Falls in older people: Examining risk factors in specific sub-groups and the effectiveness of a specialist-led falls prevention intervention

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Statement of originality

This is to certify that to the best of my knowledge; the content of this thesis is my own work. This thesis has not been submitted for any degree or other purposes.

I certify that the intellectual content of this thesis is the product of my own work and that all assistance received in preparing this thesis and sources have been acknowledged.

Nichola Boyle

Signature:

As supervisor for the candidature upon which this thesis is based, I can confirm that the authorship attribution statements above are correct.

Supervisor Name: Associate Professor Vasi Naganathan

Signature

Date:

Synopsis

This thesis explores three major themes specific to older people and accidental falls: risk predictors for Emergency Department (E.D.) re-presentations with falls and mortality in older E.D. attenders; risk for falls and fall injury hospitalisations in community dwelling older men; falls prevention using a specific intervention to prevent further falls in community living older men and women.

Chapter 2 and 3 describe a prospective cohort study of people aged 65 years and older, who attended an E.D. with a fall or fall-related problem (n = 498). The majority of re-attendances occurred in the first 3 years, but up to 42% had fallen by 5 years. Age was the greatest predictor of further falls re-attendances, age 80 years and older at 5 years (HR 2.00; 95% C.I. 1.42 – 2.82), when adjusted for sex and prior history of falls. Other factors which predicted further falls were requiring assistance with activities of daily living (ADLs) (at 1 and 3 years), and more than 3 comorbidities or the use of diuretics or nitrate medications (at 5 years). We were unable to demonstrate an association between a history of falls in the previous 12 months and E.D. re-attendance with a fall.

In the same prospective cohort study, mortality was examined up to 5 years in Chapter 3. At 1 year 19% of the cohort had died, and by 5 years that proportion had increased to over 50% since the index fall E.D. presentation. Age 80 years and older (HR 1.54; 95% C.I. 1.09 – 2.19) and assistance with ADLs (HR 1.55; 95% C.I. 1.07 – 2.24) were associated with increased mortality, when adjusted for sex. Cognitive impairment, impaired mobility requiring physical assistance, history of malignancy and the use of diuretics and nitrate medications were all associated with mortality at 5 years. Females and those whose index presentation was due to syncope were more likely to survive to 5 years. Older people who attend the E.D. with a fall and are aged 80 years and older and who require assistance with ADLs are at greater risk of further falls and mortality, and may require greater focus in terms of falls prevention and supportive care than previously thought.

Chapters 4 and 5 report on outcome data from the Concord Health and Ageing in Men (CHAMP) prospective cohort study of (n = 1705) representative community dwelling older men. In the multivariate analysis previous history of falls was the most significant predictor of future falls (IRR 3.12; 95% C.I. 2.49 – 3.91). Additional risk factors for falls included age 80 years and older, being single, disability in ADLs, dementia, having 3 or more comorbidities, and reduced visual acuity in a multivariate analysis excluding history of falls. When history of falls was retained in the multivariate analysis, disability in ADLs was substituted for polypharmacy (use of more than 4 medications) in the analysis (IRR 1.26; 95% C.I. 1.00 – 1.58). Men who were born in a non-English speaking country were at lower risk of falls when followed for 2 years (HR 0.58; 95% C.I. 0.46 – 0.73) adjusted for previous history of falls. Poor performance on chair stand test was the only physical measure associated with increased risk of falls.

In chapter 5, the CHAMP cohort was examined with respect to their risk of fall injury hospitalisation over 10 years. No other study has reported on fall injury hospitalisations to 10 years. Previous history of falls was significantly associated with time to first fall injury hospitalisation at 10 years (HR 1.48; 95% C.I. 1.09 – 1.99). The strongest risk factor predicting fall injury hospitalisation was dementia (HR 2.67; 95% C.I. 1.69 – 4.22) at 10 years, when adjusted for history of falls. Age 80 years and older and polypharmacy were also associated with increased risk of fall injury hospitalisation. Physical parameters associated with fall injury hospitalisation were poor grip strength and slow walking speed when adjusted for age and fall history. Men who were born in a non-English-speaking country and those who were still employed were at lower risk of hospitalisations due to falls.

Chapter 6 reports on the results of a randomised controlled trial (n = 81) of a falls prevention intervention "falls clinic", with enhanced G.P. coordinated care at reducing rate and risk of falls at 1 year. Both rate of falls (IRR 2.39; 95% C.I. 1.09 – 5.27) and risk of falls (RR 1.79; 95% C.I. 1.10 – 2.96) was significantly increased in the Concord Falls and Bone Service (CONFABS) clinic intervention arm. There was no significant difference in the rate of injurious falls or in the number of fractures in each of the intervention arms. A greater number of participants in the CONFABS clinic intervention arm were recommended to receive falls prevention strategies, particularly exercise interventions. However, there was no significant difference in compliance with recommendations between the interventions. There were no significant adverse events attributable to the falls prevention strategies to account for the increased rate of falls in the CONFABS clinic intervention arm. Recruitment to this study was a significant barrier, highlighting the difficulty in engaging older people in clinical research. This study also suggests that effective falls prevention interventions can be coordinated in General Practice, by facilitating risk factor assessment and advising on appropriate falls prevention strategies by specialist medical, nursing and allied health Geriatrics services.

Author’s contributions

The cohort of older people who were studied in the retrospective cohort study in chapters 2 and 3 was previously identified and formed the basis of another MSc thesis. I built on the original cross-sectional study, by planning the retrospective study, submitting the ethics application, collecting the data on falls presentations from electronic and hard-copy medical records and analysing the data. The mortality study also included application to the AIHW National Death Index with additional ethics approval, merging of the NDI data and the retrospective cohort data and further data analysis. In addition, I presented provisional results at a conference and prepared a poster presentation, and wrote this thesis in consultation with my supervisors.

The CHAMP study is an established prospective cohort study that was set up to investigate a broad range of health issues in older men. I planned and conducted the data analysis on falls risk factors and fall injury hospitalisations. I wrote this thesis in conjunction with my supervisors.

For the CONFABS randomised controlled trial, I designed and planned the study including ethics submission. I was involved in the recruitment process, including ways to increase recruitment, and coordinated and provided the specialist-led multifactorial falls prevention intervention. I assisted in data management, including development of databases, analysed all the data and wrote this thesis in conjunction with my supervisors.

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My first words of thanks go to my primary supervisor A/Prof Vasi Naganathan for without him this thesis and the studies it contains would never have been possible. He provides unending positive support and enthusiasm for research that I hope to be able to reflect in my future. He has provided ready support and guidance throughout this journey. I have been able to call upon his expertise and professional collaborations, particularly in development of the falls prevention clinical trial by visiting other researchers with similar services. I also acknowledge the support that my co-supervisors Prof Bob Cumming and Dr Vasant Hirani, have provided in the past and the access to the CHAMP cohort for additional studies. And my colleagues in the Department of Geriatric Medicine, especially Clinical A/Profs John Cullen and Louise Waite and Dr Natasha Spalding, who have given me encouragement and advice on how to" get this over the line".

I would not have been able to develop the retrospective cohort study without the initial FAB study coordinated by Dr Lisa Ng. She provided ready access to her own research, to allow further work and to provide me with advice and support, especially her experience in completing her MSc thesis and that you can get writing completed, even with small children. And the initial phase of my research journey was a shared experience with the CERA staff including Mari, Joe and Janet.

The CONFABS study was only made possible by the support from financial support from the Ageing and Alzheimer's Research Foundation (AARF) and the CONFABS team of Leanne, Melissa, Mian, the Emily's, Brooke and Rosemary. I have learned a lot from Leanne and her research experience – she is a font of knowledge and a shared sense of humour. The clinic staff of the Aged Care and Rehabilitation outpatients assisted the falls clinic patients to get to the clinic and have their assessments, and provide me with a working space and atmosphere that was always a pleasure to be in, even when we were busy. Special thanks to Liz, Nevene, Yessica, Nesrien and Wayne for all their assistance.

Research is dependent upon the goodwill of the participants to endure the assessments when they are time-consuming, and to continue to be involved over prolonged periods. The CHAMP men I have met in my clinical work all appreciate the benefits that come from research, even if not directly helping them. The CONFABS participants engaged fully in the study, from first assessment at home, to the last clinic visit. I thank them whole-heartedly for their engagement in the study.

And last, but by no means least is my family, both here in Australia and at home in Ireland. My husband Fergal, who has been a tower of strength and encouragement, and who has always thought I would achieve this mammoth task, even when I was struggling with morning sickness. And our two beautiful children, whose arrivals have punctuated this process, and who are now desperate for mummy to stop working so much. And my parents, siblings and extended family, who have allowed us to be so far away from them to complete this work and to gain invaluable experience. This thesis is dedicated to Fergal, Cormac and Hannah.

List of abbreviations

A & E	Accident and Emergency
ACE	Addenbrooke's Cognitive Examination
ADLs	Activities of Daily Living
AIHW	Australian Institute of Health and Welfare
AMTS	Abbreviated Mental Test Score
AUC	Area under the curve
CI	Confidence interval
CINAHL	Cumulative Index to Nursing and Allied Health database
CNS	Central Nervous System
ED	Emergency Department
eMR	Electronic Medical Record
GDS	Geriatric Depression Scale
HMO	Health Maintenance Organisation
HR	Hazards Ratio
IADL	Instrumental Activities of Daily Living
ICD	International statistical Classification of Disease
ICD-10-AM	International Statistical Classification of Disease 10th revision Australian modification
IQR	Interquartile Range
IRR	Incident Rate Ratio
LR	Likelihood Ratio
MMSE	Mini Mental Test Score
NDI	National Death Index
NESB	Non-English-Speaking background
NICE	National Institute of Clinical Excellence
NSAID	Non-Steroidal Anti-inflammatory Drugs

OR	Odds ratio
PD	Parkinson's Disease
PPA	Physiological Profile Assessment
ProFaNE	Prevention of Falls Network Europe
RaR	Rate ratio
RR	Risk Ratio
SD	Standard Deviation
SSRI	Selective Serotonin Reuptake Inhibitor
TCA	Tricyclic Antidepressant
TUGT	Timed Up and Go Test
U.K.	United Kingdom
U.S.	United States

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Chapter 1: Literature review

1.1 Rationale for Literature Review

Before undertaking any studies on the risk factors for falls or trials looking at falls prevention strategies, it is important to have an appreciation of the incidence, prevalence and risk predictors for falls and falls-related injuries as well as the morbidity and mortality associated with falls and injurious falls. The purpose of this literature review is to examine these areas in some detail focusing on the two sub-groups of older people experiencing falls that are part of the focus of this thesis: community dwelling older men and older people of both sexes who present to the Emergency Department with a fall. The literature review provides the background and rationale for the studies contained within this thesis. This thesis also includes a falls prevention intervention study. The literature review also provides a rationale for the interventions used in this study.

1.2 Prevalence of falls in community dwelling older people.

When considering the problem of accidental falls in older people, it is important to describe what we mean by an accidental fall. For the purposes of this thesis and the individual studies contained within, the definition proposed by Lamb et al. in 2005 has been used. (1) That is, a fall should be defined as "an unexpected event in which the participants come to rest on the ground, floor, or lower level".

The prevalence of falls in community dwelling older people is often quoted at approximately 30% within the previous 12 months. This means that in a sample of older people from the community approximately 30% would have had one or more falls in the previous 12 months. This oft quoted figure is based on cross-sectional studies from a variety of populations, and these studies were performed in the 1980's and early 1990's. Prudham et al. surveyed 2,793 men and women living in the community aged 65 years or older in the United States. (2) The annual prevalence rate of falls was reported as 28%, with the age standardised rate of falls in women being twice that of men. Further cross-sectional studies reported prevalence rates of falls over 12 months as between 27% and 35%. (3, 4) It was found that women had 2.7 times the risk of falls than men. The prevalence rate has changed little over the following decades with further studies in the United States and the U.K. reporting prevalence rates of between 24% and 32%. (5, 6)

The prevalence of falls in the Australian population appears to be similar to that described above. The Randwick Falls and Fracture study examined the prevalence of falls in women aged 65 years or older, living in the Eastern suburbs of Sydney. (7) Of the 704 participants, 34% had fallen in the previous 12 months. The fallers were significantly older than those who had not experienced a fall (mean age 76.0 years vs 73.9 years; $p<0.001$). In keeping with what has been reported in other countries, the prevalence of falls in Australia has remained similar in other cross-sectional studies performed in the 2000's and 2010's, ranging from 26% to 35%. (8, 9) The New South Wales Falls Prevention Baseline survey performed telephone interviews with a random sample of 5,681 residents of New South Wales, who were living in the community and were aged 65 years and older. (8) Of those who participated 26% reported falling in the previous 12 months. Of those who reported at least one fall, 61% fell only once, 21% fell twice and 17% fell 3 or more times in the preceding year. Two thirds of those interviewed also reported sustaining an injury directly related to the fall.

One of the main limitations of these cross-sectional studies is the recall bias inherent in the retrospective reporting of falls. There is a possibility of under or over reporting by the participants in these studies. This is demonstrated by the findings of Mackenzie, Byles and D'Este in 2006. (10) As part of a randomised controlled trial examining a preventive health assessment in people over the age of 70 years, participants were asked to record falls on a monthly calendar over a six-month period. At the end of this period participants were asked to report the falls based on recall of events, in addition to submitting the monthly falls' calendars. Agreement between self-report and calendar reporting of falls was 84% with a sensitivity of 56% (95% confidence interval (CI) 44.1 – 67.5). Of note 13% gave a false negative self-report of falls versus 4% of participants falsely reporting a fall which had not occurred. Similar findings were reported by Sanders et al. in 2015, with 12-month falls recall showing a 77% sensitivity and 94% specificity compared to monthly falls diary returns. (11) They also reported that 6% of women in the study cohort incorrectly reported a fall which had not been recorded on the monthly falls diaries. Both studies reported a greater tendency to under-report falls, especially in those participants who had repeated falls. (10, 11) This indicates a tendency to minimise events leading to under self-reporting of falls events.

1.2.1 Prospective ascertainment of falls events

A more accurate reflection of the burden of falls on community dwelling older people is obtained through prospective cohort studies examining the incidence of falls over a defined study period, usually over 12 months. Most of these studies also used the prospective data to look at the risk factors for falls.

As with cross-sectional studies, there have been many studies from the 1980's onwards examining the incidence of falls in populations of older people living in the community, including studies in sex specific sub-groups. It has been suggested that the optimum methods for assessing falls as an outcome include completion of a daily falls diary or calendar, with monthly collection of these calendars and telephone or face-to-face follow-up to clarify any discrepancies. (1) Therefore, for the purposes of this literature review, the incidence and risk predictors for falls is discussed on the basis of studies with high quality falls ascertainment where possible.

Deandrea et al. performed a systematic review and meta-analysis of prospective studies examining the risk factors for falls in older people. (12) This review included studies with number of fallers as an outcome and with a sample size of greater than 200 subjects, where at least 80% of subjects were aged 65 years or older, and at least 80% lived in the community. The studies were further sub-categorised in terms of outcomes – all fallers and recurrent fallers; and in terms of frequency of falls assessment – high frequency assessment was defined as falls recorded on a calendar or during an interview at least every 3 months. In studies with high falls ascertainment, the prevalence of at least one fall in a 12-month follow-up ranged from 19% to 41%. (13-18) Incidence rates were reported in a number of studies, based on at least one fall in the study period, as number of falls per 1000-person months or years. Studies in North American populations have variously described falls rates as 41.4 falls per 1000-person months or 375.2 falls per 1000-person years. (19, 20) In comparison, Chu et al. reported a falls rate of 270 per 1000-person years in a Chinese population in Hong Kong, which might suggest that falls rates vary in differing populations. (16)

Does the difference in falls incidence rates reported in the North American and Chinese populations suggest there will be a different rate of falls seen in Australian populations? Deandrea et al. included 5 studies in the meta-analysis with Australian populations. (12) Three of these studies were based on populations with a proportion of females between 45% to 69%, and reported falls rates over 12 months ranging from 28% to 41%. (14, 21, 22) Cumming et al. reported that participants at enrolment reported a falls prevalence of 39% in the 12 months prior to enrolment, and prospectively collected information on falls prevalence of 41%. (14) The Australian Longitudinal Study on Women's Health studied 8188 women over 6 years. Interviews were conducted at 3 years and 6 years following recruitment in those women who reported no prior falls at baseline, and questions were asked about falls in the preceding 12 months. Heesch et al. reported 17.4% falls prevalence at the first follow up assessment (1427 fallers in 8,188 participants), and again 17.4% falls prevalence at the second follow up assessment (1126 fallers in 6,468 participants). (23) Lord et al. provided a more robust falls ascertainment with participants in the Randwick Falls and Fractures Study reporting falls via a mailed questionnaire every 2 months, with telephone contact to those who did not return their questionnaire. (24) A falls incidence rate of 39% was reported with 21% of participants reporting more than one fall in the 12 months follow up period.

1.3 Injurious falls and their burden on healthcare

Although any fall may contribute to a decline in physical and psychological health in an older person, injurious falls have a significant impact on healthcare usage and mortality. The prevalence of injurious falls can be examined both from prospective trial data, and real-world data based on healthcare usage.

1.3.1 The prevalence and incidence of injurious falls in observational studies

When examining the prevalence or incidence of injurious falls we again return to studies performed in the 1980's and 1990's. Studies vary in the categorisation of falls with some reporting on all injurious falls, and others reporting on those resulting in serious injury.

Nevitt et al., O'Loughlin et al., and Campbell et al. all report on the rate of injurious falls based on incidence rates of falls. (19, 25, 26) In a community based study in the United States (U.S.) using weekly falls ascertainment over a 52-week period, 539 falls were reported of which 55% resulted in minor soft tissue injury and 6% resulted in major injury described as a fracture or dislocation, or laceration requiring suturing. (25) A nurse researcher reviewed each reported fall incident to ascertain the degree of injury sustained, providing a robust ascertainment of injury rates. A Canadian population demonstrated a similar proportion of minor injurious falls of 46% and major injurious falls proportion of 6%. (19) Campbell et al. reported 10% of falls resulted in a significant injury in a population of community dwelling older people recruited from General Practices in New Zealand. (26)

In 1988 Tinetti et al. reported on the proportion of fallers who sustained an injurious fall rather than the proportion of falls which were injurious. (13) In a population of community dwelling people aged 75 years or older, 32% of subjects fell in a 12-month follow-up period, with 24% of fallers sustaining a serious injury and 6% sustaining a fracture. Eleven per cent of the falls experienced by subjects in this study resulted in a serious injury.

The rates of injurious falls in Australian populations support these findings. Heesch et al. reported 12% of respondents having had an injurious fall in the preceding 12 months with 5% reporting a fracture due to a fall. (23) A similar picture is seen in a small group of community dwelling women aged 70 years or older in Melbourne, Australia. Hill et al., reported 9% of women who fell sustained a fracture and 10% sustained a soft tissue injury. (27)

These studies do demonstrate that injurious falls constitute a smaller proportion of falls, however, with fracture rates of between 5 and 10%, the propensity for these falls to impact on healthcare usage is of concern.

1.3.2 Hospitalisation and Emergency Department attendances due to falls.

At an individual level, sustaining a fall resulting in an injury can be devastating in terms of the associated morbidity and mortality. It is also important to examine the effect of injurious falls on healthcare usage more broadly. The increasing use of linked health care data allows the examination of the impact of injurious falls from a wider population perspective than can be achieved in individual cross-sectional studies.

A number of studies in a range of settings have been performed to estimate the impact of falls on hospitalisations and Emergency Department (E.D.) attendances. Within the Australian healthcare system, 5 studies have examined fall injury hospitalisations in 4 different states. (28-32) In a retrospective study based at one Emergency Department in Sydney, New South Wales, all falls presentations over a 6 month period were examined. (31) People aged 65 years or older comprised 19.7% of Emergency Department attendances (4,489 of 22,782 attendances) and of these attendances 17.8% (803 of 4,489 attendances) were directly attributable to a fall. Of these falls attendances 57.2% resulted in hospitalisation, and injuries were associated with 70.5% of these attendances (36.6% fractures, 16% soft tissue injuries and 14.5% lacerations or skin tears). In a study based in Western Australia, Hendrie et al.

reported on 18,706 Emergency Department presentations and 6,222 fall injury admissions using hospital administrative records for 2001-2002. (32) Rates of Emergency Department attendance were also reported showing falls related Emergency Department attendance rates of 89.2 per 1,000 population with females over represented (females 113.0 vs males 59.8 per 1,000 population). In the other 3 studies conducted in Brisbane, Queensland, New South Wales and Western Australia, the total fall injury hospitalisation rates over a 12-month period were reported as 10.6 – 23.8 per 1,000 population per year. (28-30) The rate of injury hospitalisations was greater in females than males (males 6.1 – 10.6 per 1,000 population per year and females 13.9 – 25.8 per 1000 population per year). (28, 29) Fractures were associated with 89% of falls injury hospitalisations reported by Peel et al. (28) Of these 48% were fractures of the neck of femur with a higher proportion sustained by females than male (females 50% vs males 45%), a finding which was also demonstrated by Lord et al. (female 40% vs male 31%). (29) Peel et al. also reported on intracranial injuries which accounted for 4.5% of all fall injury hospitalisations, and converse to what was reported for fractures, was associated with a higher rate in males than females (males 6.8% vs females 3.7%). (28)

Greater use of linked data sets with information collected and collated by National Health institutions permits the examination of population based data, which would otherwise not be feasible from an individual study perspective. Hill et al. reported on falls injury hospitalisation rates using linked data from the Victorian Inpatient Minimum Dataset and the South Australian Department of Human Services. Hospital discharges with a primary diagnosis related to falls, using appropriate ICD-9 codes, were included and were used to derive a hospitalisation rate per 1,000 population. In the Victorian population the rate of falls hospitalisations increased significantly from 14 to 20 per 1,000 population over a 10-year period from 1988 to 1997. In contrast a similar increase in falls hospitalisations could not be demonstrated in the South Australian population data (figures not provided). Falls hospitalisations rates were significantly higher in those aged 85 years or older compared to those aged 65 to 69 years in Victoria (46.8 vs 5.3 per 1,000 population) and this increased rate remained over time and was replicated in the South Australian data. (30)

Some caution must be exercised when comparing the data on falls hospitalisations in Australia to that in other countries as data collection may vary across jurisdictions. However, even with this proviso, comparable rates of Emergency Department attendance with falls and falls hospitalisations are seen. Emergency Department attendance rates for falls of 53.5 per 1,000 population have been reported in the United Kingdom (U.K.) (33), and falls hospitalisation rates of 14.9, 35.6 and 53.5 per 1,000 population in studies in Ireland, United States of America (U.S.) and U.K. respectively. (34-36) Care must also be exercised in the interpretations of the results particularly with respect to linked data, as there is difficulty in excluding data pertaining to linked admissions, such as transfers between facilities or readmissions for the same fall event. This may lead to an over estimate of the rate of falls injuries or attendances / hospitalisations.

Clearly falls hospitalisations and Emergency Department attendances contribute significantly to the healthcare usage by older people, both at a state level and internationally. It is also important to understand if there is an ongoing trend to increasing falls related hospitalisations.

1.3.3 Australian National Trends in Falls Hospitalisations

The studies examined above give information at a local, regional and state level. Australian population based data examined periodically can provide information on trends in hospitalisations and injury rates across the whole country.

The Australian Institute of Health and Welfare (AIHW) produced a report examining the trends in hospitalisation due to falls by older people using information based on hospital separations. (37) A separation is defined as "the process by which an episode of care for an admitted patient ceases" and provides a standardised approach to capture data about hospital admissions. The International Statistical Classification of Disease, 10th revision, Australian Modification (ICD-10-AM) is used to code the diagnoses and external causes for all hospital separations. Information on public hospital separations are collected and collated in the National Hospital Separation data which is administered by the Australian Institute of Health and Welfare. All hospital separations for people aged 65 years and older with injury diagnoses and external cause codes for unintentional falls were included. (37)

The AIHW study reported an estimated 92,150 hospitalised fall injury cases for Australians aged 65 years and older in 2010-11, which represented 2.7% of the total number of hospitalisations for people in this age category. As has been found in the previous studies, women constituted the majority of hospitalised falls injuries (females 69% vs males 31%), with men experiencing 0.7 falls injury hospitalisations for every 1 female hospitalisation. As also reported by Hill et al. (30), age specific rates of falls injury hospitalisations increased with increasing age. Bradley also found that the most common cause of these falls injuries was slipping, tripping or stumbling on the same level (33%) and most occurred in or around the home (49%). (37) Fifty-nine per cent of all fall injury hospitalisations were due to a fracture, again accounting for the majority of injuries in women and men (63% and 51% respectively). The majority (91%) of fractures were due to fractured neck of femur with the greater proportion occurring in women (682 cases vs 412 cases per 100,000 population). Age specific rates of fall related fractured neck of femur also increased significantly with age – those over 95 years old had the highest rate of fractured neck of femur (42 per 1,000 population).

In terms of healthcare usage, falls injury hospitalisations by people aged 65 years and older accounted for 1,353,710 patient days in 2010-11. This figure represents 11% of all patient days for this age group and represented a 5% increase from the period 2009-10. The total mean length of stay also includes care related to rehabilitation for a fall related injury and hospitalisations due to a "tendency to fall", and therefore may overestimate the mean length of stay due to the acute falls injury hospitalisation. For the period 2010-11 the mean length of stay was 14.7 days, which was nearly a day shorter than the estimated mean length of stay in 2009-10.

Using similarly derived data, Bradley examined the trend in falls injury hospitalisations between 1999-2000 and 2010-11. (37) In the study period the age standardised rates of falls injury hospitalisations increased by 2.3% per year (95% C.I. 2.0 – 2.6), with the rate of increase greater in men than women (3.3% vs 2.1% increase respectively). This increase in rate of injury accounts for an estimated 25,000 extra falls injury hospitalisations in those 65 years and older in 2010-11, than if the age standardised rates remained unchanged. Rates of injuries to the hip and thigh remained stable over the study time period, but there was an increase in the rates of injuries to the head, trunk and shoulders and upper limbs. The rate of increase in these injuries was greatest for injuries to the head (6.9% per year; 95% C.I 6.6 –

7.3). The rate of hip fractures injuries decreased between 1999-2000 and 2010-11 (-1.4% per year; 95% C.I. -1.8 – -1.1), which was estimated to account for 2,800 fewer hip fractures in those aged 65 years and older than would have been expected if age standardised rates remained stable since 1999-2000. There was also a substantial increase in the number of patient days due to falls injury care, increasing from 736,128 patient days in 1999-2000 to 1,353,710 patient days in 2010-11. However, the mean length of stay remained unchanged, 14.4 days in 1999-2000 compared with 14.7 days in 2010-11.

These trends in the rates of falls injury hospitalisations and number of patient days directly attributable to the care of falls injuries are concerning. An increasing rate of falls injury hospitalisations will exert pressure on the healthcare system in Australia both financially and in terms of resources required to care for an increasingly frail patient population. There is also a gap in knowledge about this group of fallers in terms of their risk for re-presentation to the Emergency Department, particularly those who re-present with a fall or fall-related problem. Information on risk for re-presentation may serve to advise on falls prevention strategies in this cohort.

1.4 Risk factors for falls in community dwelling older people

1.4.1 Systematic reviews and meta-analyses of falls risk factors

As prevalence and incidence rates of falls in older people living in the community are important, so too is an understanding of the risk factors which contribute to an older person's risk of falling. A large volume of research has now been collected over the past 4 decades adding to the evidence of which factors contribute to a first or further falls. Several meta-analyses have also been performed in an effort to pool the data from individual studies. (12, 38) The objectives of these studies have been to determine the risk factors for falls, and in the case of Ganz et al., to identify the prognostic value of risk factors for further falls. (38)

As described above, Deandrea et al. sought to expand on the evidence contained within the 2003 National Institute of Clinical Excellence (NICE) guidelines on the assessment and prevention of falls in older people. (12) The NICE guidelines included meta-analyses of prospective studies published from 1988 to 2002. Deandrea et al. expanded the search to include prospective cohort studies published from 2002 to December 2008, with inclusion criteria as described previously. The meta-analysis was restricted to look at potential risk factors that had been assessed for their association with falls in at least 5 studies. The outcome data was analysed in 3 stages: first using data from all studies identified, then from the subgroup of studies that had conducted multivariate analyses and finally only the subgroup of studies for which the quality of falls ascertainment was described as "high". Tables 1.1 and 1.2 show details on the combined odds ratios (OR) and 95% confidence intervals (95% C.I.), and heterogeneity tests for risk factors where a significant association with one or more falls and recurrent falls was demonstrated in the meta-analysis. The meta-analyses for those studies which included a multivariate analysis and those with high frequency falls outcome ascertainment are shown in these tables, as this is the more robust evidence.

Examining the risk factors associated with one or more falls, the meta-analysis of studies that had reported a multivariate analysis reported the following associations (Table 1.1). The strongest associations with one or more falls were seen with a prior history of falls (OR 2.92; 95% C.I. 2.50 – 3.40), the use of a walking aid (OR 2.50; 95% C.I. 1.80 – 3.47), cognitive impairment (OR 2.24; 95% C.I. 1.25 – 4.03), dizziness and vertigo (OR 2.30; 95% C.I. 1.35 – 3.93), Parkinson's disease (OR 2.73; 95% C.I. 1.00 – 7.45) and gait problems (OR 2.06; 95% C.I. 1.76 – 2.41). For those studies with high frequency falls ascertainment, the meta-analysis reported a strong association between the following factors and having one or more falls: prior history of falls (OR 2.79; 95% C.I. 2.43 – 3.20), physical disability (OR 2.30; 95% C.I. 1.55 – 3.43), use of a walking aid (OR 2.46; 95% C.I. 1.91 – 3.15), cognitive impairment (OR 2.21; 95% C.I. 1.18 – 4.14), Parkinson's disease (OR 3.89; 95% C.I. 3.88 – 3.90), and gait problems (OR 2.02; 95% C.I. 1.39 – 2.93). A range of other socio-demographic, medical and psychological, medication and mobility and sensory risk factors had a more modest association with increased risk of falling in both analyses.

Table 1.2 shows the combined odds ratios (OR), 95% confidence intervals and heterogeneity tests for risk factors with a significant association with recurrent falls in the meta-analysis. In studies which reported multivariate analyses the risk factors strongly associated with recurrent falls were as follows: history of falls (OR 3.07; 95% C.I. 2.31 – 4.08), physical disability (OR 2.63; 95% C.I. 1.06 – 6.51), use of a walking aid (OR 3.20; 95% C.I. 1.70 – 6.01), cognitive impairment (OR 3.65; 95% C.I. 1.71 – 7.79), history of stroke (OR 2.94; 95% C.I. 1.77 – 4.87), dizziness and vertigo (OR 2.14; 95% C.I. 1.54 – 2.99), Parkinson's disease (OR 3.79; 95% C.I. 1.00 – 14.30), use of antiepileptics (OR 2.52; 95% C.I. 1.61 – 3.93) and gait problems (OR 3.68; 95% C.I. 1.87– 7.22). The magnitude of association between risk factors and the outcome of recurrent falls was higher than when the outcome was one or more falls. History of falls, use of a walking aid, cognitive impairment, Parkinson's disease and gait problems were all associated with a 3-fold increased risk of recurrent falls. Physical disability, history of stroke and use of antiepileptics had a 2-fold increased risk of recurrent falls, compared with a modest association for history of stroke with one or more fall, and no significant association between these other risk factors and one or more falls. In the studies with high frequency of falls assessment the following factors were strongly associated with recurrent falls: history of falls (OR 3.09; 95% C.I. 2.63 – 3.63), physical disability (OR 2.24; 95% C.I. 1.81 – 2.77), use of a walking aid (OR 3.05; 95% C.I. 1.87 – 4.95), history of Parkinson's disease (OR 6.57; 95% C.I. 2.11 – 20.44) and gait problems (OR 2.58; 1.79 – 3.74). The risk of having recurrent falls in the 12 months after follow-up was increased by between 2-fold and 6-fold in the presence of these risk factors and this list of factors is similar to what was found for the outcome of at least one fall. Additional risk factors for recurrent falls were history of stroke (OR 2.35; 95% C.I. 1.51 – 3.66), dizziness and vertigo (OR 2.18; 95% C.I. 1.77 – 2.68) and fear of falling (OR 2.21; 95% C.I. 1.55 – 3.15).

Table 1.1: Meta-analysis of risk factors associated with at least one fall in community dwelling older people*

Characteristic	Studies with a multivariate analysis			Studies with high frequency of falls assessment		
	No. Studies	Heterogeneity P	OR (95% C.I.)	No. Studies	Heterogeneity P	OR (95% C.I.)
Sociodemographic risk factors						
Age (5-year increase)	8	0.0002	1.12 (1.05 – 1.19)	8	0.007	1.11 (1.05 – 1.17)
Sex (women vs men)	7	0.003	1.28 (1.06 – 1.54)	12	0.22	1.37 (1.21 – 1.55)
Living situation (alone vs not alone)	1		NS	3	0.52	1.26 (1.04 – 1.53)
History of falls (yes vs no)	12	0.002	2.92 (2.50 – 3.40)	9	0.35	2.79 (2.43 – 3.20)
Physical activity (limitation vs no limitation)	1		NS	7	0.008	1.22 (1.00 – 1.50)
Physical disability (yes vs no)	4		NS	4	0.20	2.30 (1.55 – 3.43)
Instrumental disability (yes vs no)	2	0.70	1.25 (1.02 – 1.53)	1		NS
Walking aid use (yes vs no)	3	0.80	2.50 (1.80 – 3.47)	6	0.12	2.46 (1.91 – 3.15)
Medical and psychological risk factors						
Cognitive impairment (yes vs no)	4	0.07	2.24 (1.25 – 4.03)	4	0.07	2.21 (1.18 – 4.14)
Depression (yes vs no)	6	<0.0001	1.44 (1.11 – 1.86)	8	0.88	1.70 (1.46 – 1.97)
History of stroke (yes vs no)	2	0.7	1.65 (1.22 – 2.22)	4	0.81	1.59 (1.28 – 1.98)
Urinary incontinence (yes vs no)	6	0.001	1.33 (1.11 – 1.61)	3	0.17	1.74 (1.32 – 2.28)
Rheumatic disease (yes vs no)	4	0.03	1.41 (1.09 – 1.81)	4	0.24	1.76 (1.44 – 2.16)
Dizziness and vertigo (yes vs no)	1	NA	2.30 (1.35 – 3.93)	4	0.26	1.50 (1.23 – 1.82)
Diabetes (yes vs no)	3	0.99	1.36 (1.15 – 1.61)	2		NS
Comorbidity (increment of 1 condition)	2		NS	3	0.54	1.18 (1.13 – 1.23)
Self-perceived health status (poor vs good)	1		NS	2	0.94	1.32 (1.08 – 1.61)
Fear of falling (yes vs no)	3		NS	5	<0.0001	1.57 (1.03 – 2.40)
Parkinson disease (yes vs no)	4	0.0001	2.73 (1.00 – 7.45)	2	0.79	3.89 (3.88 – 3.90)
Medication risk factors						
Number of medications (for 1-drug increase)	4	1.00	1.05 (1.01 – 1.09)	2	0.80	1.05 (1.00 – 1.10)
Use of sedatives (yes vs no)	6	0.30	1.38 (1.18 – 1.62)	5	0.05	1.65 (1.06 – 2.57)
Use of antihypertensives (use vs no use)	4	0.11	1.25 (1.02 – 1.54)	3		NS
Mobility and sensory risk factors						
Gait problems (yes vs no)	3	0.32	2.06 (1.76 – 2.41)	2	0.17	2.02 (1.39 – 2.93)
Vision impairment (yes vs no)	6		NS	7	0.61	1.51 (1.29 – 1.78)
Hearing impairment (yes vs no)	0	…	…	4	0.15	1.25 (1.03 – 1.51)

*Adapted from Deandrea et al. 2010 (12); NA – not applicable; NS – non-significant

Table 1.2: Meta-analysis of risk factors associated with recurrent falls in community dwelling older people *

	Studies with a multivariate analysis			Studies with high frequency of falls assessment		
Characteristic	**No. Studies**	**Heterogeneity *P***	**OR (95% C.I.)**	**No. Studies**	**Heterogeneity *P***	**OR (95% C.I.)**
Sociodemographic risk factors						
Age (5-year increase)	6	0.0007	1.15 (1.00 – 1.32)	9	0.10	1.12 (1.07 – 1.18)
Sex (women vs men)	6		NS	12	0.0002	1.34(1.08 – 1.68)
Living situation (alone vs not alone)	1	NA	1.59 (1.00 – 2.52)	4		NS
History of falls (yes vs no)	7	0.04	3.07 (2.31 – 4.08)	9	0.54	3.09 (2.63 – 3.63)
Physical disability (yes vs no)	2	0.02	2.63 (1.06 – 6.51)	6	0.22	2.24 (1.81 – 2.77)
Instrumental disability (yes vs no)	0	…	…	1	NA	2.00 (1.35 – 2.96)
Walking aid use (yes vs no)	1	NA	3.20 (1.70 – 6.01)	4	0.01	3.05 (1.87 – 4.95)
Medical and psychological risk factors						
Cognitive impairment (yes vs no)	2	0.40	3.65 (1.71 – 7.79)	12	0.02	1.56 (1.26 – 1.94)
Depression (yes vs no)	3		NS	8	0.98	1.79 (1.53 – 2.09)
History of stroke (yes vs no)	2	0.60	2.94 (1.77 – 4.87)	2	0.72	2.35 (1.51 – 3.66)
Urinary incontinence (yes vs no)	4	0.009	1.71(1.17 – 2.49)	7	0.34	1.75 (1.53 – 2.01)
Rheumatic disease (yes vs no)	4	0.12	1.91 (1.43 – 2.56)	6	0.58	1.54 (1.34 – 1.77)
Dizziness and vertigo (yes vs no)	2	0.94	2.14 (1.54 – 2.99)	6	0.18	2.18 (1.77 – 2.68)
Diabetes (yes vs no)	2	0.88	1.43 (1.15 – 1.77)	2	0.31	1.48 (1.06 – 2.07)
Comorbidity (increment of 1 condition)	0	…	…	3	0.52	1.25 (1.12 – 1.40)
Pain (yes vs no)	3	0.64	1.55 (1.38 – 1.75)	3	0.94	1.78 (1.49 – 2.13)
Fear of falling (yes vs no)	3	0.12	1.88 (1.24 – 2.85)	5	0.02	2.21 (1.55 – 3.15)
Parkinson disease (yes vs no)	2	0.12	3.79 (1.00 – 14.30)	2	0.55	6.57 (2.11 – 20.44)
Medication risk factors						
Number of medications (for 1-drug increase)	3	0.62	1.04 (1.01 – 1.07)	5	0.37	1.05 (1.03 – 1.07)
Use of sedatives (yes vs no)	3	0.65	1.44 (1.16 – 1.78)	4	0.58	1.53 (1.21 – 1.93)
Use of antihypertensives (use vs no use)	3		NS	4	0.15	1.32 (1.07 – 1.64)
Use of antiepileptics (use vs no use)	3	0.38	2.52 (1.61 – 3.93)	2	0.84	3.19 (1.53 – 6.66)
Mobility and sensory risk factors						
Gait problems (yes vs no)	2	0.11	3.68 (1.87– 7.22)	4	0.04	2.58 (1.79 – 3.74)
Vision impairment (yes vs no)	4		NS	8	0.50	1.81 (1.58 – 2.08)
Hearing impairment (yes vs no)	0	…	…	5	0.28	1.50 (1.27 – 1.78)

*Adapted from Deandrea et al. 2010 (12); NA – not applicable; NS – non-significant

Ganz et al. approached the assessment of risk of having falls from the perspective of how a falls risk at baseline predicted the likelihood of developing a fall in the following 12 months. (38) The objective of the study was to more closely mimic the clinical scenario that is faced in the real world. Data was extracted from prospective cohort studies that published the results of multivariate analyses that looked at common risk factors associated with falls, including studies which had high falls ascertainment only. Individual risk factors were examined, and where the data permitted, likelihood ratios for further falls were calculated for these risk factors. The risk factors examined were age, prior history of falls, orthostatic hypotension, visual impairment, impaired gait or balance, medications, impairment in activities of daily living (ADLs) and cognitive impairment.

Age is commonly included in multivariate analyses of risk factors for falls. Ganz et al. reported that of 11 studies which included age in their multivariate analyses, only 4 studies reported a significant association between age and falls in their original analyses. Three studies provided data that could be used to calculate a likelihood ratio. (16, 39-41) Only one study demonstrated a significant association between age and one or more falls in terms of the calculated likelihood ratio. (41) A prior history of falls was a strong predictor of future falls and all 11 studies within the Ganz analysis, found a significant association between prior falls and future falls. The likelihood ratio (LR) ranged from LR 2.8 (95% C.I. 2.1 – 3.8) for one or more falls in the next year after experiencing one or more fall in the preceding year (16), to LR 3.8 (95% C.I. 2.2 – 6.4) if there was a history of one fall in the previous month (41). Impaired gait and/or balance also had a strong association with future falls. Four studies provided data for calculation of likelihood ratios as follows: accumulation of gait abnormalities (6 of 7 abnormalities) (LR 1.9; 95% C.I. 1.4 – 2.6), lower extremity disability (sensory loss, weakness or impaired balance) (LR 1.8; 95% C.I. 1.5 – 2.2) and an inability to tandem stand (LR 2.0; 95% C.I. 1.7 – 2.4) were all associated with increased likelihood of having one or more falls in the following 12 months. (13, 16) Self perceived mobility issues were associated with both increased likelihood of one or more falls (LR 1.7; 95% C.I. 1.5 – 1.9) and recurrent falls, defined as 2 or more falls (LR 2.0; 95% C.I. 1.7 – 2.4). (16) More than 2 falls in one year was also associated with inability to tandem walk (LR 2.4; 95% C.I. 2.0 – 2.9) and slow 10m walking speed (LR 2.0; 95% C.I. 1.5 – 2.7). (16, 42) Medications, both specific classes of medications and polypharmacy were significantly associated with increased risk of falls. Psychotropic medications were associated with increased risk of one or more falls in the next year (LR 1.7; 95% C.I. 1.3 – 2.2) (39), with a further study specifying benzodiazepines, phenothiazine and antidepressants (LR 27; 95% C.I. 3.6 – 207). (13) Polypharmacy, defined as taking 4 or more medications, was associated with increased likelihood of falls in women only (LR 1.9; 95% C.I. 1.4 – 2.5). (39) The authors of this study postulated that the lack of association in males may have been due to the smaller cohort of male subjects within the study population. Cognitive impairment also had a strong association with one or more falls in 2 studies with extractable data, either as demonstrated by a history of dementia (LR 13; 95% C.I. 2.3 – 79) (16), or 5 or more errors on the Short Portable Mental Status Questionnaire (SPMSQ) (LR 4.2; 95% C.I. 1.9 – 9.6). (13)

The associations between impairment in activities of daily living, visual impairment and orthostatic hypotension and one or more falls in the following 12 months, were weaker than for the previous risk factors discussed. Ganz et al. calculated the likelihood of falling in those with impairment in activities of daily living, based on 2 studies. An inability to rise from a chair without using upper limbs had a significant association with further falls in men (LR 4.3; 95% C.I. 2.3 – 7.9), but not in women. (39) The accumulation of 5 or more of 11 physical impairments was associated with increased risk of one or more falls (LR 1.9; 95%

C.I. 1.4 – 2.6). (43) Although there were no extractable data to perform further analysis, Ganz et al. also reported on the association between falls and visual impairment, with poor vision as demonstrated by an inability to recognise a face at 4m or inability to read a newspaper, associated with an increased risk of fall of between 60% and 100%. (15, 44) Another study demonstrated that for each additional letter recognised on a Bailey-Lovie chart there was an associated lower rate of falling (OR 0.96). (45) Orthostatic hypotension did not have a strong association with the risk of further falls in the next year when adjusted for other known risk factors. (15, 39, 40, 46)

In this study a pre-test probability of having falls could be calculated using the incidence rates for each of 18 included studies. The pre-test probability of having one or more falls was 27% (95% C.I. 19 – 36%) and of having 2 or more falls was 10% (95% C.I. 7 – 15%). Ganz et al. went on to discuss how pre-test odds of having a further fall at baseline for older patients ranges from 1:4 to 1:2, and with the addition of a risk factor with a positive likelihood of 2 to 4 that risk of having one or more fall in the next year could be increased to 50%. Risk factors which would increase the annual risk to 50% would include prior history of falls in the past year or month, and a clinically detected abnormality of gait or balance, such as the inability to tandem walk. (38)

Medications have also been associated with increasing the risk of falling. Three additional meta-analyses looked at the effect of medications on this risk. (47-49) Studies spanning from 1966 to 1996 (47, 48) and 1996 to 2007 (49) were selected based on the quality of the falls and medication ascertainment to examine the pooled effects of a variety of medications on falls. The results of these 3 meta-analyses including a Bayesian pooled odds ratio from

Woolcott et al. combining all the information from the studies identified from 1966 to 2007, are included in Table 1.3. (49, 50)

Table 1.3: Summary of the pooled Odds Ratios from Leipzig et al. and Woolcott et al.: meta-analyses of the effect of drugs on risk of falling.

Drug type	Leipzig Pooled Odds Ratio (95% CI)	Woolcott (studies from 1996 to 2007) Random effects pooled Odds Ratio (95% CI)	Woolcott (studies from 1960 to 2007) Pooled Bayesian Odds Ratio (95% CI)
Antihypertensives	Non-informative*	1.26 (1.01 to 1.50) †	1.24 (1.01 to 1.50) †
Diuretics	1.08 (1.02 to 1.16) †	1.03 (0.84 to 1.26)	1.07 (1.01 to 1.14) †
Beta blockers	0.93 (0.77 to 1.11)	1.14 (0.97 to 1.33)	1.01 (0.86 to 1.17)
Sedatives/hypnotics	1.54 (1.40 to 1.70) †	1.31 (1.14 to 1.50) †	1.47 (1.35 to 1.62) †
Neuroleptics/ Antipsychotics	1.50 (1.25 to 1.79) †	1.71 (1.44 to 2.04) †	1.59 (1.37 to 1.83) †
Antidepressants	1.66 (1.41 to 1.95) †	1.72 (1.40 to 2.11) †	1.68 (1.47 to 1.91) †
Benzodiazepines	1.48 (1.23 to 1.77) †	1.60 (1.46 to 1.75) †	1.57 (1.43 to 1.72) †
Narcotics	0.97 (0.78 to 1.20)	0.89 (0.50 to 1.58)	0.96 (0.78 to 1.18)
NSAIDs	1.16 (0.97 to 1.38)	1.65 (0.98 to 2.77)	1.21 (1.01 to 1.44) †

Table reproduced from Boyle N, Naganathan V and Cumming RG. (50)
Data from Leipzig et al. (47, 48) and Woolcott JC et al. (49).
[#]NSAIDs - Non-steroidal anti-inflammatory drugs; C.I. – confidence intervals;
†Statistically significant Odds Ratio.
* The term "non-informative" relates to the Bayesian pooled estimates use of this information in further calculations of risk.

From the Table it can be seen that CNS active medications have the strongest association with falls. The meta-analysis by Leipzig et al. estimated this increased risk of falls to be 73% (OR 1.73; 95% C.I. 1.52 – 1.97). (48) Of the CNS active medications, antidepressants have consistently had the strongest association with falls as demonstrated in Table 1.3. Across the 2 meta-analyses and the Bayesian analysis, antidepressants have been associated with an increased risk of falls of between 66% and 72%. The time span of the publications included suggested that the effect of antidepressants on the increased risk of falling is similar for both tricyclic antidepressants (TCA) and selective serotonin reuptake inhibitors (SSRI). Sedative/hypnotics have consistently been demonstrated to be associated with increased risk of falling (Bayesian Odds Ratio 1.47; 95% C.I. 1.35 – 1.62). When examined separately, Benzodiazepines have a 1.57-fold increased risk of falling (Bayesian odds ratio 1.57; 95% C.I. 1.42 – 1.72). In addition, antipsychotics also have an association with falls, with an up to 59% increase in the risk of falls with any antipsychotic drug used. (49)

The associations between cardiovascular medications, and analgesic medications and falls are weaker than that seen with CNS active medications. There is difficulty in interpreting the association between these classes of medications and falls using the same methodology as for CNS active medications for several reasons. Cardiovascular medications have been categorised in different ways (cardiovascular medications vs antihypertensives and antiarrhythmics) in various studies, and medication use has changed in the intervening decades. Opiate analgesics have been variously categorised as CNS active medications or as analgesics, without a consistent approach. The association with antihypertensives, diuretics and non-steroidal anti-inflammatories is weaker and inconsistent across the various analyses. Opiate analgesics were not significantly associated with increased risk of falling. (47, 49)

These meta-analyses allow us to examine the strength of association between risk factors and falls, and can provide a template for risk assessment in the clinical setting. Many of the studies included examined these associations in majority female cohorts, recruited from the community. If this information is to be used routinely in the clinical setting, it is important to understand if there is a variation in risk profile based on gender, and based on where the sample is derived.

1.4.2 Gender variation in falls risk factors – do males differ from females?

In the description of the studies included in the systematic review and meta-analysis by Deandrea et al., care was taken to ascertain and report the gender balance within the study cohorts. (12) Cohorts with a predominance of female subjects constitute the bulk of research in terms of incidence, prevalence and risk identification. Of the 74 studies included in the meta-analysis, 20 studies consisted of female only cohorts and an additional 22 studies consisted of cohorts with greater than 60% female subjects. (12) In the analysis by Deandrea et al., male gender was protective against having one or more falls in the next 12 months. Female gender was associated with increased risk for one or more falls in all studies (OR 1.30; 95% C.I. 1.18 – 1.42), in studies that reported multivariate analyses (OR 1.28; 95% C.I. 1.06 – 1.54) and in those studies with high frequency falls ascertainment (OR 1.37; 95% C.I. 1.21 – 1.55). Female gender was associated with increased risk of recurrent falls in the next 12 months in studies that had high frequency falls outcome assessment (OR 1.34; 95% CI 1.08 – 1.68), but the association became non-significant in the studies that undertook multivariate analyses (OR 1.68; 95% CI 0.97 – 2.89). (12)

Acknowledging that gender affects the risk of falling, it is important to examine the risk predictors for falling in community dwelling older men. In reviewing studies on cohorts with a mixed population, the majority of the multivariate analyses undertaken reported adjustment for gender along with other covariates, but did not report a specific risk profile for the male subjects within the cohort. An assumption is made, therefore, that the risk factors identified in these mixed cohorts are the same for males as they are for females. As discussed above, Campbell et al. reported a difference in the association between polypharmacy and the risk of falls between genders, with the association being weaker in males. (39) Vellas et al. reported both combined and gender specific risk factor analyses in a community dwelling cohort in the

U.S. (51) The gender specific multivariate analyses reported only slight differences in risk factors for men compared to women. In men, low physical health score was associated with increased risk of all falls (RR 1.66; 95% C.I. 1.03 – 2.69) and low mobility score associated with reduced risk of injurious falls (RR 0.25; 95% C.I. 0.10 – 0.61) compared to that seen in women.

Although Deandrea et al. included six prospective studies with male only cohorts, 3 of the published studies provided analyses based on the same cohort. (52-56) In a cohort of men recruited from Veterans' ambulatory care clinics in the U.S., Duncan et al. examined the risk factors for one or more falls and recurrent falls in 6 months of follow-up. (55) Fall outcomes were ascertained from monthly calendar returns and phone calls to participants. In comparison to non-fallers, fallers were significantly older, had reduced functional reach and were more likely to have a history of depression. Recurrent fallers in comparison to non-fallers were also older, had reduced functional reach and were more likely to have a history of depression. In addition, recurrent fallers, as a group, had significantly lower MMSE scores. Further analysis demonstrated an association between impaired functional reach and recurrent falls, with the strongest association seen in those with who were unable to reach at all (OR 8.07; 95% CI 2.48 – 26.2). In a further study of Veterans in the U.S., Weiner et al. examined the association between central nervous system (CNS) active medications and falls in 305 men aged 70 to 104 years. (56) In the 6 months of follow-up 33% of men fell at least once, and 28% used one CNS active medications and 10% used 2 or more CNS active medications. Once adjusted for age, cognition, depression and mobility, use of CNS active medications was significantly associated with one or more fall (one CNS mediation OR 1.54; 95% CI 1.07 – 2.22; two or more CNS active medications OR 2.37; 95% CI 1.14 – 4.94).

The Osteoporotic Fractures in Men (MrOS) Study is a prospective cohort study of men 65 years and older recruited from 6 academic medical centres in the U.S., designed to identify risk factors for falls and fractures. Three studies examined the influence of a range of factors on the risk of falling in the cohort of 5,995 community-dwelling older men.(52-54) Fink et al. examined the relationship between Parkinson's disease (PD) and falls in the next year. (52) A significantly greater number of subjects with PD experienced 2 or more falls (28.6%) compared to those without PD (11.7%; p<0.0001). In the adjusted model, PD was associated with more than double the risk of multiple falls when adjusted for age and prior history of falls (OR 2.30; 95% C.I. 1.15 – 4.59), but the association was no longer significant in the fully adjusted model (OR 1.62; 95% C.I. 0.77 – 3.38). Cawthon et al. examined the relationship between alcohol intake and falls in the next year in the same cohort. (53) The 4 question CAGE questionnaire was administered to define a history of problem drinking., with an answer of "yes" to 2 or more questions indicating problem drinking. (57) Light alcohol intake was associated with reduced risk of recurrent falls in the multivariate analysis (RR 0.77; 95% C.I. 0.65 – 0.92), but a history of problem drinking was associated with increased risk of falls (RR 1.59; 95% C.I. 1.30 – 1.94) as was a history of heavy drinking (drinking >5 drinks most days) (RR 1.43; 95% C.I. 1.16 – 1.76). In the same cohort, Orwoll et al. examined the association between testosterone, physical performance measures and falls in the MrOS cohort. (54) A history of falling at least once in the preceding 12 months was associated with increased risk of falling in the follow-up period (RR 2.63; 95% C.I. 2.29 – 3.03). Age was also strongly associated with risk of falling, with increased incidence of falls (0.6 falls per year in 65-69 years versus 1.0 falls per year in ≥80 years) and age was associated with increased frequency of falls. Measures of poor physical performance were also associated with falls risk. Subjects with grip strength in the lowest quartile or who could not perform the test, had a 40% increased risk of falling compared to those in the highest quartile of grip strength (RR 1.7; 95% C.I. 1.4 – 2.1). Reduced leg power, and inability to perform the narrow walk test were both associated with increase in falls risk. Testosterone level did have an association with increased risk of falling, but the association was strongest in the youngest sub-group of men, with the association weakening with increasing age (65-69 years RR 1.8; 95% C.I. 1.2 – 2.7; versus ≥80 years RR 1.15; 95% C.I. 0.7 – 1.8). In all men, the association with increased risk of falling was strongest in the lowest quartile of testosterone level and remained significant even when adjusted for multiple confounders, such as the physical parameters previously described (RR 1.40; 95% C.I. 1.17 – 1.67).

An additional cross-sectional study in the United Kingdom examined the association between prior falls history, fear of falling and other health status and demographic characteristics in a group of older men recruited from primary care. (58) Men were asked to wear an accelerometer for 7 days to map their physical activity. Those who had experienced recurrent falls in the previous year had lower daily activity levels as measured by fewer steps per day (942 steps; 95% C.I. 503 – 1381), less minutes in light (12 minutes; 95% C.I. 2 –22) and moderate to vigorous activity (10 minutes; 95% C.I. 5 – 15) and more minutes in sedentary activity (22 minutes; 95% C.I. 9 – 35). The reduction in physical activity was even more pronounced in those with fear of falling; 1766 fewer steps per day (95% C.I. 1391 – 2142), 27 minutes less in light activity (95% C.I. 13 – 22), 18 minutes less in moderate to vigorous activity (95% C.I. 13 – 22) and 45 minutes more sedentary activity (95% C.I. 34 – 56), than those who did not fear falling. When adjusted for history of falls, exercise outcome expectations, exercise self-efficacy, number of days leaving the house, mobility limitations, fear of falling, depression and quality of life, these associations were no longer significant either for one fall, or 2 or more falls.

There remains a gap in the knowledge about the baseline risk predictors for falls in community dwelling older men, and how much of the previous assumptions about similar risk factors for future falls between the sexes holds true. Female sex is associated with greater risk of falling and many studies adjust for sex, even if a significant association between sex and falls is not demonstrated in their cohort. Females make up the majority of subjects in cohort studies examining the risk of falls, and may have a greater influence on the association between risk factors and falls in mixed gender cohorts.

In male-only cohorts a question arises about the representativeness of the cohorts. Two of the prospective cohort studies on male cohorts were Veterans' studies and the MrOS study is a volunteer study, which influences the representativeness of these samples. In addition, the MrOS study was designed to understand the risk of osteoporosis in men and therefore has reported the risk of falling in terms of known risk factors for low bone mineral density. As far as we are aware, there has not been a prospective cohort study that has looked at the risk factors for falls in a large, representative sample of community-dwelling older men.

1.5 Risk predictors for injurious falls.

1.5.1 Community based studies.

As previously discussed, there is a trend towards increased hospitalisation due to falls and fall-related injuries, and falls continue to account for significant mortality in older people. (37, 59) Understanding the risk factors which predict injurious falls in older people who fall, may assist in targeting falls prevention interventions to "at risk" individuals and groups. Many of the community based observational studies discussed above have also examined the risk predictors for all injurious falls, minor injury falls and severe injury falls. In general, the risk predictors for injurious falls are similar to those seen for all falls and are discussed in more detail below.

A range of community based prospective cohort studies have demonstrated that impairments in mobility and balance, function, cognition, certain medications and comorbidities along with situational factors and accumulation of risk factors, contribute to increased risk of any injurious falls. (19, 60-63) In a Canadian community population, O'Loughlin et al. found that the following factors were associated with a 2-fold increased risk of having an injurious fall when adjusted for age: increasing number of days of limited activity (OR 2.2; 95% C.I. 1.4 – 3.6), previous stroke (OR 2.4; 95% C.I. 1.3 – 4.5) and being involved in 10 or more activities in the previous week (OR 2.1; 95% C.I. 1.1 – 3.8). (19) Respiratory disease was also associated with increased risk of having an injurious fall (OR 1.7; 95% C.I. 1.1 – 2.8). Use of heart medications (OR 0.5; 95% C.I. 0.3 – 0.9) and being involved in 2 or more activities in the previous week (OR 0.5; 95% C.I. 0.3 – 0.8) were protective. This suggests that both limited activity and high levels of activity increase the risk of injurious falls, but that a certain level of activity is required to reduce the risk of injurious falls. Koski et al. reported on risk factors for injurious falls in a Finnish community based cohort of males and females. (63)

Over 2 years of follow-up, gait impairment, described as path deviation (which constituted 1 of 6 measures of gait), was associated with injurious falls (OR 1.8; 95% C.I.1.0 – 3.3). (63) In males, gait impairment was strongly associated with injurious falls (OR 3.5; 95% C.I. 1.4 – 8.8). The use of digoxin was associated with a non-significant increased risk of injurious falls (OR 2.2; 95% C.I. 0.9 – 5.7). In females, short step length had the strongest association with injurious falls (OR 32.1; 95% C.I. 2.4 – 43.8). The use of calcium channel blockers was associated with a 2.5-fold increased risk of having an injurious fall (OR 2.5; 95% C.I. 1.2 – 5.2), and the use of medication for peripheral vascular disease showed a non-significant trend to increasing the risk of an injurious fall (OR 3.7; 95% C.I. 0.8 – 17.6).

The risk profile for falls resulting in minor injuries is similar to that seen for all injurious falls. Nevitt et al. described a significant association between turning around or reaching and injurious falls (OR 3.5; 95% CI 1.7 – 7.3). (25) There were weaker associations with injurious falls and slower reaction time, reduced grip strength, falls whilst using stairs or steps and being of White racial background. In the Finnish study mentioned above path deviation and the use of calcium channel blockers were associated with minor falls. (63) In males, gait disturbance and the use of calcium channel blockers were also associated with increased risk minor injurious falls. Females had a similar risk profile with path deviation, use of calcium channel blockers and the additional use of anti-inflammatories increasing the risk of minor injurious falls.

Major or serious injurious falls are falls resulting in the requirement for medical interventions, E.D. attendance or hospitalisation. Nevitt et al. found in their multivariate analysis that having had a previous fall with a fracture, slower trail making B test (a test of cognition) and being of White racial background were all associated with increased risk of a major injurious fall. (25) In another prospective U.S. cohort study, Tinetti et al. reported that cognitive impairment (MMSE <26), being female, having at least 2 chronic conditions, balance and gait score <12/22 (Tinetti score) and body mass index <22 kg/m^2 were associated with increased risk of serious injurious falls in multivariate analysis. (60) In the Finnish prospective cohort study by Koski et al., absence of Achilles reflex, reduced sternal pain sensation and use of long-acting benzodiazepines were all strongly associated with injurious falls, and 2- to 3-fold increased risk of falling and sustaining a major injury. (63) Tinetti et al. also looked at the circumstances of the fall to identify situational issues which may be associated with serious injurious falls. (61) This study found that falls on stairs, whilst performing displacing activities, and falls from at least body height, approximately doubled the risk of injurious falls. In addition, this study found that increasing numbers of predisposing risk factors was significantly associated with a linear trend to increased risk of falling ($p<0.0001$).

We can again examine the differences in risk factors for injurious falls between the sexes, and between those who are independent and those termed disabled. Cohort studies in the United States and Finland have found different rates and risk factors for injurious falls between the sexes. Tinetti et al. reported that females were more likely to sustain a fracture than males however there was no difference in the likelihood of having a fall. (61) In addition, in the subgroup who had recurrent falls, females had a 1.9-fold increased risk of sustaining a serious injury in the adjusted model (OR 1.9; 95% C.I. 1.1 – 3.1) compared to males. In the Finnish study, in males, the risk of major injurious falls was increased 4-fold by absence of quadriceps tendon reflex (OR 4.8; 95% C.I. 1.15 – 19.6). (63) There was a non-significant trend to increased risk of falls in those with gait disturbance and digoxin use. In females, the use of long-acting benzodiazepines increased the risk of major injurious falls (OR 4.0; 95%

C.I. 1.25 – 12.5). There was a non-significant increased risk with foot deformities, short step length and the use of calcium channel blockers. In a second study Koski et al. also reported on the risk of major injurious falls in those who were independent, based on their ability to perform activities of daily living (ADLs), including domestic chores. (62) The presence of peripheral neuropathy was associated with a 2-fold increased risk of major injurious falls and insomnia was associated with a 4-fold increased risk. In those who were categorised as disabled, having 2 or more deficits in ADLs, being divorced, widowed or unmarried, low body mass index, impaired gait, poor distant visual acuity and the use of long-acting benzodiazepines were all associated with sustaining a major injurious fall.

1.5.2 Emergency Department based studies – characteristics of fallers and risk factors for falls requiring Emergency Department care.

Perhaps the most significant group of falls occurring in community dwelling older people are those that result in an attendance to an Emergency Department (E.D.) which may or may not result in hospitalisation. This group of fallers have been the focus of clinical trials on falls prevention interventions. (64, 65) There are however, limited studies examining the risk predictors of falls in those attending the E.D. with a fall.

There are a range of studies which have examined the characteristics of those who have fallen and attended the E.D. Davies and Kenny described 200 patients who attended an Accident and Emergency Department (A&E) in the north of England with a fall over a 28 day period. (66) Thirty per cent of patients attending with a fall were admitted to hospital of whom almost half (48%) had no significant bony or soft tissue injury (i.e. fracture, laceration requiring sutures). Cognitive impairment was found in 26% of fallers. A slip/trip or environmental cause for the fall was evident in 29% and 15% had an explained loss of consciousness, such as due to acute myocardial infarction, stroke, seizure or drug overdose. Bleijlevens et al. performed a cross-sectional study of those who attended an E.D. with a fall and established the circumstances of their falls by postal questionnaire. (67) There was a significant association between location and cause of injurious falls. Intrinsic causes of falls were described as those due to physiological or pathological impairments, and were more likely to occur when toileting, or whilst performing ADLs elsewhere in the home. Extrinsic causes for falls were more likely to occur when outdoors, away from home, performing a mobility related activity. Younger aged fallers were more likely to fall outdoors, away from home, indicating that they were ambulant in the community. Older aged fallers were more likely to engage in activity avoidance, with more of their falls occurring within the home.

In an Australian population, Russell et al. examined the baseline characteristics of older people living in the community who had recently presented to the Emergency Department with a fall and were discharged home. (68) The researchers performed an in-home assessment after the ED attendance and made adjustments in the analysis to account for any delays in performing the baseline assessment, and any falls that occurred during the time. The baseline characteristics were similar to those that have been previously discussed in community based cohorts – the mean age of participants was 76.9 years (95% C.I. 76.0 – 77.8), and was a predominantly female cohort (69.7%). Ninety-one per cent of participants sustained an injury from the index fall and 5.7 % had a fall which could be considered a "hot fall" – that is a fall due to an acute medical condition such as infection, pre-fall orthopaedic injury or dehydration. A series of functional and mobility tests were performed and examined for their association with functional decline following the index fall. Four baseline characteristics were associated with functional decline in the multivariate analysis – being female (OR 2.58;

95% C.I. 1.34 – 4.96), sustaining a fracture (OR 3.76; 95% C.I. 2.12 – 6.69), higher Geriatric Depression Scale (GDS) (OR 1.40; 95% C.I. 1.13 – 1.73) and slower Timed Up and Go Test (TUGT) (OR 1.47; 95% C.I. 1.18 – 1.84).

There are fewer studies examining the risk of further falls after attending the E. D. with a fall. Close et al. reported on the outcomes for the control arm of the PROFET trial which provided a multifactorial targeted intervention for older people who fell and attended Accident and Emergency. (69) The aim of the study was to identify older people with an increased risk of falling, in the group who did not receive any specific falls prevention intervention. Inability to get up after a fall was a strong predictor of future falls, with over 5 times increased risk of a future fall (OR 5.5; 95% C.I. 2.3 – 13.0). Falling indoors and a history of falls in the previous year were also significantly associated with further falls. Negative predictors of further falls were moderate alcohol consumption, a reduced abbreviated mental test score (AMTS) and admission to hospital as a result of the fall. In the intervention arm, the baseline risk factors significantly associated with future falls included a fall in the previous year, indoors falls and an inability to get up after a fall. Negative predictors of future falls in the intervention arm included moderate alcohol intake, a reduced abbreviated mental test score, and hospitalisation due to the index fall. The association between future falls and reduced AMTS runs counter to what has been demonstrated in previous community based studies. (12) Reduced AMTS was significantly associated with increased risk of being lost to follow-up. This could have led to under-reporting of falls in this group, affecting any association between cognitive impairment and future falls. The authors also postulated that the presence of a resident carer may mitigate the risk of falling. In a further study in the U.S., Carpenter et al. reported that 14% of participants of a prospective cohort study of 263 people who came to E.D. fell again during 6 months of follow-up. (70) The baseline characteristics associated with increased risk of further falls included non-healing foot sores (HR 3.71; 95% C.I. 1.73 – 7.95), history of falls in the previous 12 months (HR 2.62; 95% C.I. 1.32 – 5.18), inability to cut their own toenails (HR 2.04; 95% C.I. 1.04 – 4.01) and self-reported depression (HR 1.72; 95% C.I. 0.83 – 3.55).

A further prospective study in Australia looked at risk factors for further falls following an E.D. attendance for falls, in order to develop a screening tool to predict future falls in those presenting to the E.D. (71) In the initial cohort study, Tiedemann et al. followed 219 participants for 6 months. Thirty-one per cent of participants fell and 62% of 151 falls were injurious. In the multivariate analysis of baseline risk factors, having 2 or more falls in the preceding 12 months (OR 4.95; 95% C.I. 2.58 – 9.51), using 6 or more medications (OR 1.80; 95% C.I. 0.94 – 3.46) and using a walking aid outdoors were all associated with increased of falling (OR 1.71; 95% C.I. 0.90 – 3.27). A second cohort was again followed for 6 months and the same risk factors were assessed for their association with further falls. In these analyses, the use of a walking aid outdoors was not associated with falls (OR 0.76; 95% C.I. 0.36 – 1.59), whereas having 2 or more falls in the preceding 12 months (OR 4.02; 95% C.I. 1.92 – 8.41) and using 6 or more medications were still significantly associated with increased risk of falling (OR 2.31; 95% C.I. 1.09 – 4.89). The sample was combined to examine how a two-question screening tool could predict future falls. The two questions were: “Did the person have 2 or more falls in the prior 12 months?” and “Was the person taking 6 or more medications?” The AUC (area under the curve) for the 2-item tool was 0.70 (0.64 – 0.76). The authors hoped that such a simple screening tool might be universally adapted into standard post-fall care in the Emergency Department, and older people referred for appropriate post-fall interventions.

These studies provide us with a measure of risk of falling after attending the Emergency Department, but do not inform us about the risk of further injurious falls requiring another ED attendance or hospitalisation. Bradley et al. has reported on the trend to increased hospitalisation due to fall injuries in Australia, therefore demonstrating the urgency in addressing the risks associated further falls. (37) Understanding the risk factors that increase the risk of further falls related E. D. attendances and falls injury hospitalisations, may assist in targeting falls prevention interventions.

1.6 Impact of falls on mortality

Mortality associated with falls can be directly attributable to the fall and injury sustained, or can be associated with increased frailty and functional decline which may develop as a consequence of a fall.

The National Death Index (NDI) in Australia collates data on cause of death using data from death certificates registered in every State and Territory. Using the data from the NDI in 2009-10 the Australian Institute of Health and Welfare reported that 7.6% of all deaths in Australia were due to injuries, with falls accounting for the majority of injury related deaths (32.2%). (72) Falls were the main cause of accidental deaths in people aged 65 years and older, with more than 93% of all fall injury deaths occurring in this age group. Two thirds of female injury related deaths occurred in people aged 65 years and older.

1.6.1 Community based cohort studies

Community based prospective cohort studies have also identified falls as a risk factor for mortality. The Gloucester Longitudinal study of Disability surveyed 1,815 people over the age of 75 years living in the community, recruited via their General Practitioner, with follow-up over 3 years. (73) A history of one or more falls in the preceding 3 months was seen in 12% of the cohort. Mortality was reported at 1, 2 and 3 years and the risk of death was reported comparing those who had reported a fall in the preceding 3 months at the last annual assessment and those who had not. A history of more than one fall in the 3 months prior to interview was associated with an increased risk of mortality compared with non-fallers. One-year mortality was 2.6-fold that of non-fallers (95% CI 1.4 - 4.7), and recurrent fallers had an overall 1.9-fold increase in 3-year mortality (95% CI 1.2 - 3.0) adjusted for age and gender. A history of a single fall in the 3 months prior to initial interview was not associated with an increased risk of mortality. The association between falls and mortality was similar to that reported by Dunn et al. in 1992. (74) A U.S. based study, the Longitudinal Study on Aging, was a prospective cohort study of 4,270 people aged 70 years and older. The participants were interviewed as part of the 1984 National Health Interview Survey, and were identified for further interview in 1986. The odds of death at 2 years were increased for those who reported a single fall at baseline assessment (OR 1.4; 95% C.I. 1.1 – 1.9) and those with two or more falls (OR 2.0; 95% C.I. 1.5 – 2.6) when adjusted for demographic details, compared with those who did not report a history of falls. With additional adjustment for chronic conditions and disability, the association became non-significant. In a New Zealand based cohort, Campbell et al. reported in 1990, a significant association between falls and mortality in men only. (26) Seven hundred and sixteen people aged 70 years and older, attending one Health Centre (primary care) where enrolled and prospectively followed for one year. Falls were recorded during monthly contact from the research nurse. Follow-up with respect to death was continued for up to 46 months. Men who had reported a fall in the 1-year follow-up period were at significantly increased risk of death (RR 3.2; 95% C.I. 1.7 – 6.0), when adjusted for age. The risk of death in women who fell was not significantly increased in the age adjusted analysis (RR 1.6; 95% C.I. 0.9 – 2.7).

In terms of risk factors that predict increased risk of death following a fall, there is limited data and this may reflect the shorter periods of follow-up, and the small number of deaths in some cohort studies. These factors limit the power of these studies to find significant associations between potential risks factor and death. In one prospective study examining the effect of frailty on falls and fractures, Ensrud et al. found that frail women were at increased risk of death (HR 1.82; 95% C.I. 1.56 – 2.13) during an average of 9 years of follow-up. (75) Tinetti et al. were unable to demonstrate a significant association between more than one fall and an inability to get up following the fall, and mortality at 1 year. (76) The cohort described in this 1993 report were predominantly female (72%) and the multivariate analysis reported was fully adjusted for age, gender, comorbidities, MMSE score, disability, and balance and gait scores. The number of deaths was small, which along with the extensive adjustment in the multivariate analysis, may account for why an association could not be demonstrated. When Dunn et al. also included variables, such as number of comorbidities and disability, into their multivariate analysis, the association between falls and death at 2 years became non-significant. (74)

The association between falls and mortality may be explained by the disease burden and the frailty of the older person, with the fall acting as proxy for these variables. This may explain why the association between falls and mortality becomes non-significant in models that account for the many shared risk factors for falls and death.

1.6.2 Mortality associated with falls requiring Emergency Department assessment and treatment.

Section 1.6.1 focussed on the risk of death following falls in community based studies. These studies may represent a more robust group of older people, or reflect non-injurious falls and those with only minor injuries compared to those who attend the E.D. with a fall or fall-related problem. Is there a difference in the risk of mortality for older people who have fallen and required E.D. assessment and treatment?

In a U.S. based retrospective cohort study, Liu et al. examined outcomes for 21,340 patients aged 65 years or older who presented to an Emergency Department in two level 1 urban trauma teaching hospitals from February 2005 to December 2011 with a fall or fall-related injury. (77) Follow-up in this study was continued until to December 2012. The percentage of patients revisiting the E.D. or dying at 3 days, 7 days, 30 days and 1 year was examined. The percentage of patients revisiting the E.D. at 3 days was 2% which increased to 25 % at 1 year and the percentage of deaths at 3 days was 1.2% increasing to 15% at 1 year. In the multivariate analysis predictors of E.D. revisit included male gender, ethnicity, median income, comorbidities and Injury Severity Scale (ISS) score. Predictors of death in the same group included age, hospital admission for the index fall, ethnicity, comorbidities and ISS score. The 1-year mortality rate was similar to that reported by Donald and Bulpitt, and Dunn et al. in community living cohorts. (73, 74) In an additional U.S. based retrospective study using a hospital trauma registry data linked to hospital discharge data and death certification, Ayoung-Chee et al. identified all patients hospitalised in one centre between 2005 and 2008 with follow-up to December 2010. (78) There were 1,352 consecutive admissions with a ground level fall in the study period. Twelve per cent of these subjects died during the course of their admission, with the remaining subjects discharged to home (33%), a skilled nursing facility (51%), home with assistance (6%) or to inpatient rehabilitation (5%). Over forty per cent of patients were readmitted within 1 year, and 33% of the entire cohort had died by the end of the 1st year. Being discharged to a skilled nursing facility was significantly associated with increased risk of death (HR 2.82; 95% C.I. 1.86 – 4.28). The 33% 1-year mortality rate is higher than that reported by Liu et al., and could reflect the severity of injury sustained necessitating admission to hospital.

A Taiwanese prospective study by Yu et al. reported on a cohort of people age 65 years or older, attending the ED of a general hospital with a fall between January 2006 and December 2007. (79) Seven hundred and sixty-two participants agreed to a baseline assessment and were reassessed at 6 months and 12 months. At one year 78 subjects had died, representing 10.2% of the total cohort. This is in keeping with the findings of Liu et al. and the community based studies described in section 1.5.1. The features at baseline associated with death at one year were traumatic brain injury (TBI) compared to sustaining a soft tissue injury (RR 3.59; 95% C.I. 1.65 – 7.80), being discharged to a nursing home (RR 2.08; 95% C.I. 1.18 – 3.64) and hospital admission (RR 2.05; 95% C.I. 1.19 – 3.58). Females had a 1.64-fold increased risk of further falls (RR 1.64; 95% C.I. 1.15 – 2.34) compared with men, but did were not at greater risk of hospital admission or death.

These studies demonstrate that older people attending the E.D. with a fall are at great risk of residential care and death within 1 year. However, it is unclear how representative these cohorts are of older people attending E.D.'s in Australia, given that these studies are based in the U.S. and Taiwan. The type of hospital at which the study is performed may also influence mortality, particularly if the facility is a major trauma centre. Many of the studies have reported mortality rates for 1 year, but there is value in knowing more about longer term mortality rates. The cohort attending the E.D. will include those who are resident in residential aged care facilities, which may in fact be a more important risk factor for increased mortality than other measures of frailty. Older people who attend an E.D. with a fall should be a cohort of fallers who are targeted for falls prevention interventions as a matter of urgency. Knowing more about the predictors for mortality is important in targeting prevention interventions to those who require preventative measures versus those who require more supportive or palliative approaches due to their disease burden, severity of injury or frailty.

1.7 Falls prevention interventions

1.7.1 Cochrane review of interventions for preventing falls in older people living in the community.

There are a large number of randomised controlled trials that have investigated the effectiveness of a range of interventions to reduce the risk and the rate of falling in older people living in the community. The most robust evidence is derived from large, well-conducted trials with methodology that limits bias, or from meta-analyses that have conducted rigorous systematic reviews and then collated the data from the included trials. As the number of studies increased, the need for systematic reviews and meta-analyses increased. A look at these systematic reviews is the best way to determine which interventions have the strongest evidence of efficacy to prevent falls. The first Cochrane review of falls prevention interventions in older people living in the community was published in 2003, with an updated review published in 2009 and 2012. (80-82) A further review is in progress and has not been reported at this time. This review will focus on the information provided by the 2012 Cochrane review and will then examine some of the individual studies in more detail later. (80)

The objective of the 2012 Cochrane review by Gillespie et al. was to assess the efficacy of interventions designed to reduce the incidence of falls in older people living in the community. Randomised controlled trials were included if the participants were 60 years or older (or mean age minus one standard deviation was more than 60 years), and if the majority of participants were living in the community in accommodation which was not residential care or a rehabilitation setting. If the study had a mixed population, it was suitable to be included in the review if there was a subgroup analysis based on place of residence. Trials involving patients with Parkinson's disease or stroke were not included. The study outcomes included rate of falls and/or number of fallers, while secondary outcomes included number of participants sustaining fall-related fractures, adverse effects of interventions and economic outcomes. The searches for all appropriate studies were conducted to include studies published up to March 2012 and included a range of databases including MEDLINE, EMBASE, CINAHL, and Cochrane Library registers. The details of the specific search strategy are beyond the scope of this review. Interventions were grouped using the fall prevention classification developed by the Prevention of Falls Network Europe (ProFaNE), based on single, multiple and multifactorial interventions and the type of intervention. (83) The pooled data were used in a series of meta-analyses to estimate pooled risk and rate ratios of falls for all the interventions. Additional subgroup analyses were also performed, for example to examine the effect of high and low falls risk on interventions, and whether active treatment was provided versus interventions which depended on referral to other services or primary care physicians for their provision.

This review will focus on the impact of multifactorial interventions on falls prevention. These interventions are most closely aligned to the development of falls prevention clinical services, and formed the basis for the study design reported in this thesis.

1.7.1.1 Multifactorial falls prevention interventions – Cochrane review

Multifactorial interventions are interventions which consist of more than one main category of intervention, with participants receiving different combinations of intervention based on their fall risk factor assessment. (80) The aim of the multifactorial intervention is to provide comprehensive and individualised interventions. Using data from 19 trials with 9,503 participants, the pooled analysis showed that multifactorial interventions significantly reduced the rate of falls (RaR 0.76; 95% CI 0.67 – 0.86). That is multifactorial interventions reduce the number of falls. In contrast, the pooled data from 34 trials and 13,617 participants did not show a significant reduction in the number of fallers and therefore the risk of falling (RR 0.93; 95% CI 0.86 – 1.02). There was also no significant reduction in the risk of fractures using pooled data from 11 trials (RR 0.84; 95% CI 0.67 – 1.05). There was significant heterogeneity between the studies in the pooled analyses of the rate of falls (I^2 = 85%; p<0.00001) and the risk of falls (I^2 = 69%; p<0.00001). Additional analyses were performed to assess if baseline risk of falls or intensity of intervention affected the outcomes of rate of falls and risk of falls. It was hypothesised that high risk fallers may benefit more from these interventions than low risk fallers. The subgroup analysis by baseline risk of falls did not show evidence of difference in the rate of falling (p = 0.50; I^2 = 0%), or risk of falling (p = 0.88; I^2 = 0%). There was no evidence that the scope and intensity of interventions affected the rate of falls (p = 0.36; I^2 = 0%) however there was a suggestion that the risk of falling was affected (p = 0.05; I^2 = 74.3%). Interventions which provided advice only and depended upon the primary care physician to implement the specific treatment plans were less effective at reducing the risk of falling than those interventions which were provided directly and included direct organisation of any additional referrals. Table 1.4 shows details of the studies included in the Cochrane review and the outcomes from each study. (80)

Table 1.4: Randomised controlled trials of multifactorial falls prevention interventions for community dwelling older people.

Author	Participants	Follow-up period	Intervention	Control	Results
Carpenter 1990 (84) **United Kingdom**	N = 539 Age ≥75 years (13% >85years old) 65% female. Recruited from 2 GP practices Inclusion: ≥75 years, living in area Exclusion: living in residential aged care facility	3 years	Trained volunteers administer the Winchester disability rating scale. Those with no disability assessed every 6 months. Those with disability assessed every 3 months. Referral to GP if increase in disability score.	Usual care. No disability surveillance between evaluations	Number of falls Rate of falls RaR 0.34 (0.18 – 0.65)
Ciaschini 2009 (85) **Canada**	N = 201 Mean age 72 years (SD 8.4) 94% female. Recruited from community Inclusion: >55 years, at risk of fracture due to falls, previous fragility fracture or high risk of falls TUGT >14sec Exclusion: On treatment for Osteoporosis	6 months (12 months in total with cross-over for control group at 6 months)	Nurse led multifactorial risk assessment and counselling. Referral for PT, OT and interventions. Recommendations for Osteoporosis therapy to physicians and patients.	Usual care for 6 months then offered same as intervention group	Number of fallers Risk of falling RR 1.51 (0.87 – 2.61) Number of fractures Risk of fractures
Close 1999 (64) **United Kingdom**	N = 397 Mean age 78.2 years (SD 7.5). 68% female. Recruited from A&E (after discharge). Inclusion: ≥65 years, history of falling, community dwelling. Exclusion: cognitive impairment, no regular carer, limited English, not living locally.	1 year	Comprehensive medical assessment of multifactorial risks of falling. Interventions and referrals as required. OT assessment – functional and home environmental hazards. Funded minor modifications, equipment and advice.	Usual care.	Number of falls Rate of falls RaR 0.41 (0.34 – 0.49) Number of fallers Risk of falling RR 0.39 (0.23 – 0.66)

RaR – rate ratio; RR – relative risk; SD – standard deviation; GP – General Practice; TUGT – Timed Up and Go Test; PT – physiotherapy or physiotherapist; OT – occupational therapist or therapy; A&E – Accident and Emergency; E.D. – Emergency Department;

Table 1.4: Randomised controlled trials of multifactorial falls prevention interventions for community dwelling older people (Continued)

Author	Participants	Follow-up period	Intervention	Control	Results
Coleman 1999 (86) **United States**	N = 169 Mean age 77 years. 49% female. Recruited from 9 ambulatory care clinics – cluster randomised. Inclusion: ≥65 years, community dwelling, high risk of hospitalisation or functional decline. Exclusion: Living in residential aged care, terminal illness, moderate to severe dementia, and if physician determined "too ill".	12 months (24 months complete collection of data)	Chronic care clinics every 3-4 months in 5 practices. Physician and nurse led chronic disease management. Pharmacist led medication review – polypharmacy and falls risk increasing drugs (FRID). Self-management and support group.	Usual care (4 practices)	Number of fallers Risk of falling RR 1.14 (0.74 – 1.75)
Conroy 2010 (87) **United Kingdom**	N = 364 Mean age 78.6 years (SD 5.7). 60% female. Recruited from General Practices. Inclusion: community dwelling, >70 years, high risk of falling by postal questionnaire. Exclusion: living in residential aged care, receiving end of life care, already receiving falls prevention program, unable to consent.	12 months	Screening questionnaire, information leaflets, invitation to attend day hospital for multifactorial assessment and interventions.	Screening questionnaire, information leaflets, and usual care from primary care service. Offered day hospital intervention at the end of collection of outcome data.	Number of falls Rate of falls RaR 0.86 (0.74 – 1.01)

RaR – rate ratio; RR – relative risk; SD – standard deviation; GP – General Practice; TUGT – Timed Up and Go Test; PT – physiotherapy or physiotherapist; OT – occupational therapist or therapy; A&E – Accident and Emergency; E.D. – Emergency Department;

Table 1.4: Randomised controlled trials of multifactorial falls prevention interventions for community dwelling older people (Continued)

Author	Participants	Follow-up period	Intervention	Control	Results
Davison 2005 (88) **United Kingdom**	N = 313 Mean age 77 years (SD 7). 72% female. Recruited from A&E Inclusion: >65 years, community dwelling, presenting to A&E with fall or fall-related injury, ≥1 fall in prior 12 months. Exclusion: cognitive impairment (MMSE <24), >1 previous episode of syncope, immobile, not living locally, registered blind, aphasic, clear medical cause for fall, enrolled in another study.	12 months	Hospital based medical multifactorial falls assessment and interventions. Home based PT assessment and intervention – exercise, mobility aids, and footwear. Home based OT home hazard assessment and intervention.	Usual care	Number of falls Rate of falls RaR 0.64 (0.46 – 0.89) Number of fallers Risk of falling RR 0.95 (0.81 – 1.11)
De Vries 2010 (89) **Netherlands**	N = 217 Mean age 79.8 years (SD 7.35). 71% female. Community based – following ED or GP attendance with fall. Inclusion: ≥65 years, living independently or in assisted living facility, living near University Medical Centre, history of fall in the previous 3 months. Exclusion: unable to consent, unable to provide a fall history, cognitive impairment (MMSE <24), fall due to traffic or occupational accident, living in a nursing home, acute pathology requiring long-term rehabilitation.	1 year	Hospital based multidisciplinary assessment and tailored treatment in collaboration with GP – psychotropic drug withdrawal, strength and balance exercises, home hazard reduction, and referral to specialists.	Usual care.	Number of fallers Risk of falling RR 0.96 (0.68 – 1.37) Number sustaining fracture

RaR – rate ratio; RR – relative risk; SD – standard deviation; GP – General Practice; TUGT – Timed Up and Go Test; PT – physiotherapy or physiotherapist; OT – occupational therapist or therapy; A&E – Accident and Emergency; E.D. – Emergency Department; MMSE – Mini Mental Test Score;

Table 1.4: Randomised controlled trials of multifactorial falls prevention interventions for community dwelling older people (Continued)

Author	Participants	Follow-up period	Intervention	Control	Results
Elley 2008 (90) **New Zealand**	N = 312 Mean age 80.8 years (SD 5) 69% female. Recruited from 19 primary care practises. Inclusion: ≥75 years, fallen in last year, living independently. Exclusion: unable to consent, unstable or progressive medical condition, severe physical disability, dementia (<7 AMTS).	1 year	Nurse-led community-based falls and fracture risk assessment, home hazard assessment, strength and balance exercises and appropriate referrals to community interventions.	Usual care and social visits.	Number of falls Rate of falls RaR 0.96 (0.69 – 1.34) Number of fallers Risk of falling RR 1.11 (0.94 – 1.29)
Fabacher 1994 (91) **United States**	N = 254 Mean age 73 years. 2% female. Recruited from voter registration and service organisations. Inclusion: ≥70 years, not receiving health care at Veterans Administration Medical Centre. Exclusion: known terminal disease, dementia.	1 year	Health professional home visit to screen for falls risks, with letter of targeted recommendations for participant's physician.	Usual care. Phone contact for follow-up only.	Number of fallers Risk of falling RR 0.60 (0.33 – 1.10)

RaR – rate ratio; RR – relative risk; SD – standard deviation; GP – General Practice; TUGT – Timed Up and Go Test; PT – physiotherapy or physiotherapist; OT – occupational therapist or therapy; A&E – Accident and Emergency; E.D. – Emergency Department; AMTS – Abbreviated Mental Test Score;

Table 1.4: Randomised controlled trials of multifactorial falls prevention interventions for community dwelling older people (Continued)

Author	Participants	Follow-up period	Intervention	Control	Results
Fox 2010 (92) **United States**	N = 552 Mean age 76.9 years (SD 6.8) 67% females Recruited from 'Preventive Health Care for the Aging'(PHCA) clients Inclusion: ≥65 years, living in area for the following year, speaking English, Spanish, Cantonese or Vietnamese. Exclusion: serious cognitive impairment, medical disorders that would affect participation.	1 year	Usual PHCA care (community-based health promotion programme) and multifactorial fall prevention programme targeting 10 risk factors. Nurse led.	Usual PHCA care.	Number of fallers Risk of falling RR 1.62 (0.88 – 2.97)
Gallagher 1996 (93) **Canada**	N = 100 Mean Age 74.6 years 80% female. Recruited from community. Inclusion: ≥60 years, fallen in previous 3 months. Exclusion: not described.	6 months	2 risk assessment interviews (45mins). 1 counselling interview (60mins) – video, booklet, results of risk assessment.	Baseline interview and follow-up only.	Number of falls Rate of falls RaR 0.81 (0.60 – 1.09)

RaR – rate ratio; RR – relative risk; SD – standard deviation; GP – General Practice; TUGT – Timed Up and Go Test; PT – physiotherapy or physiotherapist; OT – occupational therapist or therapy; A&E – Accident and Emergency; E.D. – Emergency Department;

Table 1.4: Randomised controlled trials of multifactorial falls prevention interventions for community dwelling older people (Continued)

Author	Participants	Follow-up period	Intervention	Control	Results
Hendriks 2008 (94) **Netherlands**	N = 333 Mean age 74.8 years (SD 6.4) 68% female. Recruited from ED or GP Inclusion: ≥65 years, community living, history of fall requiring visit to ED or GP, living in local area. Exclusion: not able to speak or understand Dutch, unable to complete questionnaires or interviews by telephone, cognitive impairment (<4 on AMT4), long-term admission to hospital or other institution (>4 weeks from date of inclusion), permanently bedridden, fully dependent on a wheelchair.	1 year	Detailed assessment by geriatrician, rehabilitation physician, geriatric nurse. Recommendations and indications for referral sent to GP. GP driven interventions. Home assessment by OT – recommendations to participant and GP, and referral also sent for technical aids and adaptations or additional support.	Usual care	Number of fallers Risk of falling RR 1.08 (0.76 – 1.54)
Hogan 2001 (95) **Canada**	N = 163 Mean age 77.6 years (SD 6.8) 72% female Recruited from community. Inclusion: ≥65 years, fallen in previous 3 months, community living, ambulatory (with/without aid), able to provide consent. Exclusion: fall in previous 3 months resulting in lower extremity fracture, fall resulted from vigorous or high-risk activities, fall due to syncope or stroke, fall during active treatment in hospital.	1 year	In-home multifactorial falls assessment by geriatric specialist (doctor, nurse, PT or OT) – 1 – 2 hours. Multidisciplinary case conference. Recommendations sent to GP for their implementation. Referral to exercise class if problems with gait or balance and not attending an exercise programme. Instructions on home based exercises.	One home visit by recreational therapist.	Number of falls Rate of falls RaR 0.74 (0.62 – 0.88) Number of fallers Risk of falling RR 0.91 (0.77 – 1.09) Total number of fractures

RaR – rate ratio; RR – relative risk; SD – standard deviation; GP – General Practice; TUGT – Timed Up and Go Test; PT – physiotherapy or physiotherapist; OT – occupational therapist or therapy; A&E – Accident and Emergency; E.D. – Emergency Department; AMT – Abbreviated Mental Test Score;

Table 1.4: Randomised controlled trials of multifactorial falls prevention interventions for community dwelling older people (Continued)

Author	Participants	Follow-up period	Intervention	Control	Results
Hornbrook 1994 (96) **United States**	N = 3182 Mean age 73 years (SD 6) 62% female Recruited from HMO (Health Maintenance Organisation) Inclusion: >65 years, ambulatory, living within 20 miles of study site, living independently, able to consent. Exclusion: blind, deaf, institutionalised, housebound, non-English speaking, severely mentally ill, terminally ill, unwilling to travel to research site.	23 months	Home visit, safety inspection, hazards booklet, repair advice, fall prevention classes, financial and technical assistance.	Home visit, safety inspection, hazards booklet.	Rate of falls RaR 0.84 (0.80 – 0.89) Risk of falling RR 0.89 (0.82 – 0.96)
Huang 2004 (97) **Taiwan**	N = 120 Mean age 72 years (SD5.7) 46% female. Recruited from community. Inclusion: ≥65 years, community living, cognitively intact. Exclusion: not stated.	4 months	Nurse-led home visits: 1. Risk assessment. 2. 2 months later – fall prevention brochure and individualised written and verbal instructions on falls risk factors. 3. Assessment and collection of falls data.	Nurse-led home visits: 1. Risk assessment. 2. Standard fall prevention brochure. 3. Assessment and collection of falls data.	Number of fallers Risk of falling RR 0.12 (0.01 – 1.76)

RaR – rate ratio; RR – relative risk; SD – standard deviation; GP – General Practice; TUGT – Timed Up and Go Test; PT – physiotherapy or physiotherapist; OT – occupational therapist or therapy; A&E – Accident and Emergency; E.D. – Emergency Department;

Table 1.4: Randomised controlled trials of multifactorial falls prevention interventions for community dwelling older people (Continued)

Author	Participants	Follow-up period	Intervention	Control	Results
Huang 2005 (98) **Taiwan**	N = 141 Mean age 77 years (SD 7.6) Recruited from hospital. Inclusion: hospitalisation for fall-related hip fracture, ≥65 years, living in medical centre catchment area. Exclusion: cognitive impairment, too ill.	3 months	Nurse-led discharge planning intervention – review within 48 hours of admission, seen every 48 hours in hospital, home visit 3-7 days post-discharge, phone contact once per week with additional daily phone advice as required. 3 months follow-up post discharge. Individualised discharge plan with home-care services, brochures on post hip fracture care and fall prevention. Nurse directed care in terms of assistive devices and rehabilitation. Collaboration with physicians as required.	Nurse-led usual discharge planning.	Number of fallers Risk of falling RR 0.67 (0.22 – 2.01)
Jitapunkul 1998 (99) **Thailand**	N = 160 Mean age 75.6 years (SD 5.8) 65% female. Recruited from a previous study. Inclusion: ≥70 years, living at home. Exclusion: not stated.	3 months (measured at the end of 3 years) last 3 months falls	Home visit from researchers with structured questionnaire. 3 monthly visits for 3 years. Referral to nurse or geriatrician for review if decline in ADL score or ≥1 fall in the previous 3 months. Nurse / geriatrician provided a comprehensive assessment, educate, prescribe drugs or aids, rehabilitation programme and make referrals.	Visit at the end of 3 years. No intervention.	Number of fallers Risk of falling RR 0.52 (0.14 – 1.94)

RaR – rate ratio; RR – relative risk; SD – standard deviation; GP – General Practice; TUGT – Timed Up and Go Test; PT – physiotherapy or physiotherapist; OT – occupational therapist or therapy; A&E – Accident and Emergency; E.D. – Emergency Department; ADL – activities of daily living;

Table 1.4: Randomised controlled trials of multifactorial falls prevention interventions for community dwelling older people (Continued)

Author	Participants	Follow-up period	Intervention	Control	Results
Kingston 2001 (100) **United Kingdom**	N = 109 Mean age 71.9 years. 100% female. Recruited from A&E. Inclusion: attended A&E with fall, female, 65 – 79 years, history of fall, discharged to own home. Exclusion: admitted to hospital from A&E, institutional care.	12 weeks	Rapid Health Visitor review within 5 working days of index fall – pain control, medications, how to get up after a fall, fall risk factor education, advice on diet, strength exercises.	Usual post fall care – letter to GP regarding A&E attendance, interventions and recommendations for follow-up.	Number of fallers Risk of falling RR 0.64 (0.18 – 2.24)
Lightbody 2002 (101) **United Kingdom**	N = 348 Median age 75 (IQR 70-81) 74% female. Recruited from A&E. Inclusion: >65 years, attended A & E with a fall. Exclusion: admitted to hospital with a fall, living in institutional care, unable to consent, living out of area.	6 months	Nurse-led multifactorial falls risk assessment at home. Referral for specialist assessment or further action such as referral to community services or primary care. No referrals to day hospital or hospital outpatients. Home safety advice and simple modifications (mat removal etc.).	Usual care.	Number of falls Rate of falls RaR 0.85 (0.69 – 1.06) Number of fallers Risk of falling RR 0.98 (0.68 – 1.42) Number sustaining a fracture

RaR – rate ratio; RR – relative risk; SD – standard deviation; GP – General Practice; TUGT – Timed Up and Go Test; PT – physiotherapy or physiotherapist; OT – occupational therapist or therapy; A&E – Accident and Emergency; E.D. – Emergency Department; IQR – interquartile range;

Table 1.4: Randomised controlled trials of multifactorial falls prevention interventions for community dwelling older people (Continued)

Author	Participants	Follow-up period	Intervention	Control	Results
Logan 2010 (102) **United Kingdom**	N = 204 Median age 83 (IQR 77 – 86) 65% female. Recruited from 4 primary care trusts. Inclusion: ≥60 years, living at home or in a care home, called for an ambulance after a fall and not taken to hospital, or taken to hospital and not admitted. Exclusion: receiving fall prevention services.	1 year	Referral to multidisciplinary falls prevention service for assessment and tailored interventions – balance training, strengthening exercises, environmental hazard assessment, education on how to get off the floor, provision of equipment. Referral to GP for vision assessment and medication review and if necessary community geriatrician.	Usual care – no intervention by fall prevention service.	Number of falls Rate of falls RaR 0.45 (0.35 – 0.58) Number of fallers Risk of falling RR 0.32 (0.23 – 0.45) Number sustaining a fracture requiring hospitalisation.
Lord 2005 (103) **Australia**	N = 620 Mean age 80.4 years (SD4.5) 66% female. Recruited from health insurance membership database. Inclusion: low score of PPA test, community-dwelling, ≥75 years. Exclusion: minimal English language skills, blind, Parkinson's disease, cognitive impairment.	1 year	1. Extensive intervention: individualised exercise intervention (2 x per week for 12 months), visual intervention, peripheral sensation counselling intervention. 2. Minimal intervention: individualised falls risk report, specific recommendations on preventing falls based on test results.	No intervention – minimal intervention after 12 months follow-up.	Number of falls Rate of falls RaR 0.97 (0.81 – 1.16) Number of fallers Risk of falling RR 1.05 (0.88 – 1.25)

RaR – rate ratio; RR – relative risk; SD – standard deviation; GP – General Practice; TUGT – Timed Up and Go Test; PT – physiotherapy or physiotherapist; OT – occupational therapist or therapy; A&E – Accident and Emergency; E.D. – Emergency Department; PPA – Physiological Profile Assessment;

Table 1.4: Randomised controlled trials of multifactorial falls prevention interventions for community dwelling older people (Continued)

Author	Participants	Follow-up period	Intervention	Control	Results
Mahoney 2007 (104) **United States**	N = 349 Mean age 80 (SD 7.5). 79% female. Recruited from senior centres, meal sites, senior apartment buildings, other senior congregate sites. Inclusion: ≥ 65 years, living independently, ≥2 falls in the previous year or 1 injurious fall in the previous 2 years, gait and balance problems. Exclusion: unable to give informed consent, in hospice or assisted living facility, expected to move away from area.	1 year	Nurse or PT falls risk assessment over 2 home visits with recommendations and referrals – primary physician, PT, OT, ophthalmologist, podiatrist etc. Monthly exercise plan, monthly exercise calendar, 11 monthly phone calls to promote adherence.	Single OT in-home assessment for home safety recommendations and advice to see their physician about falls.	Number of falls Rate of falls RaR 0.81 (0.57 – 1.15)
Markle-Reid 2010 (105) **Canada**	N = 109 Age range 75 – 84. 72% female. Recruited from home support services. Inclusion: ≥75, community-dwelling, fallen in past 12 months, fear of falling, unsteady on feet. Exclusion: not mentally competent, not competent in English or with a translator available.	6 months	Standard home services and home visits by health professionals.	Standard home services.	Rate of falls RaR 1.09 (0.77 – 1.56) Risk of falling RR 1.23 (0.82 – 1.86)

RaR – rate ratio; RR – relative risk; SD – standard deviation; GP – General Practice; TUGT – Timed Up and Go Test; PT – physiotherapy or physiotherapist; OT – occupational therapist or therapy; A&E – Accident and Emergency; E.D. – Emergency Department;

Table 1.4: Randomised controlled trials of multifactorial falls prevention interventions for community dwelling older people (Continued)

Author	Participants	Follow-up period	Intervention	Control	Results
Newbury 2001 (106) **Australia**	N = 100. Age range 75 – 91. 63% female. Recruited from General Practices. Inclusion: ≥75 years, independently community-dwelling. Exclusion: none described.	1 year	Nurse-led health assessment. Problems were counted and reported to the participant's G.P. No other interventions.	No intervention. At 12 months a nurse-led health assessment.	Number of fallers Risk of falling RR 0.58 (0.21 – 1.58)
Rubenstein 2007 (107) **United States**	N = 792 Mean age 74.5 years (SD 6). 3% female. Recruited from ambulatory care centres. Inclusion: ≥ 65 years, previously randomised to practice groups involved in the trial, ≥ 1 clinic visit in previous 18 months, scoring ≥ 4 on GPSS. Exclusion: living over 30 miles from care centre, already enrolled in outpatient geriatric services are care centre, living in long-term care facility, scoring <4 GPSS.	3 years	Physician assistant-led structured risk and needs assessment and referral algorithm. Targeting 5 geriatric conditions including falls. Followed by referrals and recommendations for further assessment or treatment.	Usual care.	Number of falls Rate of falls RaR 1.19 (0.90 – 1.56) Number of fallers Risk of falling 1.01 (0.72 – 1.41)

RaR – rate ratio; RR – relative risk; SD – standard deviation; GP – General Practice; TUGT – Timed Up and Go Test; PT – physiotherapy or physiotherapist; OT – occupational therapist or therapy; A&E – Accident and Emergency; E.D. – Emergency Department; GPSS – Generic Patient Specific Scale;

Table 1.4: Randomised controlled trials of multifactorial falls prevention interventions for community dwelling older people (Continued)

Author	Participants	Follow-up period	Intervention	Control	Results
Russell 2010 (65) **Australia**	N = 712 Age groups: 13% 60-64, 17% 65-69, 19% 70-74, 19% 75-79, 32% ≥80. 70% female. Recruited from ED. Inclusion: ≥ 60 years, community-dwelling, presenting to ED after a fall and discharged to home (not admitted). Exclusion: unable to comply with simple instructions, unable to walk independently indoors (with/without aid).	1 year	Standard care in ED and assessed using the FROP-Com (Falls Risk of Older people in the community) and offered multifactorial falls prevention programme – referrals to existing community services and health promotion recommendations. Participants at high risk of falls (≥ 25 on FROP-Com) referred to falls clinic for comprehensive multidisciplinary assessment.	Standard care in ED and letter to participants with level of falls risks (FROP-Com) and recommendations to discuss with GP.	Number of falls Rate of falls RaR 0.68 (0.49 – 0.94) Number of fallers Risk of falling RR 1.11 (0.94 – 1.29) Number sustaining a fracture
Salminen 2009 (108) **Finland**	N = 591 Age: 62% 65-74; 38% ≥ 75 years. 84% female. Recruited from community (advertising). Inclusion: ≥ 65 years, fallen in last year, MMSE ≥ 17, Able to walk 10m independently, living at home or sheltered housing. Exclusion: none described.	1 year	Geriatric assessment, individually tailored intervention targeting muscle strength and balance, exercise in groups, vision referral, nutritional guidance or referral, medications, depression, treatment and prevention of Osteoporosis, home hazard modification, calcium and vitamin D replacement.	Counselling and guidance after comprehensive assessment.	Number of falls Rate of falls RaR 0.56 (0.42 – 0.75) Number of fallers Risk of falling RR 1.09 (0.92 – 1.31)

RaR – rate ratio; RR – relative risk; SD – standard deviation; GP – General Practice; TUGT – Timed Up and Go Test; PT – physiotherapy or physiotherapist; OT – occupational therapist or therapy; A&E – Accident and Emergency; E.D. – Emergency Department;

Table 1.4: Randomised controlled trials of multifactorial falls prevention interventions for community dwelling older people (Continued)

Author	Participants	Follow-up period	Intervention	Control	Results
Schrijnemaekers 1995 (109) **Netherlands**	N = 222 Age groups: 70% 77-84, 30% ≥ 85. 70% female. Recruited from community (N=146) or residential homes (N=76). Inclusion: ≥ 75 years, living at home or in one of 2 residential homes, having problems with ≥ 1 of the following: IADL, ADL, toileting, mobility or fallen in the last 6 months, serious agitation or confusion, informed consent from participant and their GP. Exclusion: living in nursing home, received outpatient or inpatient care from geriatric unit in previous 2 years.	6 months (follow-up for 3 years).	Comprehensive assessment in outpatient geriatric unit – geriatrician, psychologist, social worker. Advice to participant and GP about treatment and support.	Usual care.	Risk of falling RR 0.75 (0.44 – 1.27)
Shyu 2010 (110) **Taiwan**	N = 162 Mean age: 78.2 years (SD 7.8) 69% female. Recruited from hospital. Inclusion: ≥ 60 years, received hip arthroplasty or internal fixation for single accidental hip fracture, able to perform full range of motion, pre-fracture Chinese Barthel Index >70. Exclusion: severely cognitively impaired; terminally ill.	2 years	Multidisciplinary programme – geriatric consultation services, a continuous rehabilitation programme, discharge planning services.	Usual care.	Number of fallers Risk of falling RR 0.56 (0.34 – 0.93)

RaR – rate ratio; RR – relative risk; SD – standard deviation; GP – General Practice; TUGT – Timed Up and Go Test; PT – physiotherapy or physiotherapist; OT – occupational therapist or therapy; A&E – Accident and Emergency; E.D. – Emergency Department; ADL – activities of daily living; IADL – instrumental activities of daily living;

Table 1.4: Randomised controlled trials of multifactorial falls prevention interventions for community dwelling older people (Continued)

Author	Participants	Follow-up period	Intervention	Control	Results
Spice 2009 (111) **United Kingdom**	N = 516 Mean age: 82 years. % female not stated. Recruited from 18 general practices. Inclusion: ≥ 65 years, community-dwelling, history of at least 2 falls in previous year, not presenting to A & E with index fall. Exclusion: none described.	1 year	1. Secondary care – multidisciplinary day hospital assessment by physician, OT and physiotherapist. 2. Primary care – health visitor / practice nurse falls risk assessment / referral.	Usual care.	Number of fallers Risk of falling RR 0.95 (0.86 – 1.05)
Tinetti 1994 (112) **United States**	N = 301 Mean age: 77.9 years (SD 5.3). 69% female. Recruited from participating physicians' rooms. Inclusion: >70 years, community-dwelling, independently ambulant, ≥ 1 targeted risk factor for falling (postural hypotension, sedative/hypnotic use, use of >4 medications, inability to transfer, gait impairment, strength or range of motion loss, domestic environmental hazards). Exclusion: enrolment in another study, MMSE <20, current participation in vigorous exercise.	1 year	Interventions targeted to individual risk factors, according to decision rules and priority lists. 3-month programme duration.	Visits by social work students over 3 months.	Number of falls Rate of falls RaR 0.56 (0.42 – 0.75) Number of fallers Risk of falling RR 0.75 (0.55 – 1.02) Number sustaining a fracture

RaR – rate ratio; RR – relative risk; SD – standard deviation; GP – General Practice; TUGT – Timed Up and Go Test; PT – physiotherapy or physiotherapist; OT – occupational therapist or therapy; A&E – Accident and Emergency; E.D. – Emergency Department; MMSE – Mini-mental state examination;

Table 1.4: Randomised controlled trials of multifactorial falls prevention interventions for community dwelling older people (Continued)

Author	Participants	Follow-up period	Intervention	Control	Results
Van Haastregt 2000 (113) **Netherlands**	N = 316 Mean age: 77.2 years (SD 5.1). 66% female. Recruited from 6 general medical practices. Inclusion: ≥ 70 years, community-dwelling, 2 or more falls in previous 6 months or score ≥ 3 on mobility scale of Sickness Impact Profile. Exclusion: bed ridden, fully wheelchair dependent, terminally ill, awaiting nursing home placement, receiving regular care from community nurse.	12 months (18 months in total)	Community nurse-led: 5 home visits over 1 year. Screened for medical, environmental and behavioural risk factors for falls and mobility impairment. Provided with advice, referrals and "other actions".	Usual care.	Number of fallers Risk of falling RR 1.13 (0.86 – 1.48)
Vetter 1992 (114) **United Kingdom**	N = 674 Age >70 years. % female not described. Recruited from 1 GP's patient list. Inclusion: >70 years. Exclusion: none described.	4 years	Health visitor-led: ≥ 1 health visitor visits per year for 4 years, advice on nutrition, environmental modification, concomitant medical conditions, and referral to physiotherapy classes if desired.	Usual care.	Risk of falling RR 1.27 (0.99 – 1.64)

RaR – rate ratio; RR – relative risk; SD – standard deviation; GP – General Practice; TUGT – Timed Up and Go Test; PT – physiotherapy or physiotherapist; OT – occupational therapist or therapy; A&E – Accident and Emergency; E.D. – Emergency Department;

Table 1.4: Randomised controlled trials of multifactorial falls prevention interventions for community dwelling older people (Continued)

Author	Participants	Follow-up period	Intervention	Control	Results
Vind 2009 (115) **Denmark**	N = 392 Mean age: 74 years (SD 6). 74% female. Recruited from ED or following hospital discharge. Inclusion: ≥ 65 years, treated in ED or admitted to hospital because of a fall. Exclusion: fall caused by external force or alcohol intoxication, not living locally, institutionalised, unable to walk, terminally ill, impaired communication, described as suffering from dementia in hospital notes or by staff, having a planned geriatric intervention.	1 year	Comprehensive multifactorial intervention – assessed by doctor (1h), and nurse and physio (1.5h), during 2 visits to geriatric outpatient clinic. Team discussion with senior geriatrician, interventions planned and offered to participants. Carried out in clinic or referred to specialists. Included progressive individualised exercise, drug modification, treatment of untreated disease, advice or referral to ophthalmologist, etc.	Usual care as planned in ED or during admission.	Number of falls Rate of falls RaR 1.06 (0.75 – 1.51) Number of fallers Risk of falling RR 1.11 (0.84 – 1.45) Total number of fractures
Wagner 1994 (116) **United States**	N = 1559 Mean age: 72 years. 59% female. Recruited from HMO enrolees. Inclusion: ≥ 65 years, HMO members, ambulatory and independent. Exclusion: too ill to participate as defined by primary care physician.	1 year (2 years total follow-up)	1. Nurse-led: 60-90-minute interview with nurse, including review of risk factors, audiometry and BP measurement, development of tailored intervention, motivation to increase physical and social activity. 2. Chronic disease prevention nurse visit.	Usual care.	Number of fallers Risk of falling RR 0.75 (0.64 – 0.88)

RaR – rate ratio; RR – relative risk; SD – standard deviation; GP – General Practice; TUGT – Timed Up and Go Test; PT – physiotherapy or physiotherapist; OT – occupational therapist or therapy; A&E – Accident and Emergency; E.D. – Emergency Department; HMO – Health Maintenance Organisation;

Table 1.4: Randomised controlled trials of multifactorial falls prevention interventions for community dwelling older people (Continued)

Author	Participants	Follow-up period	Intervention	Control	Results
Whitehead 2003 (117) **Australia**	N = 140 Mean age: 77.8 years (SD 7.0). 71% female. Recruited from A&E. Inclusion: ≥ 65 years, fall-related attendance at A&E, community-dwelling or in low care residential care. Exclusion: resident in nursing home, presenting fall secondary to stroke, seizure, cardiac or respiratory arrest, major infection, haemorrhage, motor vehicle accident, or being knocked to the ground by another person, MMSE <25, no resident carer, not English speaking, living out of catchment area, terminal illness.	6 months	Home visit and questionnaire. "Fall risk profile" developed and participant given written care plan itemising elements of intervention. Letter to GP informing him of participant's fall, inviting them to review participant, highlighting identified risk factors, suggesting possible strategies (evidence based). GP was given 1-page evidence summary.	Home visit. No intervention. Standard medical care from GP.	Number of fallers Risk of falling RR 1.70 (0.68 – 4.27)
Wyman 2005 (118) **United States**	N = 272 Mean age: 79 years (SD 6). 100% female. Recruited from Medicare beneficiaries. Inclusion: >70 years, community-dwelling, mentally intact, ambulatory, ≥2 risk factors for falls, medically stable. Exclusion: currently involved in regular exercise.	2 years	Nurse practitioner-led: comprehensive fall risk assessment by nurse practitioner, exercise, fall prevention education, provision of 2 night lights, individualised risk reduction counselling. 12-week intervention of alternating home visits and phone calls, followed by tapered 16-week computerised telephone monitoring and support.	Health education on topics other than fall prevention. 12-week intervention of alternating home visits and telephone calls, followed by tapered 16-week computerised telephone monitoring and support.	Number of falls Rate of falls RaR 0.72 (0.54 – 0.96) Number of fallers Risk of falling RR 1.11 (0.84 – 1.45)

RaR – rate ratio; RR – relative risk; SD – standard deviation; GP – General Practice; TUGT – Timed Up and Go Test; PT – physiotherapy or physiotherapist; OT – occupational therapist or therapy; A&E – Accident and Emergency; E.D. – Emergency Department; MMSE – Mini-mental state examination;

1.7.2 Multifactorial trials – specialist-led or hospital based interventions

The multifactorial interventions discussed in the Cochrane review differed in a number of potentially important ways. As outlined in Table 1.4, the methodological variation can be broadly categorised in terms of where the subjects were recruited from – community, General Practice or following ED attendance; where the intervention was delivered – community-based, General Practice or hospital-based services; and who delivered and determined the tailored interventions – nurse or nurse practitioner, allied health professionals or specialist physicians. Further examination of the studies, with specialist-led interventions or hospital-based services is outlined below.

Four studies included in the meta-analysis demonstrated a significant reduction in the rate of falling and/or the risk of falling. The PROFET trial targeted those older people who had attended an Accident and Emergency department in London with a fall or fall-related injury, recruiting 397 subjects, with 183 subjects receiving the intervention. (64) Details of the intervention are shown in Table 1.4, but in brief subjects received a comprehensive medical assessment by a geriatrician of multifactorial falls risks followed by targeted interventions and referrals, which were directed by the intervention service. Included was an Occupational Therapist home environmental hazard assessment and recommendations. Importantly, funding was provided for minor modifications and aids. This intervention demonstrated a significant reduction in the number of falls (intervention = 183 vs control = 510; P=0.0002), risk of falling (OR 0.39; 95% CI 0.23 – 0.66) and risk of recurrent falls (OR 0.33; 95% CI 0.16 – 0.68). Hendriks et al. attempted to replicate the PROFET trial in a Dutch cohort, but found no significant difference in the time to first fall between the intervention and the control arms. (94) The authors made reference to the healthcare system differences between the Netherlands and the U.K. which altered the provision of some of the recommendations of the multifactorial assessment - their provision was dependent upon referral by the primary care physician. This meant that instead of the research team providing or referring participants to falls prevention interventions, an additional step was required to access these interventions, and was outside of the control of the research team.

Another U.K. based study in 2005, examined the effectiveness of a hospital-based falls clinic with multifactorial assessment by a geriatrician and the provision of home based physiotherapy and an Occupational Therapist provided home hazard assessment. (88) Again the interventions were provided by the research team and referrals were directed by the research team to existing services. There were 94 falls in the intervention group and 102 falls in the control group, with a reduction in the rate of falls of 36% (RaR 0.64; 95% CI 0.46 – 0.90). There was no significant reduction in the risk of falling (RR 0.95; 95% CI 0.81 – 1.12). The Winchester falls trial examined the effectiveness of 2 interventions, one based in a day hospital with Geriatrician input and one based in General Practice. The day hospital intervention provided a comprehensive assessment by a Geriatrician, a Physiotherapist and an Occupational Therapist with interventions as appropriate arranged by the day hospital team. In the General Practice arm of the trial, the intervention was implemented by a health visitor and practice nurse who undertook a comprehensive fall risk assessment followed by referral for interventions as appropriate. The day hospital intervention demonstrated significant reduction in the risk of falling with 75% (158 of 210 subjects) in the day hospital intervention group falling compared with 87% (118 of 136 subjects) in the General Practice intervention group and 84% (133 of 159 subjects) in the control group. The risk of falling was almost halved in the day hospital intervention group (OR 0.52; 95% CI 0.35 – 0.79) compared to the control group. (111)

The above-mentioned trials were all based in the U.K. and their success may not be translatable to other countries, as seen with the negative trial by Hendriks et al. An additional trial based in a Taiwanese population following admission to hospital with a hip fracture demonstrated a reduction in the risk of falling, with the risk reduced by close to 50% (RR 0.56; 95% CI 0.34 – 0.93). (110) This population is different to those reported in the previous studies, as patients who had undergone surgical fixation for a hip fracture were targeted rather than those who had fallen, and this therefore, may have an influence on the compliance of participants with recommendations.

Looking at Australian based populations, Russell et al. reported on an intervention to reduce falls in a cohort of patients who attended an Emergency Department with a fall. (65) Standard care was received in the E.D., but this was followed by an in-home assessment by trained assessor (Physiotherapist, Occupational Therapist, Doctor or Research Fellow) using the FROP-Com (Fall Risk of Older People in the Community) falls risk assessment tool. Referrals were then made by the team to existing community services along with health promotion recommendations. A comprehensive multidisciplinary assessment was offered to those subjects who scored in the high-risk range on the risk assessment tool. A significant reduction in the rate of falls was demonstrated with the rate ratio (RaR) 0.68 (95% CI 0.49 – 0.96), no difference was demonstrated in the risk of falling (RR 1.11; 95% CI 0.95 – 1.31) or the risk of injurious falls (RR 1.06; 95% CI 0.86 – 1.29). When the model was adjusted for history of falls in the previous 12 months, balance, level of ADL independence and ability to speak English, the effect of the intervention on the rate of falls became non-significant (RaR 0.87; 95% CI 0.65 – 1.17). (65) With the intervention trials discussed thus far showing a mixed picture, it is important to explore the features which were common to the interventions which were effective in reducing falls.

1.7.3 Features of successful multifactorial targeted interventions

There are a number of features common to the multifactorial intervention trials which have demonstrated a significant effect on risk of falling and/or rate of falling. Involvement of a specialist physician, usually a Geriatrician, was common in the successful intervention trials. Elley et al. hypothesised that the failure of their trial to demonstrate a reduction in the risk of falls was due to the General Practitioners reluctance to follow recommendations from nursing staff. (90) In addition, those interventions which made recommendations only, rather than implementing falls prevention strategies as part of the research teams' responsibilities, were more likely to fail to show an impact on falls. The problems with the implementation of the PROFET trial protocol in a Dutch healthcare setting, were reported by Hendriks et al. as a limitation in the effectiveness of their trial. (94) This study depending upon the General Practitioner implementing recommendations, and referring participants to Allied Health professionals for exercise and home hazard assessments. Previous studies on the barriers to falls prevention interventions have reported that primary care physicians are not aware of the importance of risks, such as medication, on falling, and are therefore less likely to implement change. (119) And finally, there are patient specific barriers, with Tinetti et al. reporting on a study which described reluctance among older people who have fallen to alter their antihypertensive medications which had been proven to contribute to their risk of falls. (120) By targeting participants who have already had a major injury and surgical intervention, could impact on patient compliance with falls prevention recommendations and underpin the success of the study by Shyu et al. (110)

1.8 Translating research in to practise

The Cochrane systematic review and meta-analysis has shown a reduction in the rate of falls with multifactorial interventions. However, the implementation of such strategies in the "real world" setting has been difficult. With the volume of data on falls prevention interventions available since the early FICSIT trials (Frailty and Injuries: Cooperative Studies of Intervention Techniques), it would not be unreasonable to expect falls prevention interventions to now be common-place in injury prevention strategies in well health resourced countries. The FICSIT trials were a group of 8 clinical trials based in the United States of America, which examined interventions to address physical frailty and injuries in older people. These trials were the first nationally sponsored approach to falls and frailty interventions and were unique in their use of a common database for 8 different trial interventions. (121) Many of the interventions investigated in the FICSIT trials became the basis for further studies included in the Cochrane reviews since 2003. (80-82) Dr Mary Tinetti, a leading light in falls research and the lead investigator in the Yale FICSIT trial, wrote a commentary following the publication of the Hendriks et al. (94) and Elley et al. (90) studies, examining the difficulty in translation of the research into practice. (122) She described some residual doubt as to the effectiveness of these interventions and the significant resource implications to institute these strategies in usual care based on a meta-analysis by Gates et al. (38) This meta-analysis concluded that multifactorial falls prevention interventions were not effective in the reduction of the rate of falls or risk of falling in older people in the community and attending the E.D. (123) Dr Tinetti examined the effect of direct provision of falls prevention interventions, highlighting that a positive effect on the risk of falling was more commonly seen in those trials that provided direct intervention. Direct interventions were those were the research team provided and coordinated falls prevention interventions rather than a referral based intervention with no direct input into management. The provision of these interventions requires the appropriately trained staff. A meta-analysis of exercise interventions by Sherrington et al. demonstrated that successful programmes require progressive increase in balance challenge and progressive resistance training to show the greatest effect. (124) And interventions with higher intensity of input from the intervention team (doctor, nurse, allied health) providing greater support for the older person and their General Practitioner were more successful, but this would not be standard practice. (122, 123)

From a research perspective, Lord et al. outlined strategies to enhance the translation of research to the Australian clinical setting. (125) The strategies they discussed encompass elements of clinical care, development of a professional society to focus on falls prevention, and to develop health policy to both address current clinical concerns and to advance a research agenda to address falls prevention. Despite the large volume of research already discussed in this thesis, there remain unanswered questions. How are these falls prevention interventions best delivered, and should specific groups be targeted with different falls prevention interventions? If interventions are confined to those who access hospital-based healthcare, how do we know which fallers will gain the greatest benefit from these interventions, and who should be provided with supportive care? To date the development of falls prevention services, differ across the Australian healthcare system, and therefore, there remains no standardised approach to determining the success of such clinical interventions. These issues remain the focus of policy development and the research agenda in Australia.

1.8.1 Falls clinics in Australia

The implementation of falls prevention strategies in Australia has seen the development and growth of “Falls Clinics”. Hill et al. conducted a survey of 20 of these clinics throughout Australia in 2000, with a 75% response rate (n=15). (126) There was no reported standardised approach to the model of care provided by these services. The clinics were variously staffed by allied health professionals especially physiotherapists and occupational therapists, Geriatricians and Rehabilitation Medicine specialists and nurses. The assessments took on average 130 minutes to complete and the wait for assessment could take up to 16 weeks. The provision of targeted interventions relied on a combination of existing services and that provided by the clinic. Assessment tools were not standardised and there was limited formal evaluation of the effectiveness of the interventions provided. These clinics were resource, staff and time intensive and in the main required the older person to attend the clinic rather than provide care in their home. This variation in practise, along with the variation in methodology in the design of multifactorial falls prevention interventions, highlights the difficulty of implementing evidence into practice.

Currently the practise of some falls clinics is not to directly provide all interventions to reduce the risk of falls, but to refer to appropriate services. This is no different to the referral only methodology of some of the falls prevention intervention trials that have had negative results. One could argue that it is not a surprise that interventions driven through general practice are not effective since too much is left to the General Practitioner to assess and organise. It may be that interventions through General Practice would be more effective if the General Practitioner were provided with the results of a falls risk assessment and given advice on an approach to the management of these risks including details on how to access the resources needed for specific interventions. It has been demonstrated that developing practice guidelines is not enough to effect change in practice and that there are competing issues that prevent maximum adherence to falls prevention guidelines. (119) The complexities of implementing falls prevention strategies in primary care are illustrated by the review by Shubert et al. (127) In the U.S. there are a range of guidelines including those from the United States Preventative Services Taskforce (USPSTF). The variations in these guidelines and the fact that there are variations in approach to older people depending on their physical fitness, increases the risk of older people not receiving adequate falls prevention interventions. Providing General Practitioners with advice on falls prevention strategies following a falls risk assessment may be a more practical solution and less resource intensive. However, the Cochrane review demonstrates that studies dependent upon General Practitioner driven referrals to be ineffective in reducing falls. (80) The success of these interventions may be dependent upon the ease of access to appropriate falls prevention strategies rather than a lack of enthusiasm on the behalf of the General Practitioner. Alternatively falls prevention interventions which have been provided by a dedicated falls prevention service appear to be more effective in reducing falls based on the studies included in the Cochrane meta-analysis. (80) A comprehensive approach to falls prevention was prosecuted by Close and McMurdo for the U.K., with guidelines which addressed all aspects of falls prevention from community to primary care, with a significant focus on specialist-led assessment of risk and a tailored management plan. (128) Some argue that this type of resource intensive service is limited in the capacity to deal with an anticipated increasing number of older people who fall and will be available to the few who live in regions with the resources and expertise to provide a “Rolls Royce” service. (129) To further examine this tension between models of care, we think that studies that directly compare a more enhanced General Practice based model of falls prevention versus a hospital-based, specialist-led service are warranted.

1.9 Aims

In light of what has been discussed above, this thesis hopes to fill some of the gaps in knowledge in terms of the risk factors for falls, risk factors for falls presentations to hospital and predictors of mortality with a particular focus on two groups – older fallers who have attended the Emergency Department (E.D.) due to falls or fall related injuries and older community living men. It is hypothesized that in older people attending the E.D. with a fall or fall-related problems have differing risk factor profiles for further falls re-presentations and mortality. Therefore, potentially helping to guide appropriate provision of falls prevention services. We also postulated that there will be differences in the risk factor profile for community dwelling older men, compared to those identified for community dwelling older women in other prospective cohort studies. This again may guide how falls prevention interventions may be targeted to those who are at risk of further falls, and falls hospital admissions. As discussed above, despite the large body of evidence about the efficacy of falls prevention interventions, it is still unclear if these interventions should be hospital based and coordinated by specialist services, or community based and coordinated in primary care. This thesis hopes to address this conundrum with a clinical trial of a multifactorial falls prevention intervention based in a hospital and led by a specialist, which was hypothesized to be the most successful model for fall prevention interventions. The comparison will not be with “usual care”, but will be with an enhanced primary care model where a comprehensive falls risk profile is provided along with standardised advice on how to intervene on these risk factors.

The aims of the studies in this thesis are as follows:

(a) To determine the risk predictors for further fall-related ED attendances in a cohort of older people who have previously presented to the ED with falls or fall-related problems. (Chapter 2)

(b) To determine the mortality associated with a fall-related ED attendance and the predictors for death in the same group of older people who have attended the ED with a fall or fall-related problem. (Chapter 3)

(c) To determine the risk factors for falls in community-dwelling older men. (Chapter 4)

(d) To determine the risk of fall-injury presentations to hospital for community-dwelling older men. (Chapter 5)

(e) To determine the effectiveness of a targeted multifactorial falls prevention intervention in reducing falls by comparing a specialist-led, hospital based service with targeted falls prevention strategies to an enhanced primary care intervention with risk assessment and advice. (Chapter 6)

Chapter 2: Predictors of future falls requiring hospital presentation in older people who have attended an Emergency Department due to a fall.

2.1 Introