Guidelines for Australian Hospitals" (2009) outlined that all older persons admitted to hospital should be screened for falls risk as soon as practicable after their admission, and again if there is a change to their health, function or environment [190]. However, the 6-PACK trial (2011-13) found only 64% of patients had a falls risk tool completed within the first day of hospital admission, that only 13% were updated during admission, and only 24% of fallers were re-assessed within a day of falling in hospital [191].

Within residential care, various falls risk assessment tools have also been trialled. Among 2005 aged care residents within New South Wales, those who could stand unaided, with either poor balance or two of three other risk factors (previous falls, nursing home residence, and urinary incontinence) increased their risk of falling threefold in the next 6 months (sensitivity 73%, specificity 55%) [192]. While among those who could not stand unaided, having one of three risk factors (previous falls, hostel residence, nine or more medications) increased the risk of falling twofold (sensitivity 87%, specificity 29%) [192]. Among 208 Swedish residential care residents (mean age 83.2 +/- 6.8 years), many identified falls risk factors did not differ significantly between fallers versus non-fallers [193]. Combining the Mobility Interaction Fall (MIF) chart, including observation of simultaneous ability to walk and interact with another person or object, visual testing, and concentration rating, and staff judgement or a history of falls was more accurate than using any approach alone [193]. While the Downton fall risk index evaluated among 71 residents in one residential care facility demonstrated 81 to 95% sensitivity and 35 to 40% specificity at 3, 6 and 12 months [194]. However, further research is required to demonstrate effectiveness of this tool [194].

2.4.2 Evidence for efficacy

Systematic review evidence has shown that clinical assessment and management of identified falls risk factors by a health care professional can substantially reduce the rate of falls by 24% among older persons living in the community [195]. However, the evidence for the role of falls risk assessment in hospital falls prevention is less consistent. Four systematic reviews (2001-7) [196-199] have identified just two screening tools, the Saint Thomas Risk Assessment Tool (STRATIFY) and the Morse Falls Scale (MFS), as being validated in more than one inpatient group. A more recent meta-analysis (2008) disproved the STRATIFY tool in terms of accuracy in detecting those patients at high risk of falling (PPV 23.1) [200]. Moreover, many screening tools have had obscure origins, arbitrary scoring, and not been trialled in multiple settings or as part of clinically effective falls prevention programs [196]. The "Preventing falls and harm from falls in older people" document in Australia (2009) [201] identified four randomized controlled trials (RCTs) that evaluated falls risk assessment tools within multicomponent hospital falls preventive strategies. Three RCTs demonstrated a reduction in hospital falls [202-204], however one did not show any change in falls rate [76].

One prospective validation study found nursing judgement of "wandering" behaviours provided higher predictive accuracy, albeit lower sensitivity, in evaluating inpatient risk of falls, compared to the STRATIFY tool [205]. Moreover, screening tools may not be superior to clinical judgement in assessing falls risk due to once-off assessments among older patients being inaccurate due to clinical fluctuations during the course of their admission [196, 198]. In addition, screening tools may need to be modified for local populations [206].

The mere act of evaluating falls risk may also provide false reassurance to staff that "something is being done", without any follow through of appropriate preventive measures [207]. A "one size fits all" approach to identifying and addressing falls risk may not be suitable, as two patients with the same falls risk score may have entirely different risk factors that warrant different strategies for management [208]. Several falls prevention programs have been shown to be successful without including falls risk assessment tools in their regimen [207]. Thus, the challenge remains in determining if falls risk assessment alone is effective in preventing patients from falling in hospital.

These factors, along with current limitations in evidence, have cause the National Safety and Quality Commission in Australia (2009), the National Institute for Health and Care Excellence (2013) and the American Agency for Healthcare Research and Quality (2013) to all issue guidelines that recommended against the routine use of falls risk assessment tools [209, 210]. The former outlined that all older persons admitted to hospital should be screened for falls risk, but that clinical judgement remained as effective as current screening tools [211], while the latter two chose to classify all patients aged 65 years and above at high risk of falls [209, 210].

However, despite the lack of high-quality evidence, falls risk assessment tools have been implemented in many hospital systems [74]. In Australia, the tools in clinical use include the STRATIFY [137], Ontario Modified STRATIFY [212], MFS [213], and Downton index [214]. The STRATIFY evaluates five clinical factors associated with falls (falls history, agitation, visual impairment, frequent toileting, difficulties with transfer/mobility), with scores of more than one out of five prompting more detailed risk assessment [137]. The Ontario Modified STRATIFY assesses falls history, mental status, vision, toileting, chair-bed transfers, and mobility, with scores assigned as low, medium and high risk [212]. The MFS asks questions about falls history, secondary diagnoses, need for ambulatory aid, gait/transferring ability, and mental status [213]. While the Downton index evaluates falls history, sensory deficits, gait, mental state, and medication use (tranquilisers, sedatives, diuretics, antihypertensive drugs, antiparkinsonian drugs, antidepressants) [214].

Within the emergency department setting, the FROP-Com screening tool [215] and the Prevention of Falls in the Elderly Trial (PROFET) tool [216] have been used to screen for falls risk. The FROP-Com assesses steadiness during walking and turning, number of falls in the past twelve months, and need for assistance with activities of daily living [215]. While the PROFET evaluates falls history, medical history, and social circumstances, and also includes a physical examination [216].

In the United Kingdom, the STRATIFY [137], Conley scale [217], MFS [213], Falls Risk Assessment Tool (FRAT) [218], and National Patient Safety Agency (NPSA) scale [219] are commonly used to assess falls risk in hospitals (Table 1) [220]. However, none of these tools have been shown to have greater than 70% sensitivity or specificity in predicting inpatient falls [220]. In Hong Kong, the STRATIFY and MFS, have frequently been used [137, 213], although a local pilot study noted other falls risk factors (e.g. cognition) were not accounted for, and hence these tools were unlikely to add value beyond experienced nursing judgment [221].

Within residential care facilities, there has also been limited evidence for any single falls risk assessment tools. The combination of any two of the MIF chart, staff judgement, and history of falls was more accurate than any approach alone; more than half of the residents classified as 'high risk' by two approaches sustained a fall within 3 months.

2.5 Falls prevention in hospital

2.5.1 Healthcare policy

Falls prevention represents a target area for intervention due to the significant impact of falls on the community and healthcare sector [222-224]. Preventing falls has also been shown to be cost-effective and potentially cost-saving [225]. Worldwide, several healthcare policies and guidelines have been developed to address the problem of falls [222-224]. The WHO has identified falls prevention as one of its five priority areas [226]. It has focused on raising public awareness, improving caregiver training and education, increasing access to preventive measures, and introducing public health guidelines to target reducing falls and falls-related injuries [226]. In Australia, the National Health Performance Framework (2009) classified falls resulting in inpatient harm as a key performance indicator [227]. While the “National Falls Prevention Plan for Older People” (2005) outlined a framework for evaluating and managing falls risk among older Australians in the acute care setting [51].

Table 1: Risk factors included in falls risk screening tools [74]

Risk factors	**STRATIFY**	**Conley**	**MFS**	**FRAT**	**NPSA**
History of falls	✓	✓	✓	✓	✓
Patient agitation	✓	✓			
Visual impairment	✓				
Frequency of toileting or altered elimination	✓	✓			
Transfer and mobility abilities or gait	✓		✓	✓	✓
Dizziness or vertigo		✓			
Use of walking aids		✓	✓		
Cognitive impairment or mental status		✓	✓		
Disease or comorbidity			✓	✓	
Therapeutic devices			✓		
Medication				✓	
Fear of falling					✓

[STRATIFY- the Saint Thomas risk assessment tool in falling elderly inpatients [137], Conley scale [217], MFS- the Morse Falls Scale [213], FRAT- Falls Risk Assessment Tool [218], and NPSA- National Patient Safety Agency scale [219]]

In the United States, the White House Conference on Aging Event (2015) highlighted falls prevention as one of its four main targets for older Americans in the next decade [224]. The American Joint Commission (2012) also identified a national patient safety goal as reducing harm from hospital falls, and made falls risk assessment mandatory across hospital systems [228]. The European Stakeholders Alliance also raised awareness for the need to improve clinicians' knowledge and action for falls prevention among older persons [224].

2.5.2 Current practice

In Australia, the Best Practice Guidelines (2009) recommended that all older persons in hospital should have multicomponent falls preventive strategies as part of routine care [190]. However, it is well-recognised that there is currently a gap between best and actual clinical practice [229, 230]. A study of 7214 hospital falls in South Australia (2011/2012) found just 11.8% and 81.9% of fallers respectively had pre-existing care plans and preventive interventions at the time of the fall [231]. These preventive interventions included having call bells or personal items within reach (42.6%), mobility or assistive aids (42.6%), bed rails (14.5%), supervision of mobility transfers (13.9%), and alarm systems (10.6%) [231]. An audit of Australian hospital practice (2012) also found just 64% of all falls and 75% of falls with injury had been documented in incident reporting databases, despite falls incident reporting being a mandatory practice and indicator of quality care [232].

2.5.3 Evidence for efficacy

Single component interventions

Despite the drive to implement falls preventive interventions, consistent and robust evidence for the efficacy of many single component strategies is lacking, especially in the hospital setting. Three systematic reviews have found insufficient evidence to support any single component intervention in avoiding inpatient falls [229, 233, 234]. There has also been a lack of research on preventing falls among older persons with cognitive impairment, who are often excluded from clinical trials [235] despite having a higher incidence of fall rates [127].

A systematic review (2013) [234] found pooled data from two RCTs supported the role of extra physiotherapy services in reducing inpatient falls risk on rehabilitation wards (RR 0.36, 95% CI 0.14-0.93) [236, 237]. However, the outcome from one of the trials involving 54 hospital patients did not demonstrate significant reduction in fall rates on its own (RR 0.54, 95% CI 0.16-1.81) [236]. Among community dwellers, there is systematic review support for the role of exercise overall in preventing falls [incidence rate ratio (IRR) 0.86, 95% CI 0.75 to 0.99, number needed to treat (NNT) 16), although there were no consistent trends for the effectiveness of different types of exercises [238].

There is RCT evidence that a nursing-led education program significantly reduced falls risk among high-risk patients (RR 0.29, 95% CI 0.11-0.74) [239]. However, another RCT found no difference in overall fall rates from providing inpatients with education (written and video-based) and one-on-one bedside follow up with a health professional [240]. However, this trial also included cognitively impaired patients, an unusual factor for many research studies, and sub-analysis of cognitively intact patients showed a reduction in hospital falls compared to those allocated to receive education materials or standard care alone (4.01 vs. 8.72 and 8.18 falls per 1,000 patient-days respectively) [240].

Integrative review evidence on the efficacy of nurse rounding, where nursing staff intentionally and regularly check on patients to proactively address their needs [241], found ten studies demonstrated efficacy for rounding in significantly reducing inpatient falls rates [242]. However, the implementation of nursing rounding resulted in unchanged hospital fall rates in two trials [243, 244], and mixed outcomes in another [245]. Thus, there is the need for further research involving participants in different settings and over longer durations [242].

The role of medication review by a pharmacist has been investigated in preventing falls in hospital. A systematic review found 5 studies investigating the role of medication review in long-term care facilities, but none in hospital settings [234]. Among older persons living in residential care, there is single RCT evidence that clinical medication review reduced the rate of falls (RR 0.62, 95% CI 0.53-0.72) [246]. At present, the justification for medication review in falls prevention remains observational with evidence for the role of medications and polypharmacy in increasing falls risk [247].

In general, many single-component falls preventive strategies lack rigorous evidence for efficacy. These include identity bracelets, wrist alert bands, bedside alarms, physical restraints, side-rails on hospital beds, using vinyl instead of carpet floors, and taking calcium and vitamin D supplements [179, 229, 234, 248, 249]. In fact, wrist alert bracelets were shown to increase the risk of falls (RR 1.3) [248]. Additionally, systematic reviews have reported the significant heterogeneity in study participants and intervention types, and overall lack of rigorous reporting, methodology and analysis in research evaluating hospital falls preventive interventions [179, 234]. This has led some authors to suggest that falls among frail older patients remain largely unpreventable, if they are to not adversely affect rehabilitation outcomes by avoiding "unsafe" mobilisation [179].

Multicomponent interventions

A integrative review incorporating 13 studies conducted in hospital settings, concluded that hospital fall and fall-injury rates were lowered by implementing a multifactorial approach involving falls risk assessment, fall-risk alerts, environmental and equipment modification, staff and patient safety education, medication review, and extra assistance during transfers and toileting [250]. This review recommended developing a culture of safety, performing timely risk assessment, implementing targeted falls preventive strategies, ensuring post-fall follow up to modify future risk, and integrating electronic health records (EHR) into falls risk management [250].

A RCT in Australia demonstrated the effectiveness of combining patient education and staff training in reducing hospital falls on rehabilitation units (n=196 vs. 380, 7·80 vs. 13.78 falls per 1,000 patient days; adjusted RR 0·60, 95% CI 0·42-0·94, p=0·003), although there was no significant difference in LOS (11 days, interquartile range [IQR] 7-19 days vs. 10 days, IQR 6-18 days) [251]. A meta-analysis of nursing strategies found multifactorial nursing interventions lowered hospital falls rates by almost 25% (OR 0.76, 95% CI 0.79-0.90), especially when nursing education was combined with environmental modification [252]. This latter intervention reduced falls by 76% (OR 0.34, 95% CI 0.28-0.42) [252].

However, an earlier umbrella review of meta-analyses [233] highlighted two systematic reviews that showed variable outcomes from multicomponent interventions. The Cochrane review found current evidence was inconclusive for the efficacy of multifactorial interventions in hospital falls prevention, citing gross heterogeneity in participant, intervention and methodology types within research [234]. The second systematic analysis found the beneficial effect of multicomponent interventions on hospital fall rates was negated on combining individual trial data (RR = 0.87, 95% CI 0.70-1.08) [229].

Multicomponent falls prevention interventions have been evaluated within Australia. The 6-PACK nursing initiative incorporated a falls risk assessment tool and individualised regimen of at least one of six interventions (“falls alert” sign, bathroom supervision, walking aids within reach, toileting regimen, low-low bed, bed/chair alarm) [191]. RCT evidence from 31,411 medical and surgical inpatients in six acute care hospitals found this multicomponent intervention did not change hospital falls rates [191]. While an audit of falls preventive strategies among nine Australian public and private hospitals found promotion of multicomponent falls prevention interventions (multidisciplinary staff education sessions, staff education packages, patient and carer education materials) by team leaders did not translate into reduced inpatient fall rates [253]. Research from the United States noted that fall prevention bundles targeting mobility, toileting, medications, cognition/mental status, and fall-related injury risk, did not lower inpatient fall rates or alter falls injury types in three acute care hospitals [254]. Moreover, there remains the challenge of identifying which individual component(s) are the effective ones within multicomponent bundles [234].

Health technology interventions

Technology-based interventions have been used to diagnose and treat falls risks [255], increase adherence to interventions [256], and detect and alert clinicians to falls incidents [257]. The WHO has defined “health technology” as “the application of organized knowledge and skills in the form of devices, medicines, vaccines, procedures and systems developed to solve a health problem and improve quality of lives” [258]. Such innovations have been viewed as essential to reducing healthcare costs and resource utilisation, and in improving quality and efficacy of healthcare [259]. However, their use to date has been limited by the lack of robust evidence on effectiveness and uptake by clinicians [260]. This section of the literature review will briefly outline some of the evidence around efficacy and uptake of health technology measures in falls prevention, which will be expounded on in the integrative review presented in Chapter 4.

Currently, there is single RCT evidence for the efficacy of health technology measures as part of multicomponent falls preventive strategies [260]. A Falls Prevention Toolkit (FPTK), incorporating bedside posters, patient education handouts, and care plans based on risk assessment using MFS, has been shown to reduce hospital falls rates compared to standard measures (4.18 (95% CI 3.45-5.06) vs. 3.15 (95% CI 2.54-3.90) per 1000 patient days. p=0.04) [261]. This finding was sustained among patients aged 65 years and above (adjusted rate difference 2.08 (95% CI 0.61-3.56) per 1000 patient days, p=0.003), although there were no significant differences in rates of falls among younger patients or in falls-related injuries overall [261]. Nursing staff identified that the effectiveness of such health technology measures was reliant on having accurate, accessible documentation of patients' fall risk status, alongside targeted intervention strategies [261]. Nurses also highlighted that clinical usefulness of health technology interventions was dependent on staff, patients and families translating this knowledge into appropriate action [261].

A case-control study of a multicomponent falls preventive intervention integrating video surveillance ("Webcam" linked to a central monitoring system) and movement sensors ("virtual bedrails") among patients with a MFS of more than 25 [262]. The case-control study found this intervention resulted in significantly fewer hospital falls per admission (34.11 vs. 18.74 falls per 1,000 admissions, p<0.05) [262] for those patients with MFS scores of more than 25 [262]. However, there was no difference in falls rate per 1,000 patient days [262]. The study also noted higher numbers of serious falls-related injuries among the control versus intervention units (n= 3 vs. 1), but due to the relatively small figures, was unable to assess for significance [262]. Moreover, the use of video surveillance engendered privacy concerns for health care workers [262].

Sensor technology holds promise for preventing falls in hospital, however at present, there is a lack of systematic review evidence for their effectiveness [263]. So far, research outcomes have been mixed and compounded by a lack of rigorous methodology and reporting of studies [263]. Currently, there is no RCT evidence for single-intervention sensor technology in reducing hospital falls, although efficacy has been demonstrated in three before-after studies [263]. A RCT of bed and chair pressure sensors linked to handheld nursing radio-pagers found no change in hospital falls or falls-injury rates [264]. While another RCT promoting staff education on falls prevention found increasing use of bed sensor alarms did not translate into meaningful change in hospital falls rates [265]. Moreover, clinicians' response towards the use of sensor systems in falls prevention has been mixed [266-270], including problems with workplace disruption, desensitisation to false alarms; and lack of acceptability, awareness, and practical experience with sensor use [268, 270, 271]

The use of EHR has resulted in mixed outcomes for falls [272]. These refer to computerised documents outlining clinical, demographic and management information to allow clinicians to implement quality improvement measures within their clinical practice [273, 274]. EHR use has resulted in mixed outcomes for fall rates [272], with mixed response from clinicians. The supporters of EHR advocated it as making their work easier [275], being easier to use than paper records, providing high quality documentation [276], Improving legibility of patient information, and increasing communication between staff [277]. However, the detractors reported EHR reduced eye contact among staff and between staff and patients [276], had modest accuracy and potential to improve patient safety [277], and suffered from lack of computers and computer literacy among staff, difficulties with technology, financial costs, and negative clinician attitudes [278, 279].

In recent years, there has been an interest in the role of video game and 3D technologies in falls prevention through improvement of muscle strength, balance, and adherence to home based exercises [256, 280]. These have included the Dance! Don't Fall program, designed to allow users to monitor and address their falls risk through a series of dance-related activities [255]. Other virtual technologies have targeted dual cognitive and functional impairment, by combining mathematical problem-solving with stepping exercises in order to assess balance while multitasking [281]. Smartphones have been used to monitor physical parameters and detect falls incidents, but have yet to be trialled in the hospital setting [257]. Thus there is a deficit in knowledge as to how efficacious these gaming and 3-D technologies are in reducing falls rates [282].

Summary

This chapter presents a literature review on the problem and risk factors of hospital falls, and the role and evidence for falls risk screening and preventive tools, Overall, despite the widespread implementation of such screening and preventive measures, there is a lack of robust and consistent evidence for their efficacy. Currently, there is systematic review evidence to support the role of multicomponent falls preventive strategies, however, the literature is inconclusive for most single component measures. Health technology has the potential to influence patient outcomes. However, the use of such tools has been limited by the lack of knowledge regarding their efficacy. Moreover, there is the growing need to characterise clinicians' perspectives on these interventions. These gaps in knowledge have resulted in the aims of this thesis, with Chapter 3 reporting on the research process, methodology and methods used to evaluate a health technology tool for hospital falls risk screening and prevention.

Chapter Three: Research Methodology and Methods

Summary

The deficit in knowledge of clinicians' perceptions and efficacy of falls risk assessment and preventive tools, especially those utilising health technology measures, has highlighted the need for further high-quality research. The ensuing chapter used the "research onion" framework to discuss research philosophy, approach, choice, strategy, time horizon, technique and procedure in evaluating acceptability and effectiveness of a health information technology tool. Pragmatism, inductive approach and mixed-methods research were described in addressing the problem of falls. Action research strategy was reported to provide understanding of the study framework and background. The time horizon was used to highlight pre- and post-trial outcomes regarding the health information technology tool. Study settings, participants and research techniques were described to provide knowledge of the type of health service and clinicians involved, and methods that guided investigation. Ethical consideration, informed consent, right to withdraw, confidentiality, de-identification and limited access of data were also reported to provide transparency of methods. Data collection and analysis processes were explained to allow replicability of study procedures, and to ensure validity and comprehensiveness of information gained.

3.1 Research process

The research process has been described as a metaphorical onion involving different layers or stages in developing and implementing a research plan (Figure 1) [283]. This permits each step within a methodological study to be described and understood [283]. Within this model, the research philosophy is defined, followed by the second step outlining research approach, the third step defining research strategy, the fourth step identifying time horizon, and the fifth step representing research technique and procedures [283]. The rest of this chapter will describe in detail, the specifics aspects of each layer of the research process as used within this thesis.

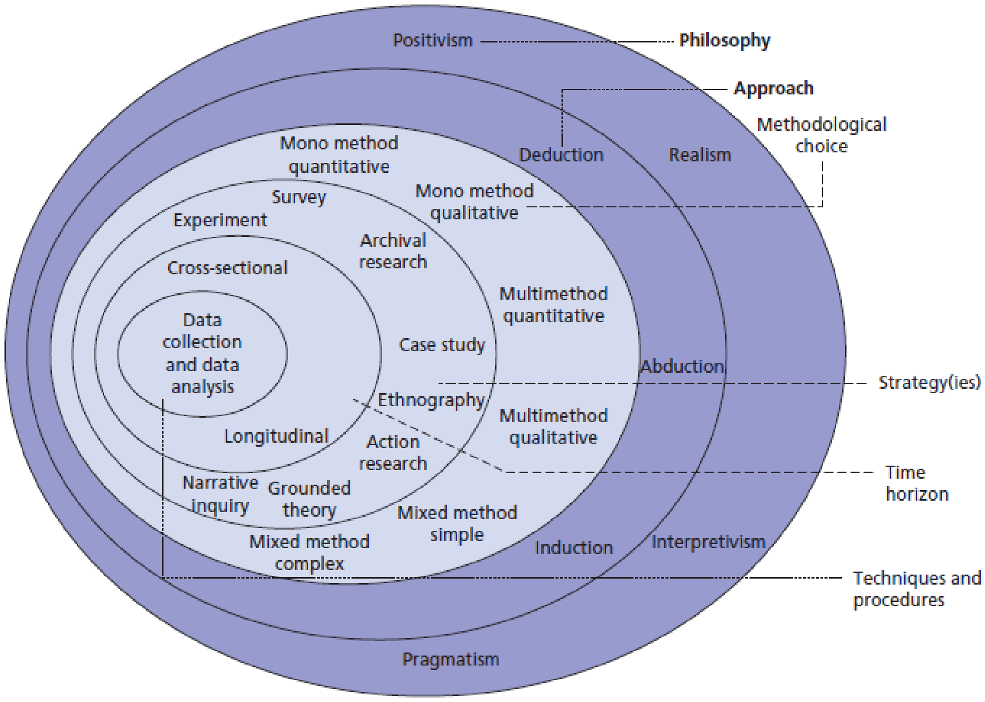

Figure 1: The research process [283] (reprinted with permission- Pearsons Education Ltd.)

3.2 Research philosophy

A research philosophy, or paradigm, may be defined as the "basic belief system or world view that guides the investigation" [284]. The choice of research philosophy justifies the research process [285] and is influenced by the type of knowledge being evaluated [286]. As such, one philosophy is not necessarily superior to another or applicable to all contexts [287]. Research philosophy embraces the concepts of ontology, epistemology and axiology, thus forming further layers within the metaphorical "research onion" [283]. Ontology outlines the nature of the reality shaping the area of inquiry [288]. It seeks to investigate whether information truly exists or is a product of the mind (i.e. realism or idealism) [284]. Epistemology is the basis of how knowledge is derived, recognised and acknowledged [289]. Axiology refers to the value judgement placed on knowledge by the researcher [290].

The ontology, epistemology and methodology of three common research paradigms- positivism, interpretivism, and pragmatism, are explained in Table 1 [291]. Positivism permits a single reality external to the issue being investigated (i.e. value-neutral) [284]. It derives objective knowledge and is often applied to quantitative research methods, such as surveys and experiments [292]. Interpretivism, or social constructionism, allows multiple constructed realities where meaning is created by the individual and understood through perceived knowledge (i.e. value-laden) [284]. It forms the basis of many qualitative research methods, including focus group research [292]. Finally, pragmatism has its foundations in practical and applied philosophy, is driven by what is appropriate to research rationale, and is heavily influenced by individual, social and cultural factors [293, 294]. As such, it may encompass both quantitative and qualitative methods within different phases of the research process [294, 295].

The objectives of this research thesis, as outlined in chapter one, fit well within the framework of pragmatism. The pragmatic approach provides epistemological reasoning behind integrating different sources of knowledge to find practical solutions to the problem of falls [296]. By exploring information from various sources, the researcher achieves greater insight into the challenges associated with hospital falls and how to best address them in clinical practice [297].

Pragmatism lays the foundation for generating information on the clinicians' world, including the factors that influence the acceptability and use of falls preventive tools [298]. It permits the combination of participants' perspectives and scientific evidence to provide subjective and objective evidence on the acceptability, usability, accuracy and efficacy of the proposed intervention [299, 300]. By collaboratively involving clinicians, knowledge can be generated based on reality and human experience [301]. This continuous acquisition of knowledge allows ongoing improvement of clinical practice [297, 302, 303]. Moreover, the pragmatic approach benefits practical problem solving as people are more likely to act on collective, democratic decisions rather than those made without their involvement [304]

The limitations of the pragmatic philosophy may include potential ambiguity in defining which solutions are useful or practical, promoting incremental rather than revolutionary societal changes, and failing to address philosophical disputes [301]. These considerations do not detract from research findings within this thesis, as study results are strengthened by the procedures to promote comprehensive, reliable information, as outlined in the rest of this chapter.

Table 1: The ontology, epistemology and methodology of three common research paradigms- positivism, interpretivism, and pragmatism [291, 305, 306]

	Positivism	Interpretivism	Pragmatism
Ontology			
Nature of the world	Direct access to real world.	No direct access to real world.	Reality is constantly renegotiated, debated and interpreted in view of its usefulness in new situations.
Reality	Reality is real and able to be understood.	No single external reality.	
Epistemology			
“Grounds” of knowledge	Hard, secure, objective knowledge.	“Perceived” knowledge.	Practical, applied knowledge.
Relationship between reality and research	Research focuses on generalization and abstraction. Governed by hypotheses and theories.	Research focuses on the specific and concrete. Understanding of specific context.	Research focuses on solving problems. Change is the underlying aim.
Methodology			
Focus of research	Testing theories and verifying hypotheses. Detached, external observer. Aim to discover external reality.	Seeking to obtain understanding and interpretation. Hermeneutical/dialectical: researcher as participant in what they are studying.	Applied, practical understanding of the issue under inquiry.

	Rational, consistent, logical approach. Clear distinction between facts and value judgements. Distinction between science and personal experience.	Feeling and reason govern actions. Partially create what is studied, the meaning of phenomena. Use of pre-understanding is important. Distinction between facts and value judgements less clear. Influence of both science and personal experience.	
Research techniques	Predominately quantitative methods. Experimental research Survey research	Predominately qualitative methods. Action research. Focus group research.	Best method is the one that solves problems. Mixed-methods. Action research.

3.2 Research approach

Inductive, deductive and abductive reasoning represent three common approaches to research (Table 2). The inductive approach generates knowledge in the absence of existing information, by gathering specific then general data [289]. It has its foundations in interpretivism and is often used in qualitative research [289]. By contrast, the deductive approach seeks to develop a hypothesis (or hypotheses) based on existing theory, and designs a research strategy to test that hypothesis [307]. It generates general then specific information [308], is based on the philosophy of positivism, and hence often applied to quantitative research [309]. While abductive reasoning generates and tests hypotheses on a practical problem or "surprising facts", by identifying phenomena, inferring causation, investigating through deduction, and verifying via induction [310-312]. Abductive reasoning combines different layers of information to gain new insights, discover meaningful patterns, enhance objective knowledge [310, 313, 314].

Existing literature on heath technology use within falls prevention is relatively sparse [230], hence the inductive approach was applied to elicit new information on this issue. Inductive reasoning used participants' perspectives to "build broader themes" [315], so that the researcher could use observations to describe a picture of the phenomenon being studied [316]. The inductive approach was primarily applied to qualitative research, which collected and summarized information using narrative or verbal means, observations, interviews and analysis of documents [316]. This approach was used within this thesis to evaluate the acceptability, usability and efficacy of the proposed falls preventive health technology tool.

Table 2: Research approach- deductive, inductive and abductive reasoning [317, 318]

	Deduction	Induction	Abduction
Logic	When premises are true, the conclusion must also be true.	Known premises generate untested conclusions.	Known premises generate testable conclusions.
Theory	Theory falsification or verification.	Theory generation and building.	Theory generation or modification.
Data collection	Generate information from general to specific. Evaluate hypotheses related to existing theory.	Generate information from specific to general. Explore phenomena, identify themes, and create a conceptual framework.	Generate information from interactions between general to specific. Explore phenomena, identify themes, and test these within a conceptual framework.

3.3 Research choice

The strengths of mixed-methods research have seen its increasing use in health sciences [319, 320], and its application to address this study's aims. Mixed-methods research refers to the collection, analysis and integration of qualitative and quantitative data in a single or series of studies, in order to investigate the same phenomenon [321-323]. Although there has been some debate as to which research philosophy is most relevant to mixed-methods research, the pragmatic approach lends itself to deriving knowledge from quantitative and qualitative inquiry of reality and the human experience [301]. Through hypothesis testing and empirical reasoning, pragmatism generates information about practical outcomes [324], and prompts further action to address real-world phenomena [301] so that meaning is intertwined with consequences" [325].

Mixed-methods research uses induction (in discovering patterns), deduction (in testing hypotheses and theories), and abduction (in understanding reasons behind study results) to generate knowledge [324].The advantage of this research choice lies in combining qualitative and quantitative approaches across data collection, analysis and interpretation procedures, so as to enhance shared strengths and minimise individual weaknesses [322, 326]. Quantitative data can explain qualitative findings, while qualitative inquiry can generate hypotheses for quantitative testing or inform development of quantitative instruments [327]. This results in deeper, more comprehensive awareness about complex phenomena, and wider application of research findings [296, 321, 322, 328]. This is perceived as superior to multi-method research, which only collects data using two methods from the same paradigm (e.g. interviews and focus groups) [329], and mono-method studies, which may miss insights due to single method inquiry [301]. Thus mixed-methods research increases generalisability of results, produces more complete knowledge, and provides stronger evidence for research conclusions [301].

Quantitative research focuses on evaluating hypotheses through deductive reasoning, using standardised data collection and statistical analysis procedures [301]. This assists in generating robust and rigorous data, provides results relatively independent of the researcher, improves credibility of research findings in some settings, and is more efficient in data collection and analysis procedures compared to qualitative research [301]. However, potential limitations of quantitative research are that phenomena may be missed due to a focus on hypothesis testing, researcher's theories may not align with local understanding, and knowledge produced may be too abstract and general for specific situations [301].

In contrast, qualitative research enhances the richness of information gained within mixed-methods design, provides research flexibility, and attains understanding of dynamic processes and the socio-cultural context of participants' experiences [301, 330, 331]. Within this study, qualitative information was used to support tool development, gain understanding of the factors influencing study outcomes, and explain results at study completion [332, 333]. However, the limitations of qualitative approach are potentially lower credibility and generalisability of research findings, greater difficulty testing hypotheses and theories, and requiring more time for data collection and analysis procedures [301].

In mixed-methods research, qualitative and quantitative data collection can occur in parallel or sequential phases [293]. This research study utilised convergent design to allow for simultaneous gathering and integrated analysis of quantitative and qualitative data [322, 334], thereby shortening the duration of data collection, but requiring more resources compared to sequential design [329, 334]. The advantage of integrated analysis was that data could "produce a whole… greater than the sum of the individual qualitative and quantitative parts" [335], which greatly enhanced the overall value of mixed methods research [321]. This differed to "mixing" quantitative and qualitative data by connection, where one approach was built upon the findings of another [334]; or embedding, where one type of data was analysed within the confines of another, usually as a qualitative component within a larger quantitative study [334].

The research findings within this thesis were presented using narrative integration, so that qualitative and quantitative findings were written as an interwoven series of chapters, each focusing on a particular aspect of the research question [328]. This allowed thematic connections to made using qualitative and quantitative data [301]. This form of reporting differed to the contiguous approach of describing quantitative and qualitative findings in different sections of the same report; and the staged approach of describing, analysing and publishing study results separately (usually in the context of multi-staged studies) [336, 337].

3.4 Research strategy

3.4.1 Background of action research

Action research methodology has increasing been used in healthcare research [338], and perceived as "the most viable process for the production of knowledge" [339]. Action research has developed from a variety of theoretical backgrounds [340], including action learning and critical social theories [341, 342]. Buckingham (1926) described a similar methodology in the text “Research for Teachers”. This was followed by John Dewey (1926), who pioneered the process of “self-reflective inquiry” to encourage participants to critique and seek to improve their own performances [341, 343], act on derived strategies, and improve knowledge and outcomes for themselves and others [342, 344-349], all within a supportive environment where participants are free and empowered to improve their practice [343]. This approach was practice-based, utilised scientifically tested methods, and was widely used to promote educational improvement in the 1940’s [350, 351].

Subsequent to Dewey, John Collier (1945) described a series of "interconnected research-action-research-action" activities [352] that were prominent in the areas of education and psychology in the early 1950’s [353]. Stephen Corey (1953) outlined a collaborative process between researchers and practitioners to improve study outcomes, increase likelihood of practice change, and enhance practices within the field of education [350]. Both men spearheaded the action research movement in the American post-World War II period [354]. However action research was abandoned by the 1950’s and 1960’s when teachers expressed difficulties collecting research data and meeting research publication standards [355].

The “founding father” of action research- Kurt Lewin (1946), came to the forefront following these other contributors. Lewin saw action research as a means of empowering group members to conduct research, evaluate findings, and collectively seek to improve social conditions [304, 356]. This approach encompasses critical social theory, where common interests and experiences drive collaborative inquiry, analysis and action to achieve social integration and reform [341, 342, 357-359]. Both critical social theory and the Lewinian model led to the conceptualisation of “action research as problem solving” [357, 358]. This concept is useful in addressing practical concerns [360], attaining scientific knowledge, promoting individual and organizational change [357], and increasing self-help competencies of group members facing a problem [356, 361]. “Action research as problem-solving” was utilised within this research thesis to address clinicians’ concerns by generating knowledge on a hospital falls preventive tool to action practice change.

In contrast, action research as “emancipatory self-reflective inquiry” allows participants to be free and enabled to improve outcomes for themselves and others affected by their practice [342, 344-349]. Ideally, this should occur within a supportive, open setting to identify issues, develop and translate plans into action, monitor consequences, obtain feedback, and share insights and outcomes [343]. The third conceptualisation of “action research as political praxis” allows marginalised and oppressed groups to be empowered to produce and act on knowledge, in order to improve their socioeconomic, educational, and political circumstances [362, 363]. This can occur through collective research, where systematic participation and dialogue are used to gain knowledge; critical recovery of history, where the past informs current struggles; evaluation and application of folk culture; and production and dissemination of new knowledge using visual, oral and written means [364, 365].

3.4.2 The cyclical process of action research

Lewin explained action research as " a spiral of steps, each composed of planning, action and evaluation of the result of action" [304]. This process of “cyclical fact-finding, action and evaluation” allows each phase to inform the other [349, 366, 367], ultimately with the goal of solving problems and continuously improving knowledge and practice [304, 360]. Carr and Kemmis (1986) described the action research as a four phase cycle of planning, acting, observing, and reflecting [341]. Susman and Evered (1978) expanded this to a five-phase cycle incorporating: a) diagnosis, where the problem is identified; b) action planning, where strategy is decided based on diagnosis; c) implementation, where action is undertaken; d) evaluation, where actions and consequences are assessed; and e) learning and refinement, where outcomes are interpreted and recorded to aid improvement (Figure 2) [356]. The later model (1983) added an initial phase of reconnaissance to describe the socio-cultural context of the study for the reader [341].

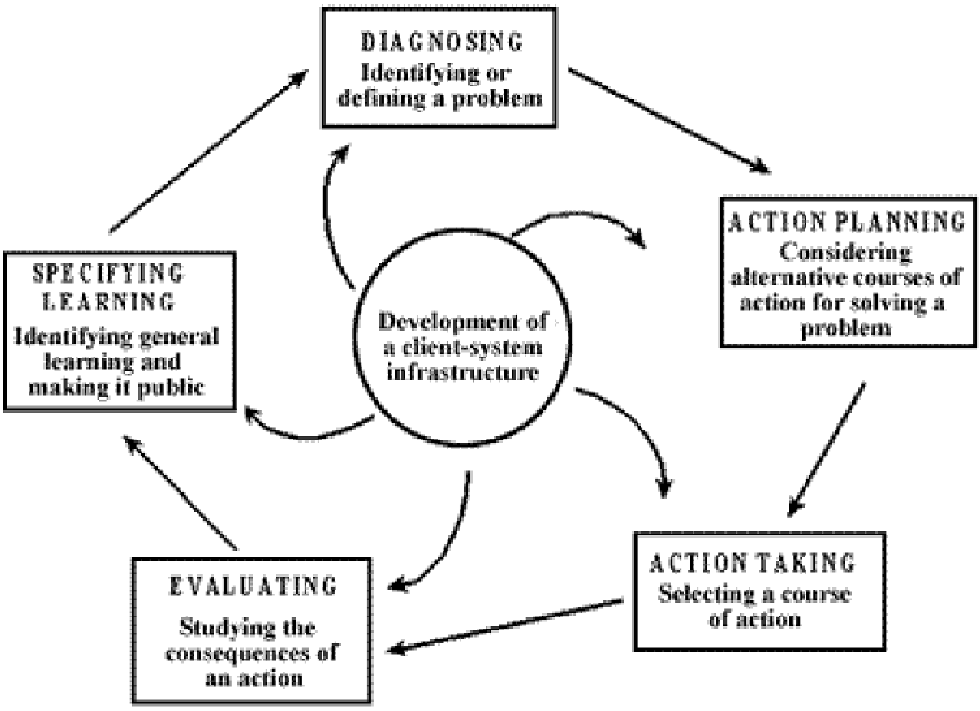

Figure 2: Action research model (Susman and Evered 1978) [356] (reprinted with permission- Sage Publications Inc., Journals)

The thematic concern for this research study was described later in this chapter. The diagnosis and action planning phases are initiated through preliminary inquiry into clinicians' concerns about hospital falls and falls preventive measures, with subsequent design of the intervention tool. This information is solidified in focus group discussion prior to tool implementation, followed by evaluation of study outcomes, and refinement of the intervention tool.

Participatory action research, as described by Pearson (1982) [368], refers to the democratic evaluation of participants' perspectives to resolve a problem [349] and promote social and political change [340]. Participation facilitates learning through shared experience, knowledge and ideas [369]. Each participant can act as a collaborator or facilitator to empower others to work towards that change [368]. The researcher's task is to accurately reflect this mutual and dynamic process [330, 370]. Participatory action research is applied within this study so that the researcher and clinicians can collectively characterise the problem of hospital falls, plan and take appropriate action, evaluate study findings, and refine falls preventive strategies within the hospital [356]. Throughout the research process, the researcher becomes a familiar presence on the hospital wards and works collaboratively with hospital clinicians towards the collective goal of reducing inpatient falls.

3.4.3 The strengths and application of action research

Action research methodology has increasingly been utilised in healthcare research [338]. Its application within this study provided flexibility in combining quantitative and qualitative inquiry to improve to the validity and richness of information gathered [371]. Action research allows the researcher and clinicians to work cooperatively to address areas of concern, reflect on practice, generate knowledge, take ownership of research processes, and gain the skills and confidence to change workplace routines [338, 342, 349, 367, 372-376].

Another advantage of action research is having research process and problem solving occur in real-life settings [331, 377]. This assists in overcoming research-practice gaps and contributes to increased applicability of research findings [369]. In this manner, the pragmatic nature of action research differs to the positivist approach, where data is systematically collected and hypotheses are tested within a controlled environment [349, 378]. Having a pragmatic approach benefits practical problem solving as people are more likely to act upon decisions made democratically as a group rather than those made without their involvement [304]. Within this study, having research occur on hospital wards and engaging clinicians directly involved in tool implementation, helps to support ongoing acceptance and sustainability of tool use. Furthermore, the action research process allows study findings to automatically be integrated into clinical practice, a benefit not always realized by other research methods [367, 379].

Participatory action research involves the researcher being an active “insider” within the research process, and “researching with” rather than “researching on” study participants, as compared to an “outsider” remaining external to their world [380, 381]. This improves the strengths of the research process, enhances understanding of issues, builds rapport and credibility with participants, addresses barriers to change, and increases the likelihood of sustaining that change [342, 371, 376, 382, 383].

3.4.4 Limitations of action research

The potential weaknesses of action research methodology must be acknowledged. The researcher-participant relationship requires time and effort, may be dominated by more powerful participants, and negatively impacted if changes are not made [371, 383, 384]. Key persons can present obstacles by not engaging in the research process, introducing their own agenda to manipulate outcomes, overpowering research discussion, and actively resisting change [369, 371, 384]. Having the researcher as an insider presents limitations when other commitments conflict with their research role, or potential bias when the researcher is too close to the subject matter [369, 371]. Furthermore, the insider researcher may not have access to sensitive or confidential information, potentially experience threats from other associations, or be in a dependent relationship with participants and vice-versa [371].

Action research can be resource-intensive and require time, staff and materials, with time often being the most critical factor [371, 384]. By focusing on the real-world, action research may produce conflict and tension on addressing complex issues, disrupt existing relationships, not meet expectations, target issues with low priority, and favour practice over theory development [371]. In addition, the action research process requires time for study, reflection and analysis, and participants may be taken away from their everyday clinical practice [371].

3.4.5 Thematic concern

Within this thesis, the thematic concern was the growing problem of hospital falls and their associated impact on the individual and healthcare system [57, 60, 63, 64, 76, 77, 92]. This issue was discussed in detail in the introductory chapter of this thesis. The rise in inpatient falls has partly arisen from the increasing incidence of older persons [57], chronic diseases [120, 125] and cognitive impairment [52] within the population. This has highlighted the importance of targeting hospital falls prevention for many local and international organizations [201, 225]. Despite the emphasis on falls prevention, the rate of hospital falls in Australia continues to rise [91].

Many hospitals have implemented falls risk assessment tools within their best practice programs [234]. However, to date, there has been inconsistent systematic review and meta-analysis evidence for their accuracy and reliability in identifying and rectifying high falls-risk [196-200]. Many of these tools have not been validated in more than one clinical setting [196], and randomised controlled trials have demonstrated mixed outcomes for their efficacy in reducing hospital falls rates [76, 202-204]. These factors have led to several Australian and international guidelines recommending against their routine use in falls preventive programs [201, 209, 225].

Furthermore, once individuals are identified as high-falls risk, there is lack of data supporting the effectiveness of single-component interventions [179, 229, 233, 234]. The literature review in chapter two outlined that inconsistent outcomes have been reported for exercise, patient education, vitamin D and calcium supplements, physical restraints, side-rails, and flooring types [229, 234].

Health technology has the potential to fill this gap by delivering useful falls preventive strategies. There has been support for the application of health technology measures to assist clinician decision-making, collaborate between clinicians and patients, access and store data, and reduce paperwork and staffing costs [385]. However, the literature review in Chapter Two highlighted that practical implementation of health technology measures has so far been limited by the lack of evidence on their acceptability, usability, and efficacy in falls prevention [230]. Thus, there is the need to develop, evaluate and confirm acceptable, effective health technology tools for falls risk screening and prevention. Chapter Four of this thesis presents a published integrative review on staff acceptability and efficacy of health technology measures in falls prevention. While Chapters Five and Six report on research evaluating clinicians' perspectives towards the HIT tool, its clinical use and efficacy in preventing hospital falls.

3.4.6 Development of the health information technology tool

This gap in literature prompted the research goal of collaborating with clinicians to develop and refine the HIT tool for hospital falls prevention. Locally within the Geriatric and Evaluation (GEM) unit at the Queen Elizabeth Hospital (TQEH), this study concept arose after a preliminary audit demonstrated just 20% staff compliance with existing bedside posters depicting patients' falls risk (Figure 3) [386]. Nursing staff reported these visual cues were time-consuming to use, as they involved placing adhesive coloured dots on eight different sections of a paper-based poster to indicate falls risk for different clinical scenarios (i.e. green for low risk, yellow for medium risk, red for high risk) [386]. Clinicians displayed these posters by each patient's bedside, and as the whole process was a tedious one, these paper-based visual cues were not being used [386].

Mindful of the poor uptake of paper posters and with the state-wide electronic health record (EHR) system due to roll out across public hospitals in South Australia, the opportunity was seized to develop the HIT tool in collaboration with GEM clinicians to address inpatients' falls risks. The HIT visual cue was designed to be a simple display of those icons relevant to individual falls risk factors, as opposed to the cluttered design of the original paper posters requiring clinicians to select from all possible falls risk factors. The HIT tool falls risk factors were chosen based on literature review findings of thirteen common falls risk activities during the day and night-time [69].

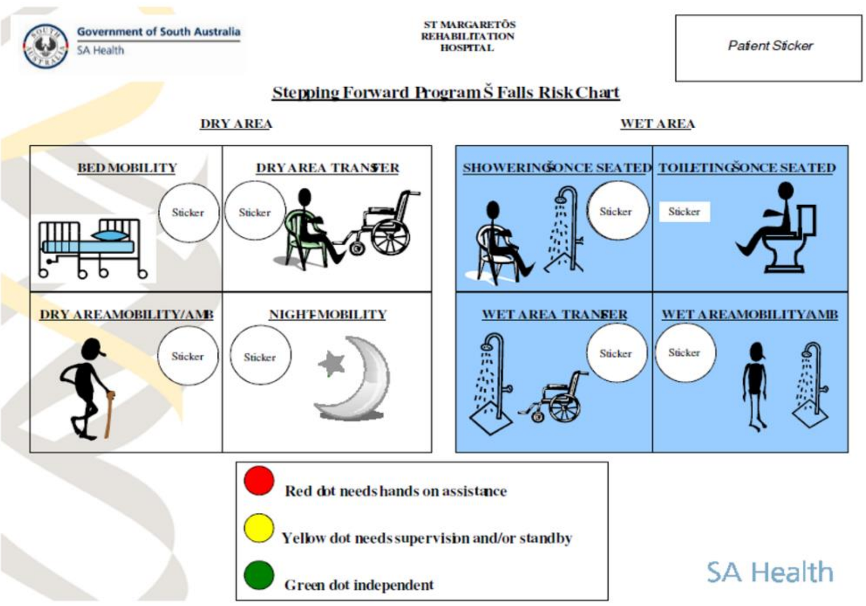

Figure 3: Example of a paper-based bedside poster using coloured stick-on dots to indicate patient's falls risk

The clinician responsible for HIT tool use carried and directly entered information into an iPad™ device. Data was recorded on patients' details (name, age, bed location, mobility aid use). The clinician also recorded their own judgement (yes/no responses) for day and night-time falls risk for each patient for thirteen movement and location types (Figure 4). Black-and-white A4-sized visual cues were automatically printed at the completion of the HIT assessment (Figure 5). The same clinician was responsible for displaying these visual cues by the patient's bedside, with the eventual aim of incorporating them into EHR. HIT scores were taken as the total number of falls-risk items selected, where scores of 8 and above were arbitrarily deemed as high falls risk. Ward staff subsequently targeted their falls preventive interventions according to their own clinical judgment. There was no automatic trigger for staff to use the HIT tool, and the tool itself took less than five minutes to administer for each patient.

Preliminary staff surveys demonstrated the majority of clinicians perceived the HIT tool as being beneficial in improving quality of patient care, and were willing to integrate it into daily practice [386]. However, further evaluation of staff's attitudes and efficacy were required before the HIT tool could be more widely implemented.

In addition, it was important to compare the HIT tool to existing fall risk assessment instruments. The Falls Risk for Older Persons (FROP) screening tool (Appendix 8) represented standard falls risk screening within TQEH. The FROP is an abbreviated 3-item version of the Falls Risk for Older Persons in the Community (FROP-Com) assessment tool, the latter of which has been validated for falls risk assessment among community-dwellers aged 65 years and above presenting to the emergency department (sensitivity 71.3%, specificity 56.1%) [387]. The FROP assesses the domains falls history, balance and function, with one point per positive response to a falls risk item. FROP scores of four and greater (out of a total possible 9) signify high falls risk and trigger staff action for supervision, specialised equipment, ensuring call bell within reach, and discussing falls prevention plans with patients and carers [388]. However, this cut-off of four points for FROP scores has been shown to have low sensitivity (0.158), albeit high specificity (0.956), for predicting falls [389]. Thus, there is the need to ensure that any falls risk screening tool implemented in clinical routine must be accurate and reliable in detecting and addressing falls risk.

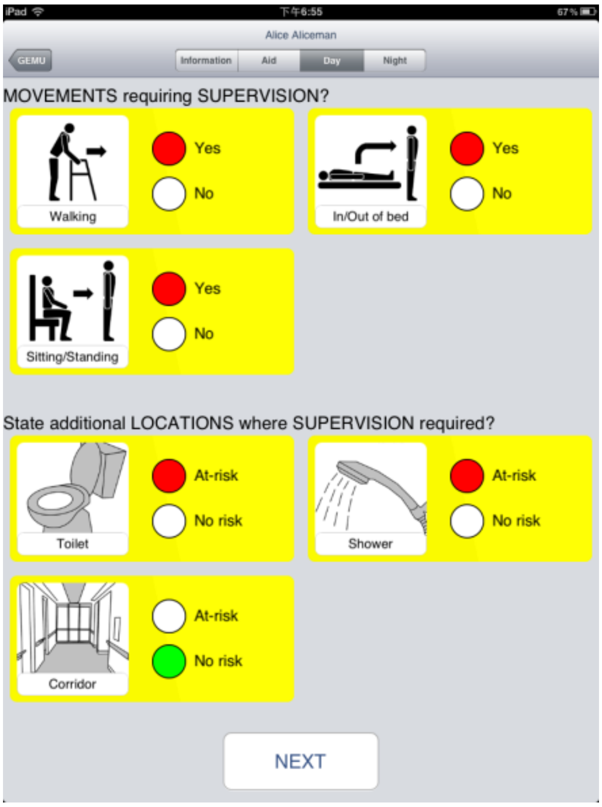

Figure 4: Example of a screenshot of direct clinician entry of patient's falls risk assessment using the Health Information Technology tool

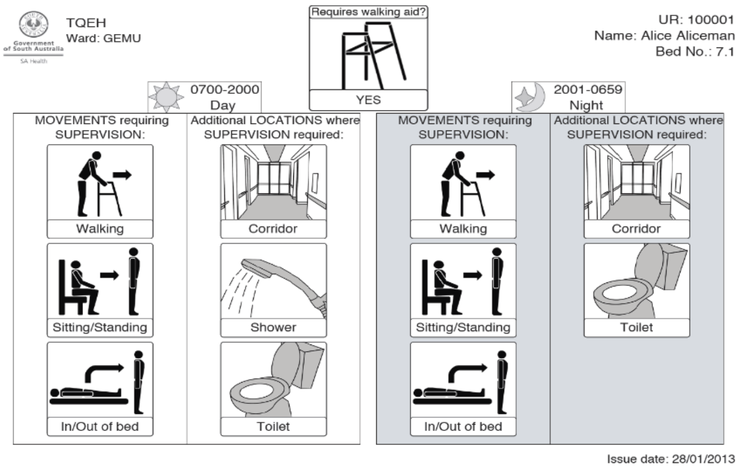

Figure 5: Example of an automatically generated visual cue from the Health Information Technology tool

3.5 Time horizon

The implementation of the HIT tool was conducted over consecutive twelve-week periods on the GEM unit (June to August 2014) and Acute Medical Unit (AMU, September to November 2014) at TQEH (Figure 6). Tool implementation occurred over consecutive, instead of concurrent, periods to allow for potential refinement of the research process from GEM to AMU. Our study took cross-sectional snapshots of HIT tool use across this time frame, to capture pre, during, and post-implementation phases. Cross-sectional studies report frequencies in a defined population (sample) at a specific instance of time, so as to evaluate exposures and outcomes in a relatively resource-efficient manner [390]. However, this process is limited in its ability to investigate aetiology or rare exposures and events [390]. The benefit then of repeating cross-sectional studies within a longitudinal framework, is to allow relationships between specific exposures and events to be explored, either prospectively or retrospectively, over a longer period of time [391]. This may involve the majority of or all participants being different at each of the different phases [391].

The potential restrictions of longitudinal design are incomplete follow up of participants- a factor discussed later in this chapter, false negatives if data is underutilised, difficulty separating the reciprocal impact of exposure and outcome, and increased resource demands [391, 392]. Therefore, it is crucial that data collection methods remain standardised across time and sites, participants be provided with regular training and communication, and participant engagement maintained throughout the research process [393, 394].

Phase 1: Pre-trial Aim: To elicit clinicians' perspectives of the concept and design of the HIT tool prior to tool trial – i.e. tool experience, positive/negative aspects, barriers to use, recommendations for improvement	
Focus Group (5 senior ward staff) Facilitated discussion with researcher and staff. Transcribed verbatim using written notes and Dictaphone recordings. Time frame: March 2014 (1-hour session).	**Survey** (29 AMU & 20 GEM staff) Likert scale & short response questions derived from focus group sessions. Non-identifiable surveys returned to designated ward tray. Time frame: March 2014 (2-week period) in GEM, August 2014 (2-week period) in AMU.

Phase 2: Trial of HIT tool Aim: To implement the HIT tool on two medical wards (ward-directed process)	
GEM Unit HIT tool performed for new admissions & altered falls risk by three RNs. iPad™ carried by one RN/CNC who entered information about patient age, bed number, mobility aids, day/ night falls risk for different movements/locations; and was responsible for bedside visual cue display. Time frame: June to Aug 2014. Weeks 1-6: researcher supported process (tool education & reminders). Weeks 7-12: ward independent in tool process.	**AMU** HIT tool performed daily on all ward patients by any RN. iPad™ carried by one RN/CNC who entered information about patient age, bed number, mobility aids, day/night falls risk for different movements/locations; and was responsible for bedside visual cue display. Time frame: Sept to Nov 2014. Weeks 1-6: staff requested researcher support (tool education & reminders) on Day 1. Weeks 7-12: ward independent in tool process.

Phase 3: Post-trial Aim: To elicit clinicians' perspectives of HIT tool after tool trial	
Focus Group (5 AMU staff – 4 staff different to Phase 1)	**Survey** (8 GEM, 20 AMU staff- 17 non-users, 11 users of HIT tool; not recorded which staff also responded in Phase 1)

Method the same as in Phase 1. Time frame: Dec 2014 (1-hour session).	Method the same as in Phase 1. Time frame: Sept 2014 (2 weeks) in GEM, Dec 2014 (2 weeks) in AMU.

Analysis	
Qualitative Aim: To perform content analysis of textual data from focus group sessions and survey short responses.	**Quantitative** Aim: To perform descriptive statistics and significance testing, using paired t-tests ($p<0.05$), of survey data.

Data Synthesis

Aim: To integrate quantitative & qualitative analyses to elicit clinicians' perspectives of HIT tool.

HIT Tool Refinement

Aim: To improve HIT tool according to clinician's recommendations for future clinical retrial.

(HIT- health information technology, AMU- acute medical unit, GEM- geriatric evaluation and management, RNs- registered nurses, CNC- clinical nurse consultant)

Figure 6: Research methodology study design

3.5.1 Study setting

The study was conducted on GEM and AMU, two ground floor medical wards at TQEH, a tertiary teaching hospital in metropolitan Adelaide, South Australia. The 20-bed GEM unit (10 single rooms, 3 double rooms and 1 four bedded bay) is a higher acuity sub-acute unit providing rehabilitative care to restore function and independence in predominately older patients. While the 16-bed AMU manages patients in the initial phase of illness, and sends many of its frailer patients for ongoing subacute management on the GEM unit.

3.5.2 Study participants

Staff's attitudes on the HIT tool were derived from clinicians working within the AMU, GEM, or Central Adelaide Local Health Network (CALHN) Falls Prevention group at the time of the study. Clinician composition on the wards included clinical nurse consultants (CNCs: 1 per ward), registered nurses (RNs: 38.68 full-time equivalent [FTE] AMU, FTE AMU), junior doctors (4 FTE GEM, 5 FTE AMU), occupational and physical therapists (2.5 FTE GEM, 2 FTE AMU), and other staff (e.g. maintenance). CNCs refer to those nursing staff in leadership position and considered experts in clinical nursing care [395]. No pharmacists, speech therapists, dieticians, social workers or senior medical staff were approached to be part of this study due to their lack of active involvement in day-to-day hospital falls prevention.

Clinicians were divided into focus group and survey participants (Figure 6). Focus group participants were identified by ward CNCs as those senior clinicians (with more than five years of clinical experience) having an interest and expertise in falls prevention. They were approached by verbal and written invitation from the researcher (Appendix 2).

Pre-trial, there were five clinicians involved in the focus group (two CNCs and two physiotherapists from AMU and GEM, and one CALHN representative). Post-trial, there were five clinicians involved (one CNC and four RNs, all from AMU). One clinician had also participated in pre-trial discussion. Post-trial, all focus group participants had used the HIT tool during the trial (defined as tool users). Six clinicians declined to participate in post-trial focus group discussion as they had not used the HIT tool (defined as tool non-users) or were unable to attend the focus group session.

Survey participants were medical, nursing, allied health and other staff working on GEM and AMU at the time of the study (Figure 6). Potential participants were approached by verbal and written invitation from the principal investigator (Appendices 5 and 6). Pre-trial, there were 49 clinicians [29 GEM (four medical, twenty-one nursing, one allied health, three other); 20 AMU (sixteen nursing, four other)] involved. Post-trial, there were 28 clinicians involved (twenty GEM, eight AMU; all RNs). Post-trial, eleven survey participants had used and seventeen had not used the HIT tool. Both tool users and non-users were included for true representation of HIT tool uptake. It was not recorded which participants were involved both pre- and post-trial. Post-trial, 54 clinicians declined to participate as they had not used the HIT tool or stated they could not provide recommendations for its improvement.

Patient data was collected from all those admitted to GEM and AMU wards during the trial period. There were no patients excluded from the data collection and analysis. For the purposes of this research, where a patient was admitted to AMU prior to GEM, only the GEM admission information was recorded and utilised.

3.6 Research techniques and procedures

This section provides a description and rationale behind the research methods used within this thesis, including data collection using focus group, survey and quantitative research; and data analysis content analysis for qualitative data, and statistical analysis for quantitative data. The strengths of the research are discussed, highlighting the benefits of gathering qualitative and quantitative information, and utilising collaborative problem-solving to address the problem of falls. The steps taken to facilitate validity and comprehensiveness of data collection and analysis are described, alongside the potential limitations of study methods, including the challenges of participant retention and potential research biases.

3.6.1 Data collection

3.6.1.1 Ethical considerations

The protocol for the research study was approved by the Human Research Ethics Committees of The Queen Elizabeth Hospital/Lyell McEwin Hospital/Modbury Hospital, Adelaide, Australia (protocol number 2013066, Appendix 1). Each participant was provided with verbal and written information on the study, and supplied written consent prior to commencement of the first study day (Appendices 2, 3 and 4). Participants were free to withdraw from the study at any stage. Participants' details were kept confidential and all material de-identified.

Data was collected and stored in accordance with the regulations of the National Health and Medical Research Council Australian Code for the Responsible Conduct of Research and the University of Adelaide. The data was de-identified by the principal investigator so that each participant was given a unique identification code according to ward and participant number. Only the principal investigator and their nominated supervisors had access to the participant names in relation to the codes used. Paper-based data was stored in a locked filing cabinet at the Geriatric Training and Research in Aged Care centre at Paradise, South Australia (a spoke service of the Aged & Extended Care Services, at the Queen Elizabeth Hospital, South Australia). Electronic data was stored on a password-protected spreadsheet. Following completion of the study, the data was transferred to the Aged & Extended Care Services, the Queen Elizabeth Hospital, South Australia where it will be stored for a minimum of five years before being securely destroyed.

Funding for the development of the HIT tool was attained as a grant to Dr. Damith Ranasinghe, at the University of Adelaide. It was intentioned that study findings would inform the ongoing refinement of the HIT tool, which was aimed to be incorporated into EHR and a newly developed movement sensor system. Funding for a clinical trial of the novel movement sensor system was received after the completion of this research, as a grant from the National Health and Medical Research Council to Dr. Damith Ranasinghe.

3.6.1.2 Study protocol

The study was divided into Phase One (pre-trial), evaluating clinicians' perspectives prior to implementation of the HIT tool; Phase Two (tool trial), informing how the HIT tool was used in every day practice; and Phase Three (post-trial), investigating clinicians' perspectives and use of the HIT tool after the trial phase had finished (Figure 6).

Phase One (pre-trial) involved the diagnosis of the problem under investigation through inquiry as to clinicians' perspectives on hospital falls and the perceived role of the HIT tool, two weeks prior to its implementation on the ward. This was achieved using focus group discussion to collect qualitative data and survey distribution to collect quantitative data. Further details on focus group and survey methods are outlined under the ensuing section on "Data Collection".

Phase Two (tool trial) involved implementation of the HIT tool over consecutive twelve-week periods on the GEM unit (June to August 2014) and AMU (September to November 2014). Information on tool use and patient details were recorded, as explained in detail in the ensuing sections on "patient details" and "score details". Implementing the HIT tool over consecutive, instead of concurrent, time periods in the two wards allowed potential refinement of the research process. However, there was no change in the research procedure from GEM to AMU. Clinicians had up to six weeks of researcher support and education on HIT tool use, and were independent in tool use for the remaining six weeks. GEM staff took full advantage of the researcher-led training period (three hour-long sessions each week for six weeks), whilst AMU staff declined training after a day due to staff confidence in using the tool. FROP screening continued as standard procedure throughout the study period.

Phase Three (post-trial) re-evaluated clinicians' perspectives and use of the HIT tool two weeks after completion of phase two, to allow for comparison of pre- and post-trial attitudes and tool use. Focus group and survey research were used with similar themes as in phase one, along with recording of patient details and HIT tool use. The recommendations for tool improvement were incorporated in its subsequent refinement (Figure 7), in keeping with the goals and processes of action research methodology.

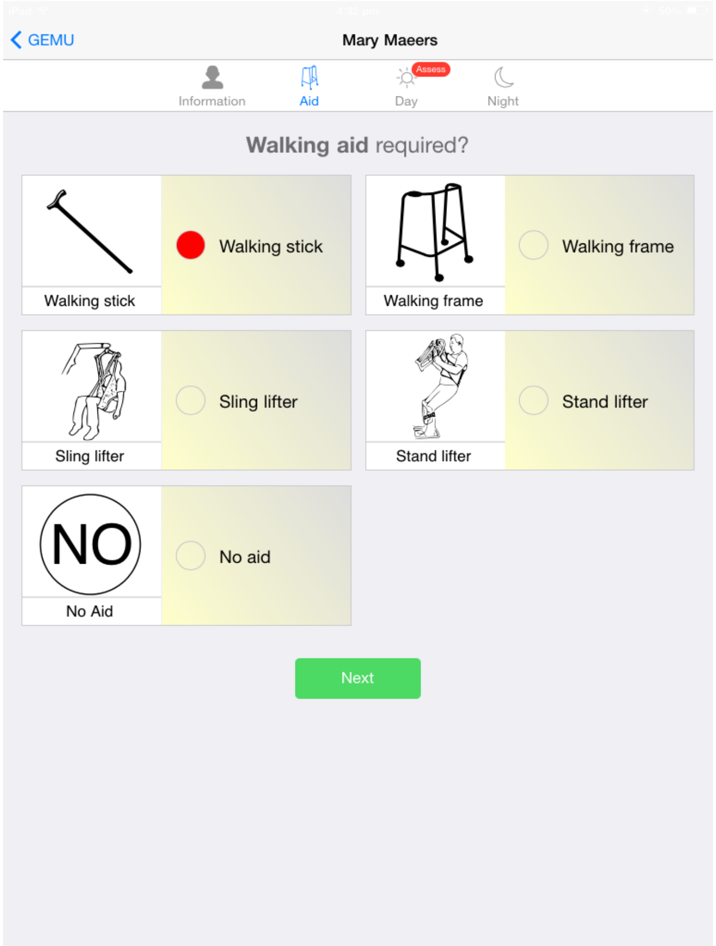

Figure 7: Example of a screenshot of direct clinician entry of patient's falls risk assessment using the refined Health Information Technology tool

3.6.1.3 Focus group research

Focus group research was the action research tool selected to collect and action qualitative information on clinicians' attitudes towards hospital falls preventive interventions. It provided "a way of collecting qualitative data, which – essentially – involves engaging a small number of people in an informal group discussion (or discussions), 'focused' around a particular set of issues" [396]. A detailed explanation of focus group findings is reported in chapter five of this thesis, outlining clinicians' perspectives towards the HIT tool.

Focus groups can be less threatening to many participants compared to individual interviews, and often facilitate active discussion of thoughts, ideas and perspectives [397]. The benefits of using focus group methods are relatively low costs, availability of candid and "piggyback' responses, and deeper exploration of the meaning behind quantitative survey data [397-399]. The potential limitations of focus group research include possible bias in participant selection, session dominance by outspoken persons, reliance on moderator's skill in facilitating discussion, and challenges in analysing large volumes of qualitative data [397-400].

Potential focus group participants were approached by verbal and written invitation from the principal investigator (Appendix 2). Those who participated in focus group discussion were asked to complete a questionnaire on their demographic details and level of clinical experience in health and aged care (Appendix 3).

Within this research study, each focus group session was conducted with five participants and the researcher and researcher's supervisor as moderators. As per typical focus groups, there were between six to twelve participants meeting in a supportive environment to simultaneously discuss a particular topic or set of issues, with a moderator (researcher) to facilitate and record discussion proceedings [396, 397]. Focus group sessions were conducted over an hour [401], or until data saturation was reached (i.e. when no new information was identified and all theory concepts were well-constructed) [330, 402]. Discussion within this study revolved around clinicians' perceptions of the HIT tool's benefits, barriers to use, and recommendations for improvement.

The researcher used open-ended questions in a semi-structured interview guide for focus group discussion (Appendix 4). The use of open-ended questioning enabled all aspects of the topic to be covered, clarifies any ambiguities, and promotes reliability of study results [342, 367, 403]. Textual data was transcribed verbatim by the researcher using Dictaphone recordings and written notes.

3.6.1.4 Survey research

Ward staff on AMU and GEM units were approached beforehand to participate in the survey by verbal and written information from the researcher (Appendices 5 and 6). Study surveys were derived following focus group discussion; and involved similar themes around clinicians' positive perceptions, negative perceptions, and suggestions for refinement of the HIT tool (Appendix 7). These surveys combined Likert-scale with the option of short answer responses. Surveys were distributed by the researcher to a consecutive sample of ward staff over the two-week periods in phases one and three, to ascertain clinicians' attitudes towards the HIT tool before and after implementation. Completed non-identifiable questionnaires were returned directly to the researcher or via a return tray in the CNCs' offices. All questionnaires were de-identified and coded with a letter and number. The findings from survey results are presented and discussed in chapter five of this thesis.

3.6.1.5 Score details

Both HIT and standard, mandatory FROP scores were recorded at admission (i.e. Day 1) for each patient on each ward. HIT tool parameters were defined as:

a) Acceptability: adherence or percentage of HIT versus FROP assessments completed over total patient number, randomly assessed once per fortnight.

b) Correlation of HIT and FROP scores: average percentage of similar falls risk factors identified on HIT visual cues (patient name, bed number, walking aid requirement, day/night supervision for movement/location types), compared to FROP screening; and correlation between HIT and FROP score values.

c) Accuracy: extent to which HIT (≥8/13) and FROP (≥4/9) scores, both classified as indicating high falls risk, detect hospital falls, as measured by sensitivity and specificity [404]

d) Clinical efficacy: comparison of hospital falls rates, recorded by hospital incident reporting systems, for the 12-week periods pre, during, and post-HIT tool trial. Hospital falls rates were defined as number of inpatient falls per 1000 occupied bed days (OBD), referring to total beds occupied multiplied by total days occupied [75]. An in-depth description and discussion of HIT and FROP score details, along with patient characteristics as described in the next chapter, are provided in chapter six outlining clinical use and efficacy of the HIT tool.

3.6.1.6 Patient characteristics

Patient characteristics were determined from usual hospital records, including clinical notes and discharge summaries. Age, gender, place of residence, requirement for walking aids, presenting problem, Charlson comorbidity index- a validated and widely used method for evaluating cumulative comorbidity impact on mortality [126], number of medications, length of stay, and falls risk screening scores, were recorded. Within this study, polypharmacy was defined as having five or more medications at presentation, as per previous literature [405].

Patient characteristics, including their falls risk screening scores, were compared between the two wards, and between those who fell (fallers) and did not fall (non-fallers) during their hospital admission. Falls incident reporting continued as standard mandatory procedure throughout the course of the study.

3.6.2 Data analysis

3.6.2.1 Qualitative analysis

Within this study, data analysis sought to capture the complexity and breadth of information gathered [284]. Participants were selected to achieve a representative sample and maximize the diversity of responses [284]. Content analysis was manually performed on qualitative data derived from focus group discussions and survey free text responses. The aim of content analysis was "to provide knowledge and understanding of the phenomenon under study" [406]. It has been variably defined as "a research technique for the objective, systematic and quantitative description of the manifest content of communication" [407], and "a research technique for making replicable and valid inferences from texts (or other meaningful matter) to the contexts of their use" [408]. Content analysis allowed the researcher to obtain information directly from participants, avoid preconceived ideas, gain new knowledge and insights, fully comprehend the problem, and have a practical guide to action [408-413]. These strengths of content analysis enhanced the investigation of clinicians' perspectives toward the HIT tool.

3.6.2.2 Quantitative analysis

Quantitative analysis allows the researcher to quantify and summarise numbers, apply mathematical processes to analyse numeric data, and express results in statistical terminologies [414]. It was used within this study to evaluate numerical data from Likert-survey responses, HIT tool use, hospital falls, HIT and FROP score details, and patient characteristics. HIT tool acceptability and usability were evaluated using "standardised measures so that the varying perspectives and experiences of people fit into a limited number of predetermined response categories to which numbers (were) assigned" [415]. Survey answers indicating "strongly agree" or "agree" were classified as positive responses, while those indicating "strongly disagree", "disagree" or "uncertain" were classified as negative responses to the question/statement.

Chi-square analysis was used to evaluate differences between pre- and post-trial attitudes, with logistic regression performed for subgroup analysis of tool users versus non-users. A logistic regression will model the chance of an outcome based on individual characteristics [416], in this case attitudes among users versus non-users of the HIT tool. Odds ratios (OR) between the two groups were compared, referring to the ratio between the probability of an event favouring the outcome versus the probability of an event against the same outcome [416], for statements regarding different perspectives of the HIT tool.

HIT tool acceptability was also evaluated by applying chi-square analysis to compare HIT score completion rates pre- and post-trial, and against FROP score completion rates. Spearman's correlation determined the association between HIT and FROP scores. Clinical efficacy was assessed by evaluating the accuracy of HIT and FROP scoring systems using sensitivity, specificity, and likelihood ratios; alongside comparison of pre- and post-trial hospital falls rates using independent t-testing. Patient details were presented as mean or percentage values, and compared pre- and post-trial using independent t-testing and chi-square analysis respectively. In all instances, two-sided alpha was taken as 5%, and statistical analysis was performed using the SPSS 10 program and MedCalc Statistical Software version 16.4.3.

Synopsis of Chapter 3

This chapter outlines and justifies the research process, methodology and methods used within the study. The objective is to inform the reader why pragmatism, abduction, mixed-methods and primarily action research methodology were chosen. It discusses in detail the characteristics distinctive to action research- collaboration with clinicians and participant involvement in research process, tool development and practice change, which were advantageous for application within the research study. Research methods are defined to provide understanding as to how study aims were investigated regarding time horizon, study setting, study participants, study protocol, ethical considerations, data collection and analysis procedures. The ensuing Chapter Four presents an integrative review on the efficacy and clinicians' perceptions of health technology use in falls prevention, thereby setting the framework for research within this thesis.

Chapter 4: Efficacy of and clinicians' perspectives towards the use of health technology in falls prevention

Summary

Health technology is emerging as a potential strategy for assessing and addressing falls risk. For any intervention, both effectiveness and uptake must be assessed to allow insight into ongoing use and further refinement of the tool in question. However, at present, there is a lack of systematic collation and integration of information on the use of health technology measures in reducing hospital fall rates or on how these interventions are perceived by clinicians involved. The following Chapter 4 presents a published paper on an integrative review describing for the first time, the evidence for the effectiveness of health technology strategies in reducing the rate of falls in hospital, alongside how these interventions are viewed by healthcare clinicians in terms of acceptability and usability. It expands on the literature review presented in Chapter 2 and outlines that current data within this field is limited and high-quality research is lacking. Chapter 4 answers the research hypothesis 1: that health technology methods would be effective in reducing inpatient falls, and be well accepted by healthcare staff. It sets the framework for the research presented in Chapters 5 and 6, evaluating the attitudes of hospital clinicians towards a novel health information technology tool, how this tool compared to standard falls risk screening measures, and its efficacy in reducing inpatient fall rates.

Paper 1: Clinical effectiveness of and attitudes and beliefs of health professionals towards the use of health technology in falls prevention among older adults (published paper)

SYSTEMATIC REVIEW

Clinical effectiveness of and attitudes and beliefs of health professionals towards the use of health technology in falls prevention among older adults

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ABSTRACT

Aims: To analyse the evidence on the effectiveness, usability and acceptability of health technology in falls detection and prevention among older adults.

Methods: Five databases were searched from February 2004 to February 2014: PubMed, Medline, Embase, Cochrane and CINAHL, with reference lists reviewed and researchers contacted for additional articles. The interventions were health technology tools used for falls detection and prevention (e.g. computers, mobile phones, motion sensors). The outcomes were effectiveness of, and the attitudes of healthcare staff towards, health technology in preventing falls. Two review authors independently assessed full texts using modified versions of the Joanna Briggs Institute Critical Appraisal Checklists.

Results: Full-texts of 51 out of 7927 articles were examined and 17 articles accepted following appraisal using Joanna Briggs Institute modified criteria. These were divided into subheadings of health information technology tool with visual cues ($n = 2$), sensors ($n = 4$), Webcam ($n = 1$) and electronic medical records ($n = 3$). Three of the seven systematic reviews evaluated sensor technology alone, whereas the remainder examined multicomponent interventions. There is a lack of research into the efficacy of and staff attitudes towards health technology in falls detection and prevention. One study found nurses accepted a health information technology toolkit with visual cues, with a single randomized controlled trial demonstrating a reduction in falls rates. Most studies regarding sensor technology were of low quality and did not find reduced falls rates or number of falls-related injuries. There was also mixed response from healthcare staff and users regarding the use of sensors, with concerns about privacy and false alarms. Video camera surveillance effectively reduced falls rates and was well accepted by nursing staff. However, patients had concerns for their privacy. Electronic medical records have not so far demonstrated a reduction in falls, with ongoing staff concerns about their usability.

Conclusion: Good-quality literature regarding the effectiveness and acceptability of health technology in falls detection and prevention is lacking. Further research into both these fields is vital prior to wider implementation of such tools in clinical practice.

Key words: attitudes, falls, health technology, integrative review, prevention

Int J Evid Based Healthc 2014; 12:000–000.

Introduction

Falls in residential care, hospitals and the community are common and costly for both the victim and health sector. As the population ages, both globally and in Australia,[1] the problem of falls is expected to grow.[2] Within Australia itself, the age-standardized rates of fall injury cases have increased by 2% each year for the past 12 years.[3] These figures are despite the implementation of best practice falls prevention guidelines within residential care and hospital settings.[4,5] As such, there exists a practice gap between mandatory preventive measures

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and actual clinical practice.[6,7] Thus, because of the present and projected burden of falls on the individual, society and healthcare system, preventive measures are a matter of private and government interest.[8]

Falls become more frequent with age.[3] A third of those 65 years and above fall at least once a year in Australia, with up to half experiencing multiple falls.[9,10] These figures are predicted to rise with an ageing global population.[11] Falls are also more common among those with dementia, in which the rate is eight to 10 times higher than among those with normal cognition,[12] and in residential care, in which the rate is six times greater than those living independently in the community.[5]

The impact of falls is also more deleterious in the older person, with physical effects ranging from soft tissue injuries to major fractures and early death.[13] These consequences are magnified in residential care, where the percentage of fractures due to falls is 20%, compared with 5% among healthy older community dwellers.[14] Moreover, the majority of the 424 000 deaths per annum from falls also occurs among those aged above 65 years.[15,16]

In addition to their physical impact, falls have significant psychological sequelae, with up to 73% of older persons who fall having a fear of subsequent falling.[17] This leads to social isolation, depression, reduced mobility and independence, and increased reliance on the healthcare system.[14,18,19] Furthermore, there is the psychosocial impact on family and caregivers who express feelings of guilt and anxiety,[20] stress, depression and an increased caregivers workload following a fall.[13]

Falls also have economic consequences. They are the leading cause of injury costs for those over 65 years in Australia and the United States,[21–23] with international figures showing up to 50% of the total cost from hospital inpatient services[24] and up to 41% of costs from residential care placement.[22,25] These economic costs are predicted to rise if the falls rate increases[26] and there is a lack of evidence to suggest it will not. By 2051, it is estimated that the total health costs from falls-related injuries in Australia will triple to A$1,375 million per annum.[8] In addition, the healthcare sector will need to provide an extra 3320 nursing home beds and 886 000 hospital bed days per annum.[8]

Therefore, as falls represent a significant problem on multiple levels, it is not surprising that falls prevention strategies, including the use of health technology, need to be evaluated for their clinical effectiveness. The term health technology has been used broadly within this integrative review to refer to any technology intervention that influences a change in patient management. It has been garnering increasing interest in the field of falls prevention,[6] although as of yet, there has not been a comprehensive assessment of its efficacy in actually preventing falls in the clinical scenario. Moreover, it is known that the clinical effectiveness of any information technology intervention is also highly influenced by its acceptability and usability among patients and staff.[27] Therefore, knowing staff attitudes and beliefs would also assist in the design and implementation of any health technology tool. However, at the time of writing, there has yet to be a systematic evaluation of staff perspectives towards the use of health technology in falls detection and prevention.

Therefore, our integrative review aims to analyse and synthesize the available evidence on both the clinical effectiveness of, and attitudes and beliefs of health professionals (physicians, nurses and physiotherapists) towards, the use of health technology in falls prevention among older adults.

Methods

Search strategy

The search strategy was developed by the authors in conjunction with research librarians using a combination of MeSH and free text words, as outlined in Supplemental Digital Content Tables 1a and b, http://links.lww.com/IJEBH/A1. Boolean connectors AND, OR and NOT were used to combine search terms such as fall, computer system, mobile phone, motion detector/sensor and attitude of doctor/nurse/physiotherapist. A systematic search was conducted of five databases from February 2004 to February 2014: PubMed, Medline, Embase, Cochrane and CINAHL. In addition, the references of potential articles retrieved were examined, and researchers within the field contacted to identify any additional articles. Language was not restricted, as long as a translated version of the article was readily available. The 10-year range between 2004 and 2014 was chosen due to the advancements made in technology interventions in the area of falls prevention in the last decade.

An initial search of the databases was conducted in June 2013 and repeated again in February 2014, using the databases and search terms as outlined in Supplemental Digital Content Table 1, http://links.lww.com/IJEBH/A1. The first search strategy, focusing on attitudes of doctors, nurses and physiotherapists, did not reveal any relevant articles. Thus, a second search strategy was implemented using just terms related to falls and technology (see Supplemental Digital Content Table 2, http://links.lww.com/IJEBH/A1). In addition, the reference lists of all identified articles were reviewed for additional relevant articles, and researchers and authors within the field were contacted about pending or future publications. The search strategy, with the included and excluded articles, is depicted in Supplemental Digital Content Tables 1 and 2, http://links.lww.com/IJEBH/A1.

Criteria for considering studies for this review

Types of studies

This review considered studies on the effectiveness, perspectives and attitudes of healthcare professionals in the use of health technology for falls prevention, involving both quantitative and qualitative data. This included randomized controlled trials (RCTs), cohort studies, case–control studies, case series, cross-sectional studies and observational studies. Studies were excluded if they were pilot studies or protocols.

Types of participants

The review considered all studies that included the efficacy of, and perspectives and attitudes of healthcare professionals towards, health technology in falls assessment and prevention in older adults (aged $\geq$60 years). This included studies undertaken in residential care, hospital or community settings. Studies were excluded if they were conducted in children (age $<$18 years) or if they were in a language other than English, wherein a translated version was not readily accessible. Studies were also excluded if they were more than 10 years old, owing to the recentness of technology interventions used in falls prevention.

Types of interventions

The interventions of interest in this review were health technology used for falls prevention such as computers (including computer systems and iPads), mobile phones (including iPhones, smart phones and cellular phones), and motion detectors or sensors.

Types of outcome measures

The outcome measures reviewed were the attitudes and beliefs of healthcare professionals towards the use of health technology in falls prevention. The primary outcomes were the usefulness, acceptability, benefits, barriers and areas for improvement for health technology. The secondary outcomes were the current uses of health technology, types of health technology, clinical effectiveness of health technology, cost-effectiveness of health technology, and patient and caregivers satisfaction.

Data collection and analysis

Data extraction and synthesis

Data was extracted using a standardized table developed by the authors with the following headings: study authors, study design, participants, setting, intervention, outcome measure and key findings.

Studies were split into groups by intervention type (visual toolkit, sensors, video camera, electronic medical records [EMRs]), or if they were part of a systematic review. There were too few studies to allow meta-analysis of their findings.

Quality appraisal

Two review authors independently assessed the full text of potentially eligible trials for inclusion into the review. An assessment was conducted using modified versions of the Joanna Briggs Institute (JBI) QARI Critical Appraisal Checklist and QUADAS checklist, and the JBI Critical Appraisal Checklist for Systematic Reviews (see Supplemental Digital Content Appendices 1 and 2 http://links.lww.com/IJEBH/A2). Studies that scored six or more on the appraisal checklist were included in the review. Any discrepancies regarding scoring or inclusion or exclusion of the article were resolved by assessment from a third review author, and a collective decision on score and inclusion agreed upon.

Results

Literature search

The initial search strategy, involving terms related to health professionals' attitudes, in addition to falls and technology, did not yield any relevant articles. The search strategy was therefore broadened to include all articles with just falls and technology terms. This yielded a total of 7924 articles, with an additional four articles located by citation searching and contact with researchers within the field. The full texts of 51 articles were analysed and a final 17 selected for inclusion in the integrative review. The selection process and reasons for exclusion are noted in Supplemental Digital Content Tables 1 and 2, http://links.lww.com/IJEBH/A1.

Study characteristics

A total of 17 articles met our inclusion criteria (see Supplemental Digital Content Table 3, http://links.lww.com/IJEBH/A1 for Study Characteristics). Overall, there were 10 clinical studies and seven systematic reviews.

Among the 10 clinical studies, six were conducted in the United States,[28–33] two in the United Kingdom[34,35] and one in Germany.[36] Sample sizes ranged from 16 to over 10 000 participants. Not all studies specified participant age or demographics. Six studies were conducted in hospitals,[28,29,32,35–37] two in community healthcare centres,[30,31] one in nursing homes[33] and one in sheltered housing.[34] Five of the systematic reviews were conducted within the residential care facility or hospital setting.

The methodology of the studies varied. There were three RCTs,[29,32,35] five cohort studies,[30–33,37] one prospective follow study,[36] one cross-sectional survey[34] and one study using focus groups.[28] The systematic reviews generally incorporated a range of study methods, except for Cameron *et al.*'s[38] review that only examined RCTs.

The interventions studied in the clinical trials included a health information technology (HIT) toolkit with visual cues ($n = 2$), sensors ($n = 4$), video camera ($n = 1$) and electronic health records ($n = 3$). Three systematic reviews examined sensor technology alone, whereas the rest reviewed a variety of intervention types. The outcomes studied ranged from falls rates, number of falls and falls-related injuries and patient and staff preferences.

Findings

Health information technology toolkit with visual cues

A Falls Prevention Tool Kit (FPTK), using HIT-derived bedside posters, patient/family education and care plans, was trialled in a large RCT in four urban hospitals.[29] The toolkit was found to significantly lower fall rate (3.15 vs. 4.18 per 1000 patient-days, $P = 0.04$), particularly so for older hospital patients aged 65 years and over (rate difference 2.08 vs. 1.03 per 1000 patient-days, $P = 0.03$). The FPTK did not, however, result in any difference in falls-related injuries. The authors identified the importance of enhancing staff adoption and adherence to the toolkit and highlighted the need for consistent management of the intervention by the staff to facilitate successful implementation. Of note though, the study did not report on participant selection criteria and withdrawals.[29]

An earlier focus group conducted by Dykes *et al.*[28] found that nurses and nursing assistants were familiar with visual cues and bed alarms as ways of communicating falls risk and preventive strategies. As 'immunity' to visual cues and inaccurate or incomplete information were identified as potential barriers to use of the tool, the participants emphasized the importance of having unambiguous, individualized visual cues in drawing attention to patients at risk and showcasing specific strategies to prevent them from falling.

Sensors

Three systematic reviews have looked at the use of sensors in falls detection and prevention. The earlier review by Bergmann[39] identified 11 relevant articles on user and clinician preferences regarding noninvasive body-worn sensors for falls prevention. Five of those articles examined the preferences of adults over 65 years, two on both patient and clinician preferences and a single article on clinician preference. None of the articles on clinician preference dealt with health information interventions. There was also a general lack of high-quality research with few participant numbers and limited reporting of research methods.

Of the two studies examining falls detection devices, both were consumer surveys conducted among older persons living in the community.[40] A survey of 100 elderly residents in North Wales found that 83% considered a wearable fall detection device both comfortable and reassuring.[40] Another survey on a similar scale of older British community residents regarding four different types of technology devices reported that 77% of them were interested in automatic falls detection.[34] The respondents reportedly commented that they would not reject any device that would help them to live independently. However, for reasons that were unclear, 21% who had fallen in the previous year declined the use of a falls detection device.[34]

Overall, Bergmann[39] concluded that clinician involvement in design and testing of any such sensor technology was important, as was the distribution of this information to make the device acceptable. Some important elements of device design highlighted by both patients and clinicians were that it be compact, simple to operate, and not disruptive to either clinician work or patient behaviour.

A recent systematic review examined the current use of sensors in falls detection, their clinical effectiveness and acceptability among older adults.[41] This review found 74 relevant articles, the majority dealing with wearable sensors. All three-sensor systems, including nonwearable and multiple-sensor systems, displayed high sensitivity, specificity and accuracy in falls detection. However, 31 articles did not provide information about device sensitivity and specificity. There was also a lack of testing in real-life situations with only 7.1% of studies on wearable sensors, and no studies on nonwearable sensors, having been examined in clinical scenarios. The rest of the studies involved older adults in simulated environments or else young healthy volunteers. Overall, the review authors identified the need for future research within real-life settings.[41]

One real-life study conducted on older persons residing in assisted living centres found the use of passive monitoring via motion sensors resulted in fewer falls, a trend towards reduced weekly hospitalizations and higher resident retention rates.[42] The response to falls detection sensors has been mixed. A pilot study on users and healthcare professionals found neither group was receptive to falls detection devices. Moreover, these devices did not result in reduced fear of falling.[43]

Older community dwellers have expressed a sense of security with an extended falls detection system, compared with standard pendant alarm service, and that it enabled them to remain living independently in their own homes. However, some felt that the system was intrusive and that they were unable to control their contact with the call centre.[44] Thus, the need to create devices that are accurate but unobtrusive was identified as an important factor in promoting user acceptability.[41]

A systematic review on the use of sensor systems as falls prevention strategies among older persons in hospitals and residential care included 12 articles in its discussion.[45] Kosse *et al*. surmised there was no consistent evidence that sensor systems reduced falls rates. Three RCTs reported no reduction in falls rate using sensor systems,[46–48] whereas three before–after studies found significantly reduced falls rates using bed alarms.[49–51] Two of these before–after studies used multicomponent interventions, which made it difficult to single out individual components or an optimal bundle of components that would result in reduced falls rate[49] and falls-related injuries.[49,52] Kosse *et al*.[45] highlighted that sensor systems that monitor a single variable in a small physical area were not appropriate for identifying falls among older persons in hospital and residential care.

Kosse *et al*.[45] also identified a general paucity of high-quality research with multiple methodological deficits, including sample size, unreported significance levels and validity subscales, and number of (false) alarms. The authors concluded there was a lack of evidence-based practice in current implementation of sensor systems. Therefore, further research into this field should be encouraged.

The findings by Kosse *et al*. highlighted that healthcare professionals need to be involved in the design and implementation of sensor devices to facilitate their success in falls prevention.[49,53–55] In the literature, the response by healthcare workers towards fall prevention sensor systems has been both positive[49,51,54] and mixed.[46,47] One trial found healthcare workers were willing to add high-risk patients to the sensor intervention group,[54] and that caregivers reported preferring sensors to mechanical restraints.[51] However, study authors concluded that limitations to the clinical effectiveness of these sensor systems included a lack of staff acceptance, awareness[46,51] and experience with the sensors, as well as the time required to install them.[51] One trial removed the sensors after staff found them disruptive to their normal care and became desensitized by false alarms.[53] Thus, having accurate sensor systems with a low rate of false alarms would be important to maintain the full attention of healthcare staff.[45]

Marschollek *et al*.[36] conducted a prospective follow-up study on geriatric inpatients using a wireless triaxial accelerometer system as part of a falls risk assessment program. The inclusion of this technology device resulted in greater identification of those patients at risk of falling compared with simple risk assessment scores. However, the study population type was unclear (see Supplemental Digital Content Table 4, http://links.lww.com/IJEBH/A1 on Study Quality), with most participants likely to have progressed on follow-up from being a hospital inpatient to resuming residence in the community. Thus, the findings by Marschollek *et al*. cannot be directly translated to either the older hospital inpatient or community population. Moreover, the study authors themselves identified that on follow-up, the participants' falls risk factors would most likely have altered and that the use of self-reported falls would be an additional limitation to the interpretation of their findings.[36,56]

The use of bed sensor alarms was promoted through educational sessions in a randomized trial conducted by Shorr *et al*.[32] This study found that alarm use was increased in those intervention units that received the extra education, compared the control units, who also had access to bed sensor alarms. However despite the rise in alarm use, there were no significant differences between the units in either the rates of falls per se or falls causing injury. Shorr *et al*.[32] however cautioned that ultimately the study was underpowered to detect the primary end point of number of falls. The study authors did reiterate the point that false alarms could also have contributed to the lack of success of the bed sensors and that some falls could have already occurred by the time the sensor alarm was activated.

More recently, a RCT by Sahota *et al*.[35] outlined the use of bed and beside chair pressure sensors in older hospital inpatients in the United Kingdom. These sensors were linked wirelessly to a hand-held radio-pager carried by the nursing staff. This health technology intervention did not result in a decrease in falls rates or rates of injurious falls. In addition, there was no change in the patients' fear of falling, length of hospital stay, functional status, discharge destination or health-related quality of life.[35] The study authors also found that there were a number of problems with the sensor system, namely faults with the pager (43%), equipment malfunction (33%) and pagers being left unattended (24%).[35]

Video camera

Hardin *et al.*[37] conducted a case–control study on the use of Webcam to view the patient's bed (linked to a central monitoring system), with the addition of a 'virtual bedrail' function if patients had a Morse Risk Assessment greater than 25. There was a low consent rate (20.7%) for the intervention group, partly attributed to privacy concerns by patient. Among those patients using the intervention though, there was a significant reduction in rate of falls per 1000 admissions (34.11 vs. 18.74) but no difference in rate of falls per 1000 patient-days. Fewer falls were attributed to the combination of Webcam surveillance and increased awareness of falls prevention in the intervention wards. The number of serious injuries was also noted to be higher in the control compared with the intervention units ($n = 3$ vs. $n = 1$); however, these figures were too small to assess for significance. In addition, Hardin *et al.*[37] did not discuss participant withdrawals or report fully on their methodology.

As an extension of the study by Hardin *et al*., a focus group of the five site coordinators was conducted post-data collection. The coordinators identified patients with confusion or limited mobility as benefiting most from the Webcam. One coordinator stated that some physicians transferred patients to the study unit to access the virtual bedrails. In general staff response was felt to be positive with nurses feeling more confident in managing patient risky behaviours. However, there were concerns about reduced privacy for patients, staff and physicians, with nurses worried that Webcams would be used to monitor their work. However, nurses also reported that Webcams were a good substitute for sitters for agitated patients at high falls risk. It was identified that timely selection of patients for the device and further technology refinements should be addressed before the device was implemented.[37] However, it is worth nothing that this article lacked reporting of methodology, selection criteria and reasons for participant withdrawal.

Electronic medical records

There have been three studies examining the use of EMRs in falls assessment and prevention. Fung[30] conducted a cohort study with 16 clinicians in which computer templates for falls and urinary incontinence were found to improve history-taking and physical examination. However, the clinicians were ambivalent as to their ease of use. Moreover, they were concerned about the computer templates duplicating material already written in the case notes. Clinicians also found ease of use of the templates moderate at best. The study authors concluded that involving clinicians in template design, educating them about the tool and having them repeatedly use it with follow-up education, would result in improved levels of usability. The authors identified the value of future research aimed at increasing the perceived usefulness and ease of use of the computer templates, to increase its actual frequency of use.

The use of health technology, namely electronic records utilizing both wireless personal digital assistants and desktop computers, did not alter falls rates in a prospective study of nursing home residents. The intervention units implementing the electronic records also scored lower in the behavioural scales compared with control units. It was postulated that this could have been due to the amount of time staff spent on the technology tools, and therefore less attention on patient care. Having said that, only a minority of residents were aware health technology devices were being used ($n = 124$, 16.3%). Of these, just 20.7% ($n = 38$) felt the hand-held personal digital assistants interfered with the amount of time staff spent with them. The majority ($n = 88$, 70.8%) agreed 'the hand-held device help staff better manage my care', with a third (30.6%) believing it had improved and only 7.1% thinking it had declined the standard of care. The authors concluded that further studies into the efficiency, cost and impact on resident behaviours of using electronic records in falls prevention were required before these tools could be widely implemented.[33]

A standardized EMR review with tailored electronic physician recommendations was trialled among older community-dwelling persons aged 70 years and above (413 intervention, 207 control).[31] This prospective randomized trial by Weber and McIlvried found that this tool did not result in significant difference in self-reported falls rate or total number of medications for a 12-month period. However, there was a decreased number of psychoactive medications among the intervention group, especially among those with two or more initial psychoactive medications. Weber and McIlvried[31] did identify having self-reported falls as being a limitation in their study design.

In addition to data on self-reported falls and numbers of medications, Weber and McIlvried[31] also sought opinions on the EMR tool from the participating physicians. Overall, the response rate from the 36 physicians was low (53%, $n = 19$), with only 18 actually reading the messages, 12 prompted to ask about falls, and eight changing medications as a result. The authors concluded that while an automated prompt could be useful, it would be unlikely to replace electronic communication from a colleague.

Published systematic reviews

Five of the seven systematic reviews on falls prevention strategies were conducted in residential care facilities or hospitals.[27,38,45,57,58] The remaining two systematic reviews did not specify a study setting.[39,41] Overall, the systematic reviews combined a variety of study types, with the exception of Cameron *et al.*,[38] which consisted exclusively of RCTs. The number of studies included ranged from 11 to 74. Those systematic reviews which discussed sensor technologies found that overall there was no evidence that they reduced falls.[38,39,45,57] The evidence was also inconclusive as often the sensors formed part of a multifactorial intervention and it was difficult to tease which component(s) were clinically effective.[27,58] All seven systematic reviews identified poor study quality and study heterogeneity as current limitations in the published data on the use of sensor technologies in the field of falls assessment and prevention.

The systematic review by Cameron *et al.*[38] identified a single trial among its 60 studies on the use of wireless position-monitoring patches in care facilities. This unpublished report found these sensor devices did not influence falls rate.[59] Cameron *et al.* highlighted that effective falls prevention strategies were vitamin D and possibly multifactorial falls prevention programs in care facilities. Within the hospital setting, the findings from Cameron *et al.* were that additional physiotherapy in subacute wards, and educating patients in falls risk and risk reduction strategies could potentially decrease falls. Multifactorial interventions were again identified as effective for longer-stay hospital inpatients; however, once more, it would be difficult to recommend any specific part of the program as being clinically effective.

Choi *et al.*[57] conducted a systematic review about falls prevention strategies in the hospital setting, which included a total of 34 articles. Effective single interventions for reducing falls and fall-related injuries were found to be medication review, patient education, volunteer programs and bedrail reduction.

Two studies with single technology-related interventions did not report a significant reduction in the number of falls.[48,51] The first article, an audit of a wireless bed alarm system, found that 91% of nurses believed it helped prevent falls. However, many nurses were unaware about the availability of the alarm system, although there had been multiple educational efforts within the hospital.[51] This study scored poorly on our quality appraisal criteria as it lacked reporting on participant selection, methodology and data collection.

The second technology article was a case–control study on a bed-exit alarm system. Tideiksaar *et al.*[48] reported this system was well accepted by patients, families and nursing staff in a hospital geriatric unit. Several participant stated they preferred the alarm to mechanical restraints. However, the article did not outline how this information on attitudes was obtained, with again a lack of reporting on methodology, participant selection and withdrawal. Therefore, it also scored low in our quality appraisal and it was difficult to draw valid conclusions from this article.

Another systematic review by Hempel *et al.*[27] found 59 studies on hospital fall prevention interventions. These authors reported that the majority of studies ($n = 48$, 81%) looked at multifactorial strategies. Most studies reported positive changes with their intervention strategies, although only 17 articles utilized statistical testing, and of these about eight demonstrated significant improvement. These successful intervention strategies included multifactorial programs and staff education. One article looked at single-intervention bed-exit alarms and found they reduced falls (incidence rate ratio 0.75, 95% confidence interval 0.50 to 1.12), but did not conduct any significance testing.[60] Overall, the authors of the systematic review concluded there was a lack of reporting of data, such as comparator groups and adherence strategies, or use of validated scales. Therefore, it was recommended that future research needs to concentrate on these parameters to provide clinically useful information.[27]

Miake-Lye *et al.*[58] conducted an updated systematic review regarding four meta-analyses on 19 studies. These authors identified two new large RCTs that supported the previous conclusions that multicomponent inpatient falls prevention programs are effective in reducing falls risk. One of these RCTs was by Dykes *et al.*[28] using the FPTK, as previously discussed by the current authors in this integrative review. This intervention resulted in lower fall rates, especially among patients aged 65 years or older. The other RCT, conducted again in a hospital setting, found tailored patient education, in addition to usual care (environmental modifications, medication review, fall history, generic falls prevention advice), resulted in a significant falls risk reduction (0.29, 95% confidence interval 0.1 to 0.87). The authors concluded that individualized multiple falls prevention strategies, in addition to usual interventions, should be implemented among patients at high falls risk.[61]

Miake-Lye *et al.* arrived at similar conclusions as the previous meta-analyses[38,62–64] in that it was difficult to identify optimal individual strategies within multicomponent falls prevention programs. Miake-Lye *et al.*[58] identified reasons for successful implementation of falls prevention programs including leadership support, staff engagement in program design, multidisciplinary supervision, pilot-testing, information technology to record and assess falls data, staff education and changing nihilistic attitudes towards falls prevention. These authors concluded that further research was required regarding which individual components of falls prevention strategies were most useful, or whether it was more the successful implementation of any falls prevention program that resulted in its success.[58]

Discussion

To the current authors' knowledge this is the first integrative review to examine both the use of health information, including sensor and nonsensor technologies, in falls prevention and detection, and healthcare staff perspectives into the usability and acceptability of such tools. This integrative review was limited by the lack of articles available and paucity of high-quality research available within this field.

The main findings of this current review are that there exists single-RCT evidence for the clinical efficacy of an HIT toolkit with visual cues and the use of video cameras with virtual bedrails in preventing falls. The evidence for sensor technologies in falls prevention is lacking, whereas no study to date has demonstrated the effectiveness of EMRs in reducing falls. In addition, no study so far has shown a decrease in falls-related injuries with the use of health technology.

The current authors have also found a profound deficiency in published data on the attitudes and beliefs of healthcare professionals in the use of health technology in falls detection and prevention, despite these being acknowledged as vital in the implementation of any successful falls prevention program. The literature thus far has shown good response towards the HIT toolkit. However, healthcare staff have cited privacy concerns for the video camera, and issues regarding interference with daily clinical work and false alarms for sensor technologies. There have also been concerns raised by clinicians about the potential duplication of work and unfamiliarity with the use of EMRs.

Efficacy of health technology in falls assessment and prevention

The evidence for the effectiveness of technology tools in falls prevention and detection, especially among older adults, is limited. There have been few studies conducted within a clinical setting using real-life scenarios. The majority of studies have also been low quality with a lack of comprehensive reporting, use of comparator groups, statistical testing or validated scales (see Supplemental Digital Content Table 4, http://links.lww.com/IJEBH/A1 for Study Quality). Future studies would need to address these shortcomings and provide comprehensive information on study methods, participant selection and withdrawal.

In general, the efficacy of health technology interventions in reducing falls has been mixed. The FPTK and video cameras with virtual bedrails were two interventions that resulted in significant reductions in fall rates. However, both studies were conducted as single trials and would need to be replicated in a variety of clinical settings to foster generalizability of the results. In addition careful documentation of participant selection criteria, withdrawals and methodology would be required.

Of the literature review, the current integrative review found the most number of articles to be within the field of sensor technology (see Supplemental Digital Content Table 3, http://links.lww.com/IJEBH/A1 for Study Characteristics). The research within this field has so far mainly been conducted in simulated settings, with a definite lack of studies in 'real-world' situations. The clinical studies available show mixed efficacy of sensor technology strategies for falls prevention. Those articles reporting on RCTs did not find sensors to be clinically effective in reducing falls. Again the majority of clinical articles within this field were of low quality with small participant numbers, and a lack of reporting of methodology and research processes (see Supplemental Digital Content Table 4, http://links.lww.com/IJEBH/A1 for Study Quality and Supplemental Digital Content Table 5, http://links.lww.com/IJEBH/A1 for Quality of Systematic Reviews). Thus, more research is required regarding the use of sensors in clinical environments with a focus on older participants, and comprehensive documentation of all research processes, to better assess their efficacy in falls detection and prevention.

EMRs in falls prevention have not been examined in many clinical trials. The few studies we identified did not demonstrate effectiveness for this tool in decreasing falls rate. However, more research would be required regarding this health technology intervention. In addition, clear and comprehensive reporting of participant selection criteria, withdrawals and methodology would be important to address in any future study, to appreciate the true effectiveness of this tool (see Supplemental Digital Content Table 4, http://links.lww.com/IJEBH/A1 for Study Quality).

Therefore, although the use of health technology has been expanding in healthcare, overall the literature examining its clinical effectiveness in falls assessment and prevention is lacking. Therefore, future research in this area, including among older persons, with clearly outlined documentation of research processes, would be imperative before these strategies can be widely implemented in the healthcare system.

Attitudes and beliefs of healthcare staff towards health technology in falls prevention

The perspectives of healthcare professionals and their involvement in implementing any intervention strategy have been identified to be crucial to its success. However, there is a definite lack of literature on the attitudes of healthcare staff towards the use of health technology in falls prevention, whether among older persons or otherwise (see Supplemental Digital Content Table 3, http://links.lww.com/IJEBH/A1 Study Characteristics).

Our review identified four individual studies that looked at staff attitudes and beliefs on technology tools in assessing and preventing falls. The single trials on the FPTK and video cameras with virtual bedrails showed these interventions were well accepted by healthcare staff. Suggestions for improvement to the toolkit were that the visual cues be unambiguous and customized to the individual patient in terms of risk factors and specific falls prevention strategies. Addressing privacy concerns and educating both patients and staff were shown to be important factors in successful implementation of video cameras and virtual bedrails for falls prevention. Careful selection of patients prior to room allocation was also noted to be important in managing the limited availability of these resources.

As with most of the literature in this field, the above two studies were single trials with a small number of staff interviewed regarding their perspectives on the health technology tools used. Future trials in multicentre settings with staff feedback would therefore be valuable in further delineating the usability and acceptability of these technology interventions.

The perspectives of healthcare staff towards sensor technology and EMRs in falls prevention have also been infrequently documented in the literature. The evidence available shows that the response so far has been mixed. Staff identified the need to have compact sensors, with refined technology, few instances of false alarms, and for sensors not to interfere with their usual clinical care. Clinicians were concerned about the usability of EMRs and the potential duplication of their work. Future studies would need to address these concerns and seek greater understanding of staff attitudes towards the role of such health technology interventions in preventing falls.

Overall, the literature on healthcare professionals' attitudes towards the use of health technology in falls assessment and prevention is deficient. What few studies are available often have few participant numbers and limited reporting on selection criteria, withdrawals, methodology and analysis (see Supplemental Digital Content Table 4, http://links.lww.com/IJEBH/A1 for Study Quality). However, this field of research needs to be expanded as it is well known that acceptability and usability are important factors in the successful implementation of any intervention. Therefore, further quality research on healthcare staff perspectives on the use of health technology in falls prevention would be invaluable. Such studies would need to clearly document the research processes involved in acquiring the information.

Conclusion

Falls in the elderly are an important clinical and societal issue, and technology has been introduced to prevent and detect falls. However the current literature is lacking in high-quality clinical trials of health technology interventions in real-world settings, including among older persons. What is required is for larger RCTs of health technology within aged care in the community, residential care facility and hospital settings and its contribution to providing evidence of reduced falls. These trials need to be conducted with rigor and transparency in reporting of participant selection, study methods, results and statistical testing. An evaluation of the cost effectiveness of these strategies would be useful prior to their wider clinical implementation. In addition, there is a great paucity of literature on healthcare staff perspectives towards the use of health technology in falls prevention, despite user acceptance being acknowledged as vital for any intervention to succeed. Therefore, there needs to be further consultation with healthcare staff, consumers and their families about the role of health technology in falls prevention, using both qualitative and quantitative methods in a variety of clinical scenarios. Such research into the efficacy, acceptability and usability of health technology tools would be invaluable before they can be widely and confidently used in the assessment and prevention of falls among the older population.

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Chapter 5: Mixed-methods findings- clinicians' perspectives of the Health Information Technology tool

Summary

The perspectives of end-users require consideration in the design and implementation of any health technology measure. The following Chapter 5 presents a published paper outlining a mixed-methods study utilising focus group and survey research to investigate clinicians' perspectives towards a health information technology (HIT) tool, incorporating iPad™ device and automatically generated visual cues. The aim of the study was to develop and refine a health technology tool that is acceptable and usable for wider implementation within the hospital setting. The findings from this study addressed thesis aims 2 and 3 in informing clinicians' attitudes and refinement of a health technology tool for use within falls prevention, thus contributing to the limited pool of evidence on this field. Overall, clinicians perceived the HIT tool as beneficial to themselves and their patients, and their feedback was incorporated as part of ongoing partnership in tool refinement.

Paper 2: Evaluation and refinement of a handheld health information technology tool to support the timely update of bedside visual cues to prevent falls in hospitals (published paper)

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ORIGINAL RESEARCH

Evaluation and refinement of a handheld health information technology tool to support the timely update of bedside visual cues to prevent falls in hospitals

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ABSTRACT

Aim: To evaluate clinicians' perspectives, before and after clinical implementation (i.e. trial) of a handheld health information technology (HIT) tool, incorporating an iPad device and automatically generated visual cues for bedside display, for falls risk assessment and prevention in hospital.

Methods: This pilot study utilized mixed-methods research with focus group discussions and Likert-scale surveys to elicit clinicians' attitudes. The study was conducted across three phases within two medical wards of the Queen Elizabeth Hospital. Phase 1 (pretrial) involved focus group discussion (five staff) and surveys (48 staff) to elicit preliminary perspectives on tool use, benefits and barriers to use and recommendations for improvement. Phase 2 (tool trial) involved HIT tool implementation on two hospital wards over consecutive 12-week periods. Phase 3 (post-trial) involved focus group discussion (five staff) and surveys (29 staff) following tool implementation, with similar themes as in Phase 1. Qualitative data were evaluated using content analysis, and quantitative data using descriptive statistics and logistic regression analysis, with subgroup analyses on user status ($P \leq 0.05$).

Results: Four findings emerged on clinicians' experience, positive perceptions, negative perceptions and recommendations for improvement of the tool. Pretrial, clinicians were familiar with using visual cues in hospital falls prevention. They identified potential benefits of the HIT tool in obtaining timely, useful falls risk assessment to improve patient care. During the trial, the wards differed in methods of tool implementation, resulting in lower uptake by clinicians on the subacute ward. Post-trial, clinicians remained supportive for incorporating the tool into clinical practice; however, there were issues with usability and lack of time for tool use. Staff who had not used the tool had less appreciation for it improving their understanding of patients' falls risk factors (odds ratio 0.12), or effectively preventing hospital falls (odds ratio 0.12). Clinicians' recommendations resulted in subsequent technological refinement of the tool, and provision of an additional iPad device for more efficient use.

Conclusion: This study adds to the limited pool of knowledge about clinicians' attitudes toward health technology use in falls avoidance. Clinicians were willing to use the HIT tool, and their concerns about its usability were addressed in ongoing tool improvement. Including end-users in the development and refinement processes, as well as having high staff uptake of new technologies, is important in improving their acceptance and usage, and in maximizing beneficial feedback to further inform tool development.

Key words: falls prevention, health information technology, mixed-methods, perspectives

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Background

Falls are the seventh most common cause of hospital-acquired injury[1] and are more prevalent among older persons.[2,3] Despite the introduction of mandatory hospital falls risk assessment and prevention strategies as a healthcare priority, the incidence of inpatient falls continues to rise by 2% each year.[3–5] Overall, the reported incidence of falls in hospital varies widely from 2–3 (acute setting) to 46% (rehabilitation setting).[6,7] Falls are more prevalent in medical compared with surgical wards,[8] in public compared with private hospitals (4.2 vs. 1.6 per 1000 hospitalizations), and among patients living in major cities compared with remote areas (3.4 vs. 1.9 per 1000 hospitalizations).[9] Actual fall rates are likely to even be higher as there is no universal definition for a fall, and falls incidents tend to be under-reported.[10]

Hospital falls tend to cause serious complications, with 44–60% resulting in harm,[11,12] especially among older persons.[13] The 6-PACK trial (2011–2013) in six Australian hospitals demonstrated that hospital falls increased length of stay (LOS) by 8 days [95% confidence interval (CI) 5.8–10.4, $P<0.001$], and hospital costs by AU$6669 (95% CI $3888–9450, $P<0.001$), even after adjusting for age, sex, cognitive impairment, comorbidities and admission type.[14] Older persons who sustain hip fractures in hospital have poorer outcomes compared with their peers who sustain hip fractures in the community,[15] including longer LOS,[16] reduced return to preadmission ambulation and functional status, increased rates of discharge to permanent residential care[15] and higher mortality rates.[16] Indeed, falls may lead to chronic pain, reduced quality of life, functional impairment, permanent disability and higher rates of inpatient mortality.[13,17,18]

Health technology has the potential to influence this outcome but has been limited by the lack of rigorous evidence for effective single-technology interventions, including sensors and electronic medical records.[19] Moreover, clinicians' perspectives toward the use of health technology in falls prevention are not well-known, despite systematic review evidence that staff attitudes are crucial to successfully integrating any falls preventive strategy.[19,20]

Nursing staff are familiar with using visual cues to communicate falls risk and preventive strategies.[21] Visual cues, as part of a Falls Prevention Tool Kit, have been shown in a single randomized controlled trial to be effective in lowering hospital falls rate (3.15 vs. 4.18 per 1000 patient-days; $P=0.04$), especially among those aged 65 years and over (rate difference 2.08 vs. 1.03 per 1000 patient-days; $P=0.03$).[22] However, further research was needed into whether such findings could be replicated in different settings. Within the Geriatric and Evaluation (GEM) unit at the Queen Elizabeth Hospital (TQEH), a preliminary audit found 20% staff compliance with existing patient bedside posters for falls prevention (Fig. 1; Visvanathan R, Ranasinghe D, Hoskins S, Wood J, Mahajan N, unpublished data). Nursing staff reported these paper-based posters were time-consuming and hence not completed, as they involved placing adhesive colored dots on eight different locations of the poster to indicate falls risk (i.e. green for low risk, yellow for medium risk, red for high risk), before displaying the poster by the patient's bedside (Visvanathan R, Ranasinghe D, Hoskins S, Wood J, Mahajan N, unpublished data). Due to poor uptake and negative feedback of the existing posters, and mindful of the pending electronic health record (EHR) system due to roll out across public hospitals statewide in South Australia, the opportunity was seized to develop a health information technology (HIT) tool in collaboration with ward clinicians. This HIT tool incorporated an iPad 2 device (model number A1315; Apple, Cupertino, California, USA) for direct clinicians' entry of up to 13 common falls risk activities[23] (Fig. 2), with automatic generation of visual cues for bedside display (Fig. 3).

Our pilot study aimed to evaluate clinicians' attitudes toward this HIT tool, in particular, their experiences, positive and negative perspectives and recommendations for improvement, both preclinical and postclinical implementation (i.e. trial), to inform ongoing tool refinement, ultimately as part of a novel movement-detection sensor technology system for hospital falls prevention.

Methods

Ethics approval

The study protocol was approved by the Human Research Ethics Committee of the Basil Hetzel Institute, South Australia (HREC/13/TQEHLMH/66), and conformed to the World Medical Association Declaration of Helsinki.[24] Each participant provided written, informed consent prior to research involvement, and participant information was deidentified.

Research methodology

Mixed methods design was applied to allow for greater robustness and richness of information gathered,[25,26] with focus group research used to obtain qualitative data simultaneously from multiple individuals on different ideas and perspectives.[27]

Study protocol

The current pilot study was divided into three phases. Phase 1 (pretrial) evaluated clinicians' perspectives on the HIT tool (i.e. study aims) prior to implementation, using focus group discussion and surveys. Phase 2 (tool trial) involved tool implementation on hospital wards. Phase 3 (post-trial) examined clinicians' perspectives on

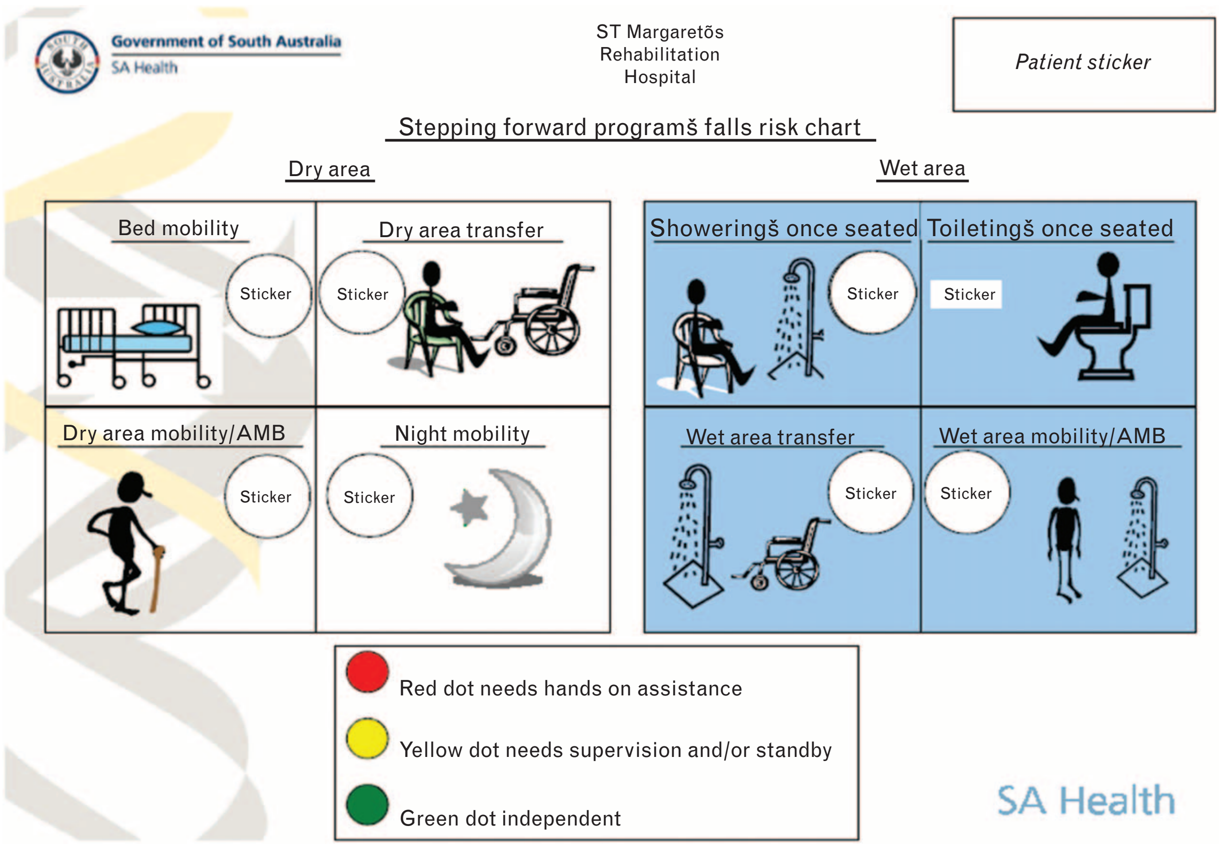

Figure 1. Example of a paper-based bedside poster using colored stick-on dots to indicate patient's falls risk.

the tool after trial completion, using focus group discussion and surveys with similar themes as in Phase 1.

Focus group sessions were led by the chief researcher, who was employed by TQEH as a medical doctor, but not working on the wards at the time of the study. The chief researcher defined focus group goals (i.e. study aims) at each session and facilitated discussion for an hour or until data saturation was reached (i.e. when information occurred so repeatedly that additional data collection had no additional worth).[28] Textual data were transcribed verbatim by the chief researcher from Dictaphone (Philips PocketMemo voice recorder DPM8000; Atlanta, Georgia, USA) recordings and written notes. Transcripts were not returned to participants for comment.

Likert-scale surveys were derived following focus group discussion and utilized similar themes. These were distributed to ward staff over 2 week periods, before and after the tool trial, by the chief researcher and two ward clinical nurse consultants (CNCs), who were considered nursing leaders and experts in clinical care.[29] Completed nonidentifiable questionnaires were returned to the researcher personally or via a designated tray on the wards.

The HIT tool was implemented on the GEM unit (June to August 2014), followed by the Acute Medical Unit (AMU) (September to November 2014), over two consecutive 12-week periods. Ward clinicians had up to 6 weeks of researcher training and reminders on tool use (3-h-long sessions each week) and were independent for the remaining 6 weeks. GEM staff utilized the full period of researcher-led support, whereas AMU staff declined researcher input after 1 day, citing staff confidence with tool use.

The HIT tool took less than 5 min to use for each patient. There was no automatic trigger for staff to use the tool, other than reminders from the researcher in the first 6 weeks. The iPad device was carried by the clinician responsible for using the tool. This person directly entered patient's details (age, bed location, mobility aid) and their own clinical judgment (yes/no responses) about the patient's day and nighttime falls risk for 13 different movement and location types (Fig. 2).

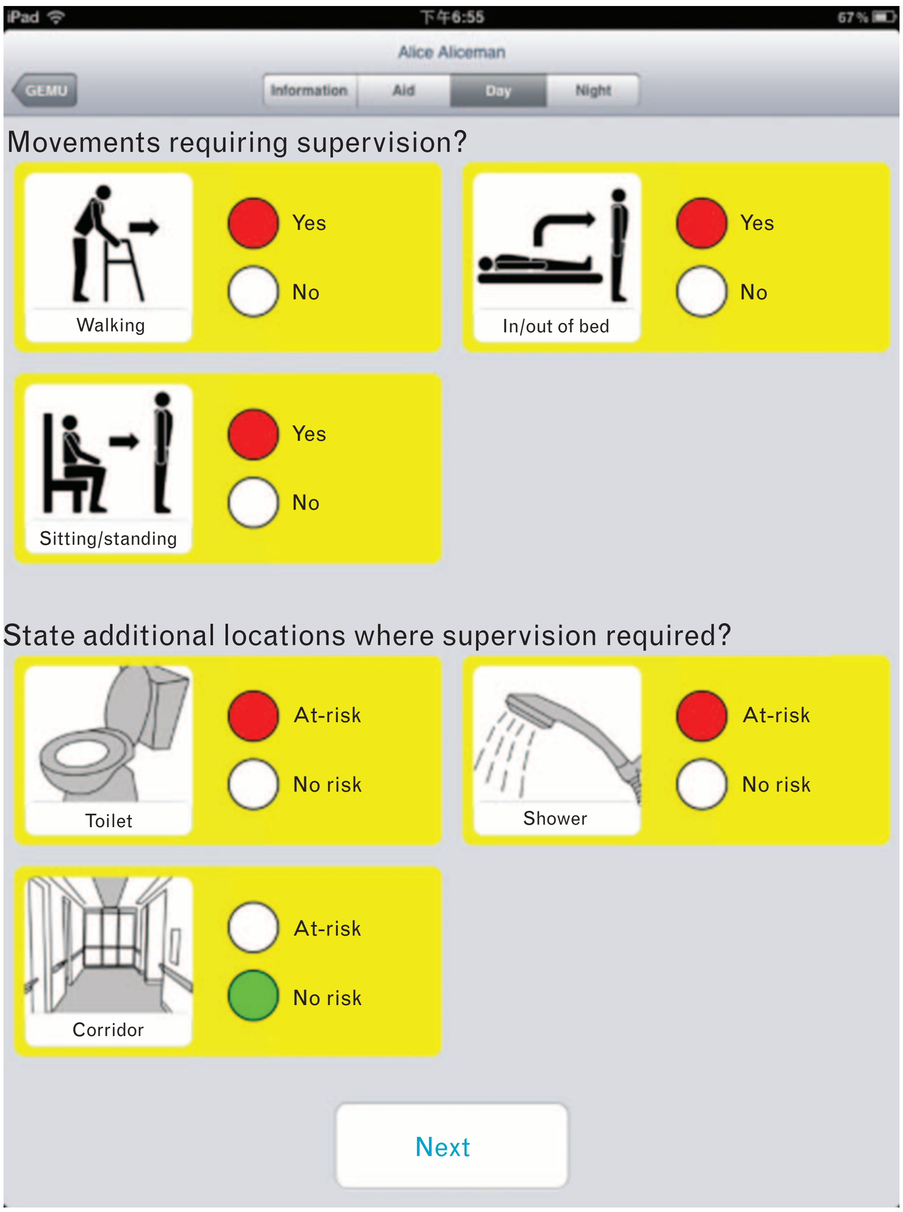

Figure 2. Example of a screenshot of direct clinician entry of patient's falls risk assessment using the health information technology tool.

Black-and-white A4-sized visual cues were automatically printed at assessment completion (Fig. 3), and the same clinician was responsible for displaying these paper-based visual cues by the patient's bedside. Ward staff subsequently targeted falls preventive interventions according to clinical judgment.

Both wards were given freedom on how to implement the HIT tool. AMU staff used the tool daily on all ward patients. All registered nurses on AMU were rotated to use the tool, which was usually completed by the registered nurse allocated to nonpatient-related duties (e.g. ward medication management), to allow for timely use of the HIT tool, unencumbered by other duties. GEM staff used the tool on new admissions and in which falls risk altered (e.g. posthospital fall), reasoning this as appropriate for a subacute setting, in which patients' falls risk changed less often compared with an acute ward. The CNC and two registered nurses from GEM used the HIT tool, due to limited confidence by the rest of the staff in using the device.

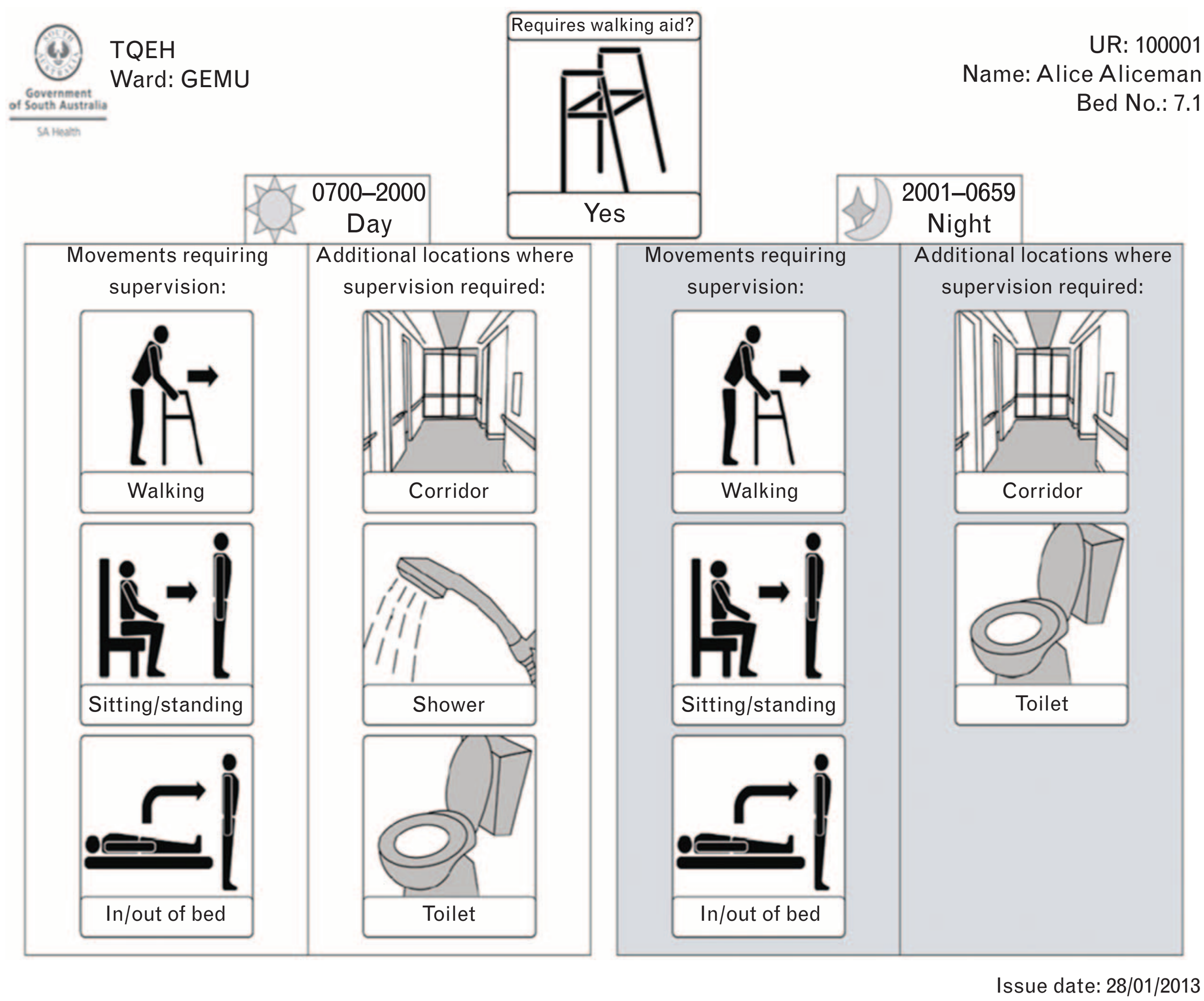

Figure 3. Example of an automatically generated visual cue from the health information technology tool.

Setting and participants

The study was conducted on two ground-floor medical wards at TQEH, a tertiary teaching hospital in metropolitan Adelaide, South Australia. The 16-bed AMU managed patients in the acute phase of illness, whereas the 20-bed GEM unit provided rehabilitative care aimed at restoring patients' function and independence after an acute illness, usually with the goal of returning back home.[30]

Ward clinicians consisted of nursing [38.68 FTE (full-time equivalent) GEM, 32 FTE AMU], junior medical (four FTE GEM, five FTE AMU), and allied health staff, meaning occupational and physical therapists (2.5 FTE GEM, two FTE AMU). No pharmacists, speech therapists, dieticians, social workers or senior medical staff were approached to be part of this study.

Focus group participants were identified by ward CNCs as clinicians having an expertise in falls prevention, with greater than 5 years of clinical experience, and working within GEM, AMU or the Central Adelaide Local Health Network (CALHN) Falls Prevention group at the time of the study. Five clinicians were involved in each pretrial and post-trial focus group discussion, with one participant involved on both occasions. All five post-trial focus group participants were HIT tool users from AMU, with six clinicians from GEM and CALHN declining to participate as they had not used the tool or were unable to attend the focus group session.

Survey participants consisted of clinicians working within GEM or AMU at the time of the study, and consecutively approached by the chief researcher in the 2-week periods, before and after the tool trial. There were 49 pretrial (29 GEM, 20 AMU) and 28 post-trial (20 GEM, eight AMU) participants. It was not recorded which participants were involved both pretrial and post-trial.

Post-trial, both those who had used the HIT tool (i.e. tool users, $n = 11$) and those who had not (i.e. nonusers, $n = 17$), were included to reflect tool uptake. Post-trial, 54 clinicians (65.9%) declined to participate as they had no experience with or recommendations for improving the HIT tool. Participation was voluntary with the option to withdraw at any point.

Analysis

Qualitative data from focus group sessions were manually analyzed using content analysis to systematically code data and identify themes, to gain new knowledge and initiate action.[31,32] Descriptive statistics and logistic regression were performed on quantitative survey data, to describe and evaluate differences between clinicians' perspectives pretrial and post-trial ($P < 0.05$), with subgroup analysis on users and nonusers using SPSS Statistics for Windows, Version 22.0 (IBM Corp., Armonk, New York, USA). Responses indicating 'strongly agree' or 'agree' were classified as positive, whereas those indicating 'strongly disagree', 'disagree' or 'uncertain' were classified as negative responses to the item statement.

Results

The qualitative and quantitative data were integrated into four main findings, and presented from Phase 1 (pretrial), followed by Phase 3 (post-trial), regarding clinicians' experience, positive perceptions, negative perceptions and barriers to use, and recommendations for refinement of the HIT tool.

Phase 1 (pretrial): Qualitative results from focus group session

Clinicians' experience

Pretrial, no participant had used the HIT tool. All participants were familiar with using visual cues in falls prevention, with four participants expressing negative views about the existing posters using colored stick-on dots to indicate falls risk. These were seen as *a bit complicated,* tedious to complete, ineffective and therefore, underutilized, due to time constraints with high patient turnover and competing clinical duties.

Positive perceptions

Incorporating technology into falls risk assessment was identified by three participants as beneficial in providing staff with a fun, quick means of risk assessment. One participant stated the HIT tool would serve as *a stress reduction tool* for staff, in providing *an immediate visual* of each patient's falls risk factors. Four participants cited benefits to patients and their families in increasing knowledge on falls risk and preventive strategies, both in hospital and on discharge.

Negative perceptions and barriers to use

Clinicians perceived the main barrier to tool implementation to be shifting a workplace culture that resisted change and did not view hospital falls as a problem. The HIT tool was seen as increasing work for clinicians, with time pressures on staff thought to compromise accuracy of falls risk assessment and placement of visual cues at the correct patient's bedside. Three participants expressed apprehension about clinicians using new health technology, with one participant especially concerned about older workers and technology use.

Recommendations for refinement

Three participants requested tool technology be simple to use, and eventually incorporated into the upcoming EHR system. They recommended providing staff with tool education, with training attendance linked to points for continuous professional development (CPD). CPD referred to the number of hours stipulated by national registration standards for clinicians to engage in ongoing professional education per annum.[33] Four participants suggested involving patients and families in the tool process, to improve adherence to falls preventive measures in hospital and at home. One participant advocated senior leadership endorsement to drive tool integration into hospital programs.

Phase 1 (pretrial): Quantitative results from survey participants

The majority of survey participants were women (81.6%), nursing staff (73.4%), aged between 18 and 39 years old (63.3%) and had 10 years or less of experience in clinical care (57.1%).

Clinicians' experience

No participants had used the HIT tool pretrial.

Positive perceptions

The majority perceived the HIT tool as an easy, accurate and timely means of assessing patients' falls risk (items 1, 2 and 3, Table 1). Over 70% thought it facilitated safer, better quality patient care, improved staff's understanding of patients' falls risk factors, effectively prevented falls, and were willing to use the tool if made available (items 4, 5, 6, 8 and 9). Half the participants cited that it would effectively prevent inpatient falls (item 7).

Negative perceptions and barriers to use

Less than half the participants considered potential barriers to tool use as being duplication of written work (44.9%), lack of time to use the tool (38.8%) and lack of

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Table 1. Comparison between pretrial and post-trial results of clinicians' perspectives of the health information technology tool, with subgroup analyses for user status

		Post-trial						
	Pretrial, n = 49 (%)	Total, n = 28 (%)	Users, n = 11 (%)	Nonusers, n = 17 (%)	Preusers vs. postusers	Prenonusers vs. postnonusers	Pre vs. post (users + nonusers)	Postusers vs. postnonusers
Benefits of HIT tool use					OR	OR	OR	OR
Easy to use during bed to bed handover	39 (75%)	13 (46.4%)	6 (54.5%)	7 (41.2%)	0.22*	0.13*	0.16*	0.58
More accurate updating falls risk information *cf.* current method	37 (75.5%)	17 (60.7%)	7 (63.6%)	10 (58.8%)	0.57	0.54	0.55	0.95
Updates falls risk information in a timely manner	36 (73.5%)	17 (60.7%)	8 (72.7%)	9 (52.9%)	0.89	0.43	0.62	0.48
Provides safer care for patients at risk of falls	39 (79.6%)	19 (67.9%)	9 (81.8%)	10 (58.8%)	1.15	0.43	0.70	0.37
Improves quality of patient care	43 (87.8%)	19 (67.9%)	9 (81.8%)	10 (58.8%)	0.63	0.23*	0.38	0.37
Improves staff's understanding of patients' falls risk factors	35 (71.4%)	12 (42.9%)	8 (72.7%)	4 (23.5%)	1.07	0.12*	0.36	0.12*
Effectively prevents falls	26 (53.1%)	7 (25%)	5 (45.5%)	2 (11.8%)	0.74	0.12*	0.29*	0.16
Allows more time for staff to attend to other duties	7 (14.3%)	3 (10.7%)	2 (18.2%)	1 (5.9%)	1.33	0.38	0.71	0.28
I will use this tool if it is made available	44 (89.8%)	21 (75%)	10 (90.9%)	11 (64.7%)	1.14	0.25	0.53	0.22
Barriers to implementing HIT tool								
Lack of time	19 (38.8%)	11 (39.3%)	6 (54.5%)	5 (29.4%)	1.90	0.66	1.11	0.35
Lack of familiarity with technology	14 (28.6%)	5 (17.9%)	3 (27.3%)	2 (11.8%)	0.94	0.33	0.56	0.36
Duplicates written work	22 (44.9%)	4 (14.3%)	3 (27.3%)	1 (5.9%)	0.46	0.08*	0.19*	0.17
Lack of usability	0 (0%)	6 (21.4%)	1 (9.1%)	5 (29.4%)	>100	>100	Undefined	4.17
Suggested tool improvements								
Providing tool feedback to staff	31 (63.3%)	4 (14.3%)	4 (36.4%)	0 (0%)	0.33	0.00	<0.01	<0.01
Providing educational presentations on tool to staff	19 (38.8%)	9 (32.1%)	8 (72.3%)	1 (5.9%)	4.21	0.10*	0.65	0.02*
Awarding CPD points to staff for attending tool education	15 (30.6%)	3 (10.7%)	3 (27.3%)	0 (0%)	0.85	0.00	<0.01	<0.01

cf., compared with; CPD, continuous professional development; HIT, health information technology; OR, odds ratio.
*$P \leq 0.05$, i.e. significant.

familiarity with tool technology (28.6%) (items 10, 11 and 12). No participants perceived the HIT tool as lacking usability (item 13).

Recommendations for refinement

Over 60% recommended providing regular feedback to clinicians to improve tool uptake (item 14, Table 1). A third felt regular staff education on tool use and awarding of CPD points for training attendance would help foster HIT tool use (items 14, 15 and 16)

Phase 3 (post-trial): Qualitative findings from focus group session

Clinicians' experience

Post-trial, all focus group participants had used the HIT tool. Participants A (tool use >10 times) and B (tool use 1–2 times) were the most verbal during discussion.

Positive perceptions

All participants were positive about the tool's benefits and wanted to continue using it after trial completion. It was perceived as beneficial to staff in being a visually appealing and useful *snapshot* of patients' falls risks. Participants A and B cited its benefit to patients and families as a teaching tool for falls risk and preventive strategies.

Negative perceptions and barriers to use

Competing clinical duties and time pressures on a busy ward were seen as barriers to tool use. One participant outlined these barriers extended to challenges ensuring visual cues were physically moved when patients were swapped into another bed. Participants A and B reported difficulties with technical aspects of the iPad application, including difficulties managing these bed swaps and surplus patient numbers, and re-entering the same medical record number and demographic details for returned patients.

Recommendations for refinement

Participants debated and decided against displaying extra falls risk information on visual cues, preferring to keep these uncluttered for simplicity and visual appeal. Having A4-sized black-and-white visual cues, as opposed to larger colored posters, was seen as appropriate given already cluttered bedside walls and ongoing printing costs. Participant B recommended coding high falls risk status as a red dot on visual cues, with an automatic trigger for staff to provide patients with printed information on falls prevention. Participants A and B requested an extra iPad device for more efficient and timely tool use.

Phase 3 (post-trial): Quantitative findings from survey participants

Post-trial, survey participants were mainly women (85.7%), nurses (92.9%), and had 10 years or less of clinical experience (67.8%). Half were aged between 18 and 39 years old (50%). More than half ($n=54$, 65.9%) of ward clinicians declined to participate, citing lack of use of, or recommendations for improving, the HIT tool.

Clinicians' experience

Of the 28 participants surveyed, 11 [eight (100%) AMU, three (15%) GEM] had used the HIT tool on researcher questioning. Most survey participants (60.7%) had not used the tool, mainly due to low uptake on GEM unit.

Positive perceptions

The majority of participants advocated ongoing use of the HIT tool in clinical practice (75%) and were positive about its accuracy, timeliness and facilitation of safer patient care (items 2, 3, 4 and 9, Table 1). Compared with pretrial, there were significantly lower numbers of nonusers who thought the tool was easy to use [odds ratio (OR) 0.13], improved quality of patient care (OR 0.23) or informed staff's understanding of patients' falls risk factors (OR 0.12) post-trial (items 1, 5 and 6, Table 1).

Negative perceptions and barriers to use

Participants identified the main barriers to tool use as lack of time to complete the tool (39.3%) and lack of tool usability (21.4%) (items 10 and 13, Table 1). Significantly, fewer participants thought duplication of written work was a barrier, post-trial vs. pretrial (OR 0.19, item 12).

Recommendations for refinement

The main recommendation for improvement was for staff education on the HIT tool (32.1%); however, this was less so among nonusers compared with users (OR 0.02, item 15, Table 1).

Discussion

The majority of clinicians advocated incorporating the HIT tool in clinical practice, both pretrial and post-trial, due to the benefits for staff and patients in hospital falls risk assessment and prevention. Pretrial, clinicians were positive about using a tool that incorporated visual cues and health technology, both well accepted methods of evaluating risk and preventing falls within literature.[20,34] Post-trial, most clinicians continued to view the HIT tool as useful to staff as an accurate, quick and timely means of assessing patients' falls risk. Indeed ease of workflow has been identified by clinicians as an advantage of incorporating EHR into clinical routine.[35] Clinicians within this study cited benefits to patients in facilitating safer, better quality care and increasing their knowledge of and participation in falls preventive strategies. This echoes previous research espousing the advantages of technology in promoting patient and family education and engagement in health care.[35]

Pretrial, clinicians were concerned about potential barriers to tool use being duplication of existing paperwork, lack of time for tool use, difficulties navigating new technology and workplace resistance to change. Paperwork duplication and time constraints are well documented barriers to clinicians using EHRs.[36,37] Systematic review evidence has shown technical concerns and opposition to change are frequently cited barriers to EHR adoption.[38] Addressing nihilistic staff attitudes and workplace resistance to change have proved important in the success of many hospital falls prevention programs.[20,39,40]

Post-trial, clinicians criticized the HIT tool in terms of lack of usability, lack of time to use it amidst competing clinical duties and lack of clinical effectiveness in preventing inpatient falls. Usability has been shown to be a key factor in determining user acceptance of health technology.[41,42] Software difficulties are known barriers to using technology in falls prevention programs,[20,43] with users often requesting increasingly sophisticated software function over time.[44] Similar to our findings, a previous qualitative study found clinicians viewed EHRs negatively as *one more thing to do* in an already overburdened healthcare system, felt time constraints limited their use and wanted technology to accommodate heavy patient volumes and busy clinical workloads.[45]

The perceived barriers of lack of usability and time to use the tool were reflected in clinicians' recommendations for technological refinement of the iPad application and provision of another iPad device for more efficient tool completion. User engagement and feedback have been used to refine the HIT tool as part of action research methodology,[46–48] by improving technology, color coding falls risk, having an automated patient education trigger and providing an additional iPad device. Other recommendations for improving tool uptake included providing staff education, a key component of many effective hospital falls prevention programs,[20] and ensuring leadership endorsement, an important factor in sustaining best nursing practice.[49]

Strengths and limitations

Despite user attitudes being a major factor in intervention uptake,[20] there remains a gap in knowledge on staff perspectives of health technology use in falls assessment and prevention.[19] This article adds to the depth and richness of understanding of this area, through the employment of mixed-methods design.[50] Research limitations included small sample size, single hospital setting, poor response rate, lack of consistency in participant follow-up and incomplete data on which participants took the survey on both occasions and how many times they had used the tool. Sample sizes and withdrawal rates within this pilot study, were influenced by the pragmatics of recruitment and the need to assess study feasibility.[51] In addition, items developed for survey data collection (based on interviews with five focus group participants) may not have been representative of all relevant issues. These survey biases may limit generalizability of outcomes and comparison of pretrial and post-trial results. Additional biases may have been introduced by focus group participants' reluctance to provide their opinions, due to researcher presence and concerns about workplace implications, and researcher bias in interpreting textual responses to match preconceived notions.

Future research directions

The refined HIT tool will be retrialed on the wards, with future research directed at evaluating clinicians' use and perspectives, and clinical effectiveness in falls avoidance, of this improved HIT tool. The HIT tool could be implemented in healthcare facilities with high prevalence of falls, and among those patients who are at high falls risk, such as older persons and those in residential care. Ensuring the same clinicians participate in pretrial and post-trial focus group discussions and surveys would enhance the robustness of data gathered. In addition, greater depth of information may be elicited by including patients and caregivers in discussion, conducting personal interviews and discussing one topic per focus group session.

Conclusion

The findings from this study contributed to the limited pool of evidence on clinicians' perspectives toward health technology use in falls prevention. Clinicians were willing to use the HIT tool, identifying benefits to themselves and patients. Their concerns about usability and time constraints were addressed in ongoing tool refinement, with technological improvement and provision of an additional iPad device for more efficient use. Including end-users in development processes, as well as having high staff uptake, are important in improving the acceptance and usage of new technologies, and in maximizing beneficial feedback to further inform tool development. Further research directions may include evaluating clinicians' and patients' perspectives of the refined HIT tool, and evaluating its clinical effectiveness in hospital falls prevention.

Acknowledgements

Conflicts of interest

The authors report no conflicts of interest.

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Chapter 6: Use and efficacy of the Health Information Technology tool

Summary

While the previous Chapter 5 outlined clinicians' perspectives towards the HIT tool, Chapter 6 presents a published paper on how clinicians used the HIT tool, as compared to the standard usual falls risk screening instrument. It evaluated the correlation between these two tools, and assessed the HIT tool in its accuracy in assessing falls risk and efficacy in preventing inpatient falls incidents. Overall the HIT tool was comparable in terms of acceptability, scoring and accuracy to standard measures, with both tools demonstrating gaps in completion and high sensitivity but low specificity for detecting falls in hospital. The research findings validated previous literature describing the challenges of assessing and addressing falls risk, with mixed outcomes on hospital fall rates. The study results have informed further refinement of the HIT tool to improve its uptake and clinical use.

Paper 3: Use and clinical efficacy of standard and health information technology falls risk assessment tools (published paper)

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Brief Report

Use and clinical efficacy of standard and health information technology fall risk assessment tools

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Objective: *To evaluate the health information technology (HIT) compared to Fall Risk for Older Persons (FROP) tool in fall risk screening.*

Methods: *A HIT tool trial was conducted on the geriatric evaluation and management (GEM, n = 111) and acute medical units (AMU, n = 424).*

Results: *Health information technology and FROP scores were higher on GEM versus AMU, with no differences between people who fell and people who did not fall. Both score completion rates were similar, and their values correlated marginally (Spearman's correlation coefficient 0.33, P < 0.01). HIT and FROP scores demonstrated similar sensitivity (80 vs 82%) and specificity (32 vs 36%) for detecting hospital falls. Hospital fall rates trended towards reduction on AMU (4.20 vs 6.96, P = 0.15) and increase on GEM (10.98 vs 6.52, P = 0.54) with HIT tool implementation.*

Conclusions: *Health information technology tool acceptability and scoring were comparable to FROP screening, with mixed effects on fall rate with HIT tool implementation. Clinician partnership remains key to effective tool development.*

Practice Impact: The health information technology tool, incorporating iPad™ and automatically generated visual cues, was created in partnership with hospital clinicians. It represents a viable technology alternative to poorly received bedside posters and is comparable in accuracy and acceptability to existing falls risk assessment tools, in targeting falls risk among inpatients.

Key words: *accidental falls, electronic health records, patients, risk assessment, technology.*

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Introduction

Falls in hospitals are common and result in significant morbidity, mortality and health-care utilisation [1]. The reported fall incidence is rising [2], possibly representing improved reporting and/or altered patient profiles [2]. To address this problem, many hospitals screen for fall risk with fall risk assessment tools [3–5]. The evidence from systematic reviews, however, is inconsistent for their validity and accuracy, with mixed results for screening tools' efficacy in reducing falls [3–5]. Thus, there is the need to develop accurate and effective fall risk screening measures.

The Fall Risk for Older Persons in the Community (FROP-Com) assessment tool is validated for screening fall risk among emergency department patients aged 65+ years [6]. The abbreviated 3-item FROP is currently utilised as mandatory paper-based screening at The Queen Elizabeth Hospital (TQEH), with scores ≥4/9 selected as the cut-off to trigger staff implementation of fall-preventive measures [7].

The use of modern health technology, such as a fall prevention toolkit incorporating electronic health record (EHR), bedside posters, patient education and care plans [8], would seem to have potential to improve the value of fall risk screening and management, but there are inadequate data on the efficacy and staff uptake of this form of technology [9].

We hypothesised health technology would support best practice fall prevention. Mindful of negative staff feedback on the usability of existing paper posters using coloured adhesive dots to indicate fall risk, and with a new EHR system due to roll-out statewide, we collaborated with clinicians at the geriatric evaluation and management (GEM) unit at TQEH in Adelaide, South Australia, to develop a health information technology (HIT) tool to support direct iPad™ entry of clinicians' judgement of patients' fall risk. Research objectives were to evaluate HIT tool acceptability, correlation with FROP, accuracy and clinical efficacy, to guide further tool refinement.

Methods

Ethics approval was received from the Human Research Ethics Committee of Basil Hetzel Institute (HREC/13/TQEHLMH/66). The study was conducted over consecutive 12-week periods on acute medical unit (AMU; September–November 2014), managing patients with acute illness; and GEM unit (June–August 2014), providing subacute rehabilitative care for patients predominately extracted from AMU at TQEH. All patients admitted to both wards during the trial period were included, with GEM information alone analysed for those initially admitted to AMU.

The responsible clinician carried the iPad™ and directly entered patients' details and their personal judgement of day- and night-time fall risk for 13 movement and location types, with total fall risk items equating HIT score out of 13 (high-risk defined as ≥12/13 as per maximal sensitivity and specificity for falls). Black-and-white A4-sized visual cues (i.e. bedside posters) were automatically printed at assessment completion, and the same clinician displayed these by patient's bedside, with the eventual aim to incorporate these into EHR. GEM staff utilised the full six weeks of researcher-led training and chose to use the HIT tool on admission and where fall risk changed (e.g. postfall), while AMU staff declined training after one day, due to staff confidence using the HIT tool, and utilised it daily on all patients. FROP evaluation continued as standard procedure on ward admission.

Health information technology and FROP scores were recorded at admission. The following outcomes were looked at:

Acceptability: average percentage of fortnightly HIT and FROP score completion rates, over total patient numbers.

Correlation of HIT and FROP scores: average percentage of similar fall risk factors identified on HIT (requirements for walking aid, supervision in toilet/shower/corridor) and FROP screening (falls, function, balance); and correlation between HIT and FROP scores.

Clinical efficacy: hospital fall rates (i.e. total inpatient falls per 1000 occupied bed-days (OBD; total beds occupied multiplied by total days occupied [10])) recorded by hospital incident reporting systems, before (two-week period), during (12-week period) and after (two-week period) HIT tool trial.

Accuracy: sensitivity, specificity, positive likelihood ratio (PLR) and negative likelihood ratio (NLR), positive predictive value (PPV) and negative predictive value (NPV) and area under the curve (AUC) measurements of high-risk HIT (defined as ≥12/13 as per maximal sensitivity and specificity) and FROP (previously defined as ≥4/9 [7], as per maximal sensitivity and specificity) scores in detecting hospital falls.

Patient and fall data, HIT and FROP score values, correlation and accuracy were presented as descriptive statistics. Independent t-testing compared mean values, chi-square analysis compared proportions and Spearman's correlation evaluated the association between scores ($P \leq 0.05$). Sensitivity, specificity and likelihood ratios were obtained for HIT and FROP tools. Statistical analysis was performed using SPSS 10 and MedCalc Statistical Software version 16.4.3.

Results

Patient characteristics

Compared to AMU patients ($n = 424$), GEM patients ($n = 111$) were older; had longer lengths of stay; and had greater incidence of walking aid use, polypharmacy and geriatric syndromes (Table 1).

HIT and FROP score values

There were no differences between people who fell and people who did not fall for HIT (9.92 ± 4.47 vs 10.00 ± 4.40, $P = 0.12$) and FROP scores (4.50 ± 2.78 vs 4.50 ± 2.77, $P = 0.65$). GEM patients had higher mean HIT (11.57 ± 2.71 vs 9.50 ± 4.77, $P < 0.01$) and FROP scores (5.47 ± 2.16 vs 4.20 ± 2.83, $P < 0.01$) than AMU patients (Items 1 and 2; Table 1).

Acceptability of HIT assessments

Fall risk for older persons and HIT score completion rates were equivalent (70 vs 63%, $P = 0.47$), with HIT score completion rates trending higher on GEM compared to AMU (70 vs 61%, $P = 0.08$; Item 1; Table 2).

Correlation between HIT and FROP scores

HIT and FROP screening agreed on half the same fall risk items, and scores correlated marginally (Spearman's correlation coefficient 0.33, $P < 0.01$; Item 2; Table 2).

Accuracy of HIT and FROP scores

HIT scores ≥4/9 and FROP scores ≥12/13 demonstrated greatest combined sensitivity and specificity for detecting hospital falls (sensitivity 80 vs 82%, specificity 32 vs 36%). HIT scores demonstrated higher PLR (0.89, 1.35); higher NLR (1.33, 0.49); and similar PPV (1, 2%), NPV (98, 99%) and AUC (0.55, 95% confidence interval (CI) 0.38–0.71; 0.50, 95% CI 0.34–0.67) as FROP scores (Item 3; Table 2). There was reduced predictive value for falls for both scoring systems.

Clinical efficacy of HIT scores

There was a trend towards reduced hospital fall rates on AMU (pretrial vs post-trial 8.80 vs 4.20 falls per 1000 OBD, $P = 0.15$), and higher rates on GEM (5.98 vs 10.98, $P = 0.54$; Item 4; Table 2) with HIT tool implementation, although these values did not reach statistical significance. One-third of hospital fall incident data were incomplete for details of patient and fall.

Table 1: Comparison of patient characteristics on acute medical unit and geriatric evaluation and management wards

	Total (n = 535)	AMU (n = 424)	GEM (n = 111)	P-value (AMU vs GEM)
HIT score (week 1), mean ± SD	10.00 ± 4.48	9.52 ± 4.74	11.57 ± 2.68	<0.01*
People who fell	11.57 ± 3.37	10.86 ± 4.81	12.29 ± 0.49	
People who did not fall	9.92 ± 4.47	9.47 ± 4.75	11.50 ± 2.82	
P-value (people who fell vs people who did not fall)	0.12	0.36	0.43	
FROP score (week 1), mean ± SD	4.50 ± 2.77	4.26 ± 2.86	5.40 ± 2.18	<0.01*
People who fell	4.20 ± 2.68	N/A due to lack of data	4.20± 2.68	
People who did not fall	4.50 ± 2.78	4.26 ± 2.86	5.56 ± 2.12	
P-value (people who fell vs people who did not fall)	0.65	N/A	0.09	
Gender, *n* (%)				
Female	323 (60)	251 (59)	72 (65)	0.16
Male	208 (39)	171 (40)	37 (33)	
Age, in years (mean ± SD)	75.44 ± 14.60	76.22 ± 15.50	85.02 ± 6.01	<0.01*
Medications, *n* (%) (Number (proportion) with polypharmacy, defined as ≥5 discharge medications [16])	400 (75)	303 (71)	97 (87)	<0.01*
Function, *n* (%)				
Walking aid preadmission	368 (69)	268 (63)	100 (90)	<0.01*
Walking aid during admission	392 (73)	292 (69)	100 (90)	<0.01*
Presenting problem, *n* (%)				
Falls	137 (26)	82 (19)	55 (50)	<0.01*
Functional decline	45 (8)	18 (4)	27 (24)	<0.01*
Delirium	71 (13)	44 (10)	27 (24)	<0.01*
Cognitive and behavioural	40 (7)	28 (7)	12 (11)	0.01
Pain	99 (19)	78 (18)	21 (19)	0.99
Infection	278 (52)	217 (51)	61 (55)	0.02*
Charlson Comorbidity Index (mean ± SD) [17]	6.26 ± 2.66	6.19 ± 2.81	6.62 ± 1.99	0.140
Length of stay, in days (mean ± SD)	9.63 ± 11.31	6.54 ± 6.17	21.04 ± 16.93	<0.01*
Place of residence on admission, *n* (%)				
Home	457 (85)	351 (83)	106 (96)	<0.01*
Residential care	70 (13)	67 (16)	3 (3)	<0.01*
Place of residence on discharge, *n* (%)				
Home	295 (55)	239 (56)	57 (51)	0.99
Residential care	79 (15)	65 (15)	13 (12)	0.91
Other hospital or ward	100 (19)	77 (18)	4 (4)	0.01*
TCP	21 (4)	0 (0)	21 (19)	<0.01*
Respite	6 (1)	1 (0)	5 (5)	<0.01*
Death	20 (4)	15 (4)	4 (4)	1.00

*$P < 0.05$, that is significant. AMU, acute medical unit; GEM, geriatric evaluation and management; HIT, health information technology; N/A, not applicable; SD, standard deviation; TCP, transitional care posthospitalisation (short-term care services for restoring independence to older persons posthospitalisation [18]).

Discussion

The HIT tool demonstrated similar acceptability, score correlation and accuracy in predicting hospital falls as FROP, although predictive value for both scoring systems was poor. With the benefits of technology and automatically generated visual cues, the HIT tool represents a viable alternative to existing paper-based fall risk screening, which has been poorly received and used by health-care staff.

Clinicians' acceptability of the HIT tool trended higher on GEM compared to AMU, possibly due to longer staff training period, and greater senior nursing endorsement and involvement in tool design. Systematic review evidence has shown staff engagement and leadership support to be crucial to successfully implementing fall-preventive strategies [9].

Suboptimal HIT tool use may have been due to reduced clinicians' confidence in its use and efficacy [11]. By comparison, incomplete FROP and fall incident reporting supports previous research that 64% of mandatory hospital admission fall risk assessments [12] and 75% of hospital fall incidents [13] are recorded in Australia.

HIT and FROP scores did not distinguish between people who fell and people who did not fall. There was a reduced hospital fall rate on AMU with HIT tool implementation, although this did not achieve statistical significance, with opposing effect on GEM. Potential reasons for the mixed effect included staff (e.g. level of clinical experience in implementing preventive strategies) and patient-related factors (e.g. frailty) not accounted for in study analysis.

Table 2: Fall risk for older persons and health information technology score completion rates, correlation, accuracy and clinical efficacy on acute medical unit and geriatric evaluation and management wards

Score	Total (n = 540)	AMU (n = 424)	GEM (n = 116)	P-value (AMU vs GEM)
Score completion rates, %				
FROP	70	71	65	0.19
HIT	63	61	70	0.08
P-value for FROP versus HIT completion rates	0.47	0.53	0.88	N/A
Correlation of HIT and FROP scores				
Average percentage of similarly identified fall risk factors, %	55	44	66	0.30
Spearman's correlation for FROP and HIT scores, P-value	0.33, <0.01*	0.39, <0.01*	−0.01, <0.01*	N/A

	FROP score (≥4/9)	AMU (falls/1000 OBDs)	HIT score (≥12/13)
Accuracy			
Sensitivity (95% CI)	80 (28–99)		67 (9–99)
Specificity (95% CI)	41 (35–47)		25 (20–31)
Positive likelihood ratio (95% CI)	1.35 (0.86–2.12)		0.89 (0.40–1.98)
Negative likelihood ratio (95% CI)	0.49 (0.08–2.84)		1.33 (0.27–6.70)
Positive predictive value (95% CI)	2 (1–4)		1 (0–2)
Negative predictive value (95% CI)	99 (95–100)		99 (93–100)
Area under curve (95% CI)	0.55 (0.38–0.71)		0.51 (0.34–0.67)
Falls/1000 OBD			
Pretrial	7.23	8.80	5.98
Trial	6.71	6.96	6.52
Post-trial	8.00	4.20	10.98
P-value (trial vs pretrial)	0.58	0.84	0.80
P-value (trial vs post-trial)	0.32	0.15	0.54

*P < 0.05, that is significant. AMU, acute medical unit; CI, confidence interval; FROP, Falls Risk for Older Persons; GEM, geriatric evaluation and management; HIT, health information technology; N/A, not applicable; OBD, occupied bed-days.

Our findings support systematic review evidence that current screening tools are inadequate for predicting falls among older patients [3–5], possibly due to clinical fluctuations among this cohort [3], lack of inclusion of relevant risk factors [14] and need for local adaptation of screening tools [15]. It remains unclear whether improving tool accuracy would reduce fall rates.

Strengths and limitations

This study adds to the limited knowledge on the acceptability and clinical efficacy of a HIT in fall risk screening and management. The ongoing clinician partnership has refined the design and use of the HIT tool design. Study limitations included single-hospital setting and incomplete score and fall incident reporting, which further highlights the importance of clinician collaboration in developing acceptable, effective fall risk screening tools.

Conclusion

The HIT tool represents a fall risk screening technology tool developed in partnership with clinicians and comparable in acceptability, scoring and accuracy to mandatory FROP screening. HIT tool use was higher on the subacute ward, which had greater leadership endorsement and staff involvement in tool design. Our study highlighted the challenges of inpatient fall risk screening (incomplete reporting, low predictability for fall and mixed effects on hospital fall rates) and informed HIT tool refinement for future implementation.

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Chapter 7: Discussion and Conclusion

7.1 Introduction

This concluding chapter summarises the main findings of this thesis. It discusses the implications of research findings and recommend future research directions to maximise study outcomes. This thesis addressed the problem of hospital falls prevention, and contributed to the gap in knowledge about the efficacy and acceptability of falls risk screening and preventive interventions. The research conducted offers new insights into clinicians' perspectives and the effectiveness of the health information technology (HIT) tool, incorporating iPad™ device and automatically generated visual cues, in screening falls risk situations and avoiding inpatient falls. Ultimately, the goal was to develop and refine a health technology strategy to be acceptable, usable and effective in preventing falls in hospital.

7.2 Key findings and recommendations for practice, policy and research

Chapter 4 set the research framework by presenting a published integrative review that demonstrates for the first time, the significant gap in knowledge about the efficacy and acceptability of health technology tools in falls prevention [230], with only single-study support for multicomponent strategies [261, 262], and a lack of consistent, robust data on single-component interventions [234, 263, 417]. This deficiency in literature offered the background and rationale to subsequent research within the thesis on the perceptions and efficacy of the HIT tool. The review also confirmed previous research demonstrating the importance of end-user collaboration in developing and successfully integrating any new interventions and practice change [260].

Chapter 5 presented a published report on clinicians' perspectives of the HIT tool, incorporating an iPad™ device and automatically generated visual cues as a health technology intervention to screen inpatient scenarios associated with falls risk. Hospital clinicians were familiar with using visual cues in falls prevention. It was perceived as a fun, accurate and timely means of screening for falls risk conditions; to improve quality of patient care; and to provide greater understanding of falls risk for patients and their families. However, non-users of the HIT tool did not perceive it as improving staff's understanding of patients' falls risk factors or effectively preventing hospital falls. This validated previous literature that clinician engagement is vital to increase uptake and contribute to design and implementation of health technology tools [260].

Consistent with action research methodology, clinicians' feedback about the usability and acceptability of the HIT tool were incorporated into its redesign. The improved HIT tool has better technology, clearer function of selection keys, colour coding of patients' falls risk statuses for easier identification, automated patient education triggers to facilitate learning, and provision of an additional iPad™ device for efficiency. The recommendations for staff education and leadership endorsement were also integrated into the roll out of the new intervention tool. The study provided further confirmation of existing literature that user feedback and collaborative approach to development of new interventions is vital to their successful and effective inclusion into clinical practice [260].

To complement the study presented in Chapter 5, Chapter 6 highlighted a published paper investigating the use, accuracy and effectiveness of the HIT tool. It provided evidence of similar clinician acceptability, score correlation, and accuracy in predicting hospital falls-risk situations, for the HIT tool compared to the standard falls risk screening tool. Both these tools demonstrated high sensitivity and low specificity for identifying these falls-risk scenarios. The study further affirmed previous research outlining the complexities of falls risk screening tools in measuring risk and effectively reducing fall rates [196, 200, 220], with higher scores on the subacute compared to acute ward, no difference in scores between fallers and non-fallers, and mixed outcomes in falls data with tool implementation. The research findings also supported current evidence that practice change often lags behind implementation of best practice guidelines [418], with incomplete completion of the mandatory falls risk screening tool and falls incident documentation by hospital clinicians.

7.3 Significance of this thesis

Taken in its entirety, this thesis contributes to the limited knowledge on the use of health technology within the field of falls risk assessment and prevention. It presents new information on the HIT tool that incorporates elements of health technology and visual cues previously found to be effective in a

RCT [261], and is designed and refined with clinician collaboration. Acceptability and accuracy of the HIT tool are comparable to the standard falls risk screening tool. Clinicians wish to continue using the HIT tool in daily practice, and acknowledge benefits to themselves and their patients. Through the process of action research methodology, clinicians remained actively involved in the research process, practice change, and ongoing tool development, to maximise useful feedback and facilitate tool uptake. Ongoing end-user participation in tool refinement has contributed to the development of the novel AmbiGEM system which builds on recommendations for improved technology and efficient workflow processes.

7.4 Strengths and limitations

Best research practice takes steps to ensure reliable data collection and reporting. Overall, many strengths of the research have contributed to its success. These included generating new knowledge about an area with limited evidence in current literature [348]. Researchers gave participants a voice by obtaining data directly from them, and gained knowledge in local settings to facilitate practical problem solving [348]. Action research methodology was applied to allow participant collaboration in research process and practice change [348]. Using mixed-methods research provided greater depth and robustness of data collected, and wider application of study findings [403]. While employing focus group research enabled deeper exploration of issues in a less-threatening environment, and reduced financial costs [398]. The accuracy of the transcription of the focus group sessions was enhanced by verifying written with verbal recordings of the discussions.

The research limitations that may have had bearing on study outcomes included difficulties surrounding participant recruitment and retainment, partly due to workplace demands, which reflected the challenges of conducting research in real-world settings. Focus group discussion may have been potentially biased due to participant selection, owing to recruitment difficulties, and dominated by outspoken persons. The latter was addressed by the researcher supervising and directing discussion session. While survey data did not record participants' level of experience using the HIT tool, although this was captured in focus group discussions. Additionally, one coder conducted the qualitative research which represented a potential limitation in introducing individual observer/recorder bias.

7.5 Future research directions

Future research directions may benefit from further exploration of issues raised in this thesis, regarding evaluating the perspectives of clinicians and other interested stakeholders, along with addressing current study limitations by:

i. Facilitating follow up of the same participants pre- and post-trial, potentially by offering incentives such as allocation of continuous professional development points, to allow more direct comparison of clinicians' perspectives before and after tool implementation.

ii. Including focus group participants from a wider scope of clinicians, patients and their families, to achieve a greater breadth of perspectives. Conducting one-on-one discussions and concentrating on specific topics for each session may promote greater depth of understanding.

iii. Recording level of clinical and aged care experience for all study participants, and evaluating the influence of such experience on research outcomes, including the use and clinicians' perspectives of falls preventive health technology.

The work arising from this thesis has informed the development of the hand held android device used in the Ambient Intelligence Geriatric Management (AmbiGEM) system. This system incorporates radio frequency identification and accelerometer sensing platform to predict and alert caregivers to high-risk situations predisposing to a fall [419]. These scenarios are customised for the individual person and environment, so that a movement sensor alarm is triggered if risky movements are noted, such as rising off a chair or bed without a carer present in the room, with printed visual cues to notify caregivers of high-risk situations [419].

Funded by the National Health and Medical Research Council of Australia, the AmbiGEM system is currently undergoing a pragmatic stepped wedge clinical trial at the Queen Elizabeth Hospital in South Australia and Sir Charles Gairdner Hospital in Western Australia. The refined intervention, arising from the contributions of this thesis and feedback from clinicians from both hospital sites, will require further evaluation as to its acceptability and usability by clinicians, patients and their families or carers. There is a patent application pending for this invention, entitled "A system, method and software application for determining movement' [419].

7.6 Conclusion

This final chapter highlights the key findings and recommendations for practice and research within each section of the study, alongside the strengths and limitations of this Master's program of research. The most important findings are that the HIT tool incorporates best practice elements of health technology and bedside visual cues, and offers an acceptable strategy in falls prevention. Having user feedback within an action research framework has led to the refinement of the intervention in terms of better technology, usability and efficiency, which have contributed to the development of the novel AmbiGEM system, which is currently undergoing clinical trial. This improved system has drawn on the findings within this thesis and clinicians' feedback to provide automatic generation of visual cues and activation of sensor alarms, to promote efficient workflow processes. Working together with clinicians to evaluate the usability, acceptability and efficacy of this refined system presents an exciting new research direction. Ultimately the aim is to provide clinicians and patients with a usable and effective intervention to reduce the incidence of falls within our hospitals.

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08 August 2013

Dr Ruth Teh
Clinical Lecturer
University of Adelaide

Dear Dr Teh

HREC reference number: HREC/13/TQEHLMH/66
Project title: Implementing Visual Cues for Falls Prevention in an Acute Medical Unit (AMU), Geriatric Management and Evaluation Unit (GEMU) and Transitional Care Program (TCP) facilities - Perspectives of Aged Care Staff.

RE: HREC/13/TQEHLMH/66 - Ethics Application Approval

Thank you for submitting additional information received on 31 July 2013 in relation to the above project for ethical and scientific review.

The Chairman has reviewed your response, and I am pleased to advise that your protocol has been granted full ethics approval and meets the requirements of the *National Statement on Ethical Conduct in Human Research*. The documents reviewed and approved include:

Document	*Version*	*Date*
Application: LNR Proposal for Research: • The Queen Elizabeth Hospital		25 July 2013
Master Participant Information Sheet and Consent Form		25 July 2013
Participant Recruitment Brochure	unknown	
Questionnaire/s: Previously Validate Questionnaire on Technology Tool	unknown	
Response to Request for Further Information		30 July 2013
Response to Request for Further Information		04 June 2013

HREC approval is valid from **08 August 2013 to 08 August 2014.**

Please note the following conditions of approval:

1. Researchers are required to immediately report to this HREC anything which might warrant review of ethical approval of the protocol, including:
   a. serious or unexpected adverse effects on participants;
   b. proposed changes in the protocol; and
   c. unforseen events that might affect continued ethical acceptability of the project.
2. Protocols are approved for up to twelve months only and a report is required at the end of the study or 12 month period. Extensions will not be granted without a report to the Committee.
3. Confidentiality of the research subjects shall be maintained at all times as required by law.
4. All research subjects shall be provided with a Participant Information Sheet and Consent Form, unless otherwise approved by the Committee.
5. The Participant Information Sheet and Consent Form shall be printed on the relevant site letterhead stating the contact details for the researchers.

6. A report and a copy of any published material should be forwarded to the Committee at the completion of the project.

This Committee is constituted in accordance with the NHMRC's *National Statement on the Ethical Conduct of Human Research* (2007).

Should you have any queries about the HREC's consideration of your project please contact Ms Melissa Kluge on 08 8222 6841 or qeh.ethics@health.sa.gov.au

You are reminded that this letter constitutes ethical approval only. You cannot commence this project until you receive site authorisation from the CEO or delegate, even if ethics approval is received.
To obtain site authorisation, a separate Site Specific Assessment (SSA) application should be made to each site involved in the study, through the Site's Research Governance Officer.
For more information, please visit: http://www.basilhetzelinstitute.com.au/research/research-ethics-governance/governance-site-specific-assessments-ssa-

The HREC wishes you every success in your research.

Yours sincerely

A/Professor Timothy Mathew
Chairman, Human Research Ethics Committee (TQEH/LMH/MH)

TM:mk

Appendix 2: Information brochure and consent form for focus group participants

Can technology help us prevent falls?

Falls have a significant impact on our health, lifestyle and finances.

As healthcare professionals, we are always looking for ways to improve patient care. We would like to find out about current practices around falls risk assessment, and to trial a health information technology (HIT) tool for falls risk assessment in your ward/facility and know how useful and acceptable you find it.

Who am I?

My name is Ruth Teh and I am an advanced trainee in Geriatric Medicine at the Queen Elizabeth Hospital. I am undertaking this study as part of my Masters of Philosophy degree.

Who can be involved?

- Any senior healthcare professional (nursing, medical, physiotherapy) with ≥5 years clinical experience.
- Currently working in the Acute Medical Unit or Geriatric Evaluation and Management Unit (GEMU) at the Queen Elizabeth Hospital.

What is involved for me?

- You will be asked to participate in a discussion group with other senior clinicians regarding current falls risk assessment practices, ways for improvement, and the possible role of a HIT tool.
- The discussion group will take about an hour at the CNC office on GEMU.
- Being in this study is voluntary and you may withdraw at any time.

Possible benefits?

- Finding ways of improving current falls risk assessment practices.
- Providing clinicians with a falls prevention tool they can use in their everyday clinical care
- Hopefully reducing patient falls and injuries.

Any inconvenience/discomfort?

- There should not be any inconvenience/discomfort to you.
- Data collected will not be passed on to the hospital where you are working.
- Study costs will be borne exclusively by the Hospital Research Fund.

Interested?

- Please indicate your interest by recording your details at the back of this brochure and returning it to the Indication of Interest box located in your ward/facility.
- One of the research investigators will be in contact with you about participating in the discussion group.

Yes, I agree to participate in the study "Visual Cues in Falls Assessment". Please contact me about participating in a discussion group about falls assessment.

Name: ___________________________

____

Ward: _________________________________

____

Contact Details (email/phone/pager):

____

____

Questions?

Please contact Ruth Teh on:

08 8222 6000 (pager 47751) or

08 8313 2144

THE UNIVERSITY of ADELAIDE

Government of South Australia

Study Investigators:

Dr Ruth Teh,

Assoc. Prof. Renuka Visvanathan

Mahajan, Neha; Wilson, Anne;

Hoskins, Stephen; Berry, Sharon

Appendix 3: Questionnaire for focus group participants

Dear Participant,

Thank you for participating in this Focus Group looking at the implementation of the iPad™ and bedside posters in falls assessment and prevention. The purpose of this focus group is to evaluate the acceptability and usability of this new technology tool and to provide recommendations on how to improve it for future use.

If you have any queries regarding completing this study, please do not hesitate to ask Dr Ruth Teh on (08) 822 8178 or (08) 8222 6000.

Background information about yourself:

(Please respond to all items by ticking the appropriate boxes or writing in the space provided).

Gender:	Male	□
	Female	□
Age:	18 to 29 years	□
	30 to 39 years	□
	40 to 49 years	□
	50 to 59 years	□
	60 to 69 years	□
	70+ years	□
Discipline:	Nursing	□
	Other	□

Main role:	Registered Nurse	□	
	Enrolled Nurse	□	
	Clinical Nurse Coordinator	□	
	Other	□	(Please specify) ______________________

Years of Experience in Health Care:

	0 to 5 years	□
	5 to 10 years	□
	10 to 15 years	□
	15 to 20 years	□
	20+ years	□

Years of Experience in Aged Care:

	0 to 5 years	□
	5 to 10 years	□
	10 to 15 years	□
	15 to 20 years	□
	20+ years	□

Number of Times I used the iPad on the Ward:

	Never	□
	1-2 times	□
	3-5 times	□
	6-10 times	□
	>10 times	□

Appendix 4: Focus group discussion guide

Welcome and Introduction

Thanks for agreeing to be part of the focus group. We appreciate your willingness to participate.

Introduce investigators.

Please fill out demographics information and pass it back.

Purpose of Focus Group

The reason we are having this focus groups is to find out what the current falls risk assessment and prevention practices are, and to understand your views about the iPad™ tool and bedside poster that is being introduced to the GEMU and AMU wards at Queen Elizabeth Hospital. We value your opinions and would like you to share your thoughts with us.

Ground Rules

1. We want you to do the talking.
a. We would like everyone to participate so I may call on you if I haven't heard from you for a while.
2. There are no right or wrong answers.
a. Every person's opinions and experiences are important.
b. Please speak up whether you agree or disagree.
3. We will be tape recording the session and taking some brief notes.
a. Please let us know if you have any objections beforehand.
b. We want to be able to capture everything that you say but will not identify anyone by name in our report. What is said in this room remains confidential.
c. For that reason, please speak one at a time for our recording.

Focus Group questions

1. What is your experience of current falls assessment and prevention strategies?
2. What strategies for falls prevention have been beneficial and why?
3. What strategies for falls prevention have not been helpful and why?
4. Do you consider there to be any gaps in falls assessment and prevention?

5. What is your experience, if any, of this HIT tool in falls assessment and prevention?
6. What aspects of the HIT tool do you like the most?
7. What aspects of the HIT tool do you like the least?
8. If you could change something about the HIT tool, what would that be?
9. Do you have any other advice for us as we introduce this HIT tool?

Closing

Thank everyone.

Give out certificate of participation.

Appendix 5: Information brochure for survey participants

Can technology help us prevent falls?

Falls have a significant impact on our health, lifestyle and finances.

As healthcare professionals, we are always looking for ways to improve patient care. We would like to trial a health information technology (HIT) tool for falls risk assessment in your ward/facility, and to know how useful and acceptable you find it. Our goal is to prevent falls and injuries.

Who am I?

My name is Ruth Teh and I am an advanced trainee in Geriatric Medicine at the Queen Elizabeth Hospital. I am undertaking this study as part of my Masters of Philosophy degree.

Who can be involved?

- Any healthcare professional working in the Acute Medical Unit or Geriatric Evaluation and Management Unit at the Queen Elizabeth Hospital.

What is involved for me?

- You will be asked to complete a confidential written questionnaire.
- It will take about 10 minutes.
- You will not be asked to provide your name or personal details.
- Being in this study is entirely voluntary and you are under no obligation to participate. You may withdraw at any time.
- Completed questionnaires can be handed in to a returns box in your ward/facility.

Possible benefits?

- Providing clinicians with a falls prevention tool they can use in their everyday clinical care to hopefully reduce patient falls and injuries.

Any inconvenience/discomfort?

- There should not be any inconvenience/discomfort to you.

- Data collected will not be passed on to the hospital where you are working.
- Study costs will be borne exclusively by the Hospital Research Fund.

Interested?

- Please indicate your interest by recording your details at the back of this brochure and returning it to the Indication of Interest box located in your ward/facility.
- One of the research investigators will be distributing copies of the questionnaire in a week's time.

Questions?

- Please contact Ruth Teh on: 08 8222 6000 or

  08 8313 2144

Yes, I am interested in participating in the study "Visual Cues in Falls Assessment". Please provide me with a written copy of the questionnaire.

Name: ___________________________

____

Ward: _________________________________

____

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SA Health

Appendix 6: Explanatory statement and consent for survey participants

VISUAL CUES IN FALLS RISK ASSESSMENT

Investigators: Teh, Ruth; Arunasalam, Haresh; Visvanathan, Renuka; Mahajan, Neha; Wilson, Anne; Hoskins, Stephen; Berry, Sue; Wood, Jackie; Yu, Solomon; Griggs, Kim

PARTICIPANT INFORMATION SHEET

Dear Healthcare Professional,

We invite you to participate in a research project which we believe is of potential importance. However, before you decide whether you wish to participate, we need to be sure that you understand

Why we are doing it, and

What it would involve if you agreed.

We are therefore providing you with the following information. Please read it carefully and be sure to ask any questions you have. The Doctor conducting the research will be happy to discuss it with you and answer any questions that you may have. You are also free to discuss it with outsiders if you wish (i.e. family and/or friends). You do not have to make an immediate decision. Your participation is purely voluntary. Should you agree to enter the trial, you may change your mind and withdraw at any stage.

PARTICIPATION IS VOLUNTARY

Participation in any research project is voluntary. If you do not wish to take part, you are not obliged to. If you decide to take part and later change your mind, you are free to withdraw from the project at any stage without providing a reason.

Your decision to take part, not to take part or to withdraw will not affect your employment, or your relationship with your employers.

Who am I?

My name is Dr Ruth Teh. I am an advanced trainee in Geriatric Medicine at the Queen Elizabeth Hospital and currently undertaking a Masters of Philosophy degree. My research study is titled Implementing Visual Cues for Falls Prevention in an Acute Medical Unit and Geriatric Evaluation Medical Unit – Perspectives of Aged Care Staff. I am the principal investigator for this study.

Why are we doing this study?

This study is being conducted to evaluate clinicians' perspectives of a tool to reduce falls in hospital wards. We would like to gain an understanding of how staff perceive the acceptability and usability of the tool, the benefits of and barriers to its use, and its effect on clinical care, both before and after implementation of the tool. We will also be measuring the falls rate before and after the intervention. This will help promote the development of more acceptable and effective falls risk assessment procedures, with the goal of reducing patient falls and subsequent injuries.

Why were you chosen for this research?

You have been chosen as part of the group of health care professionals working within the Acute Medical Unit or Geriatric Evaluation and Management Unit at the Queen Elizabeth Hospital. Data collected from our study will not be passed on to the hospital where you are working. The costs of conducting this study will be borne exclusively by the Hospital Research Fund.

Possible benefits

The findings from this study will help to provide clinicians with a tool that they are prepared to use in their everyday clinical care. The aim is to reduce patient falls and therefore to reduce subsequent injuries, including fractures and death.

What does the research involve?

To participate you are asked to complete a confidential questionnaire in a hard-copy format and return it to the investigator for your ward via a returns box located in your ward. You will not be asked to provide your name or personal details.

How much time will the questionnaire take to complete?

It will take approximately 10 minutes to complete the questionnaire.

Inconvenience/discomfort

There should be no inconvenience or discomfort to participants.

You can withdraw from the research

This study is voluntary, and you are under no obligation to participate. You may withdraw at any time.

Confidentiality

This survey is confidential. The researchers will de-identify participant data via coding for location site (A to E) and participant number (1 to 10). We will use policies and processes as outlined by the National Health and Medical Research Council Australian Code for the Responsible Conduct of Research and the University of Adelaide regulations.

Storage of data

Data will be collected and stored in accordance with National Health and Medical Research Council Australian Code for the Responsible Conduct of Research and with University of Adelaide regulations. The data will be stored in a locked filing cabinet at the Geriatric Training and Research in Aged Care centre at Paradise, South Australia for a minimum of five years.

Electronic data will be stored on a password-protected spreadsheet for a minimum of five years. Only the investigators will have access to the data. A report of the study will be published and presented but individual participants will not be identifiable in such a report.

Results

The results of this study will be shared with the health care profession. The aim of promoting the results is to develop a tool for falls risk assessment that clinicians are happy to use, with the goal of reducing patient falls and subsequent injuries.

Who is sponsoring it?

Funding for this study is provided by the Hospital Research Project Fund, as part of the grant to Dr Damith Ranasinghe.

If you would like to contact the researchers about any aspect of this study, please contact the Chief Investigator or Supervisor:	Ruth Teh Call 08 8222 6000 Email: ruth.teh@adelaide.edu.au A/Professor Renuka Visvanathan Call 08 8222 7178 Email: renuka.visvanathan@adelaide.edu.au

The Human Research Ethics Committee (TQEH/LMH/MH) has approved this study.

Should you wish to speak to a person not directly involved in the study in relation to:

- information about the conduct of the study,
- matters concerning policies,
- your rights as a participant, or
- Should you wish to make a confidential complaint

You may contact The Executive Officer of this Committee, on (08) 8222 6841.

THE QUEEN ELIZABETH HOSPITAL: CONSENT FORM

VISUAL CUES IN FALLS RISK ASSESSMENT

I, the undersigned...

Hereby consent to my involvement in the research project explained above.

- I have read the information sheet, and I understand the reasons for this study. The research worker has explained the ways in which it will affect me. My questions have been answered to my satisfaction. My consent is given voluntarily.
- I understand that the purpose of this research project is to improve the quality of medical care, but my involvement may not be of benefit to me.
- The details of the research project have been explained to me, including:
  - The expected time it will take
  - The nature of any procedures being performed, and the number of times they will be performed
  - Any discomfort which I may experience
- I have been given the opportunity to have a member of family or a friend present while the project was explained to me.
- My identity will be kept confidential, and nothing will be published which could possibly reveal my identity.
- My involvement in the study will not affect my relationship with my employer. I understand that I can withdraw from the study at any stage without having to give a reason, and that by withdrawing it will not affect my employment at this facility in the future.

PARTICIPANT SIGNATURE: **DATE**……. /……. /…….

WITNESS SIGNATURE **DATE** ……. /……. /…….

(Only to be completed when the investigator is not present)

INVESTIGATOR SIGNATURE: **DATE** ……. /……. /…….

Appendix 7: Survey for pre- and post-trial distribution

TECHNOLOGY IN FALLS ASSESSMENT: QUESTIONNAIRE FOR PARTICIPANTS

Dear Participant,

Thank you for participating in this study looking at the implementation of a technology tool (iPad) and visual cues (bedside poster) in falls prevention.

Through this questionnaire, we are hoping to acquire knowledge of your perspectives on this tool. We have kept the information we need to a minimum to maintain your privacy. The questionnaire is confidential and will only be seen by the researchers and project manager. We hope that the questions are clear and easy to complete. If you have any queries regarding completing this questionnaire, please do not hesitate to ask Dr Ruth Teh, who is available for contact on (08) 8313 2151 or (08) 8222 6000.

Please respond to all items by ticking the appropriate boxes or writing in the space provided.

A. Background information regarding you as the person completing the questionnaire:

Gender:	Male	☐
	Female	☐
Age:	18 to 29 years	☐
	30 to 39 years	☐
	40 to 49 years	☐
	50 to 59 years	☐
	60 to 69 years	☐
	70+ years	☐

Discipline:	Medical	☐
	Nursing	☐
	Physiotherapy	☐
	Allied Health	☐
	Other	☐

Main role:	Clinician	☐
	Manager/administrator	☐
	Researcher	☐

Area of work:	Hospital predominant	☐
	Community predominant	☐
	Mixed hospital/community	☐

Years of Experience in Health Care:

0 to 5 years	☐
5 to 10 years	☐
10 to 15 years	☐
15 to 20 years	☐
20+ years	☐

Years of Experience in Aged Care:

0 to 5 years	☐
5 to 10 years	☐
10 to 15 years	☐
15 to 20 years	☐
20+ years	☐

B. Your use of the tool.

1. The tool will be easy to use during the bed to bed handover.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
☐	☐	☐	☐	☐

Comments (optional)……………………………………………………………………………….

2. The tool will be easy to use during the clinical handover.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
☐	☐	☐	☐	☐

Comments (optional)……………………………………………………………………………….

3. The tool will be easy to use during the team meeting.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
☐	☐	☐	☐	☐

Comments (optional)……………………………………………………………………………….

4. The tool will be slower in terms of updating the falls risk information in a timely matter compared to the current method.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
☐	☐	☐	☐	☐

Comments (optional)……………………………………………………………………………….

5. The tool will be more accurate in terms of updating information compared to the current method.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
☐	☐	☐	☐	☐

Comments (optional)………………………………………………………………………………

6. The tool will assist me to update information about the patient's risk in a timely manner.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
☐	☐	☐	☐	☐

Comments (optional)………………………………………………………………………………

7. The tool will help me provide safer care for patients at risk of falls.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
☐	☐	☐	☐	☐

Comments (optional)………………………………………………………………………………

8. I think this tool will improve quality of patient care by (tick any applicable):

Timely assessment of falls risk ☐

Accurate assessment of falls risk ☐

Prevention of falls ☐

Allowing time to attend to other care needs ☐

Other ways it may improve care: ……………………………………………………………

9. I will use this tool if it is made available.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
☐	☐	☐	☐	☐

Comments (optional)……………………………………………………………………………

10. What will be the benefits of implementing this tool in your everyday practice?

Better understanding of patient's falls risk factors ☐

Facilitating handover process ☐

Effectively preventing falls ☐

More time to attend to other duties ☐

Other benefits (optional)…………………………………………………………………

11. What are the barriers to implementing this tool in your everyday practice?

Lack of time ☐

Lack of familiarity with device ☐

Lack of familiarity with technology ☐

Duplication of existing paperwork ☐

Other barriers (optional)……………………………………………………………………………….

12. What are some strategies we could use to support implementation of this tool?

Feedback about study progress ☐

Staff presentations (e.g. at mid/end points) ☐

Awarding CPD points ☐

Other strategies (optional)………………………………………………………………………

13. Do you have any suggestions on how this tool be improved?

Thank you for taking the time to participate in our study. I appreciate your help and giving of your valuable time. If you have any further information or comments who think would be helpful, please feel free to write on this sheet. Kind regards, Ruth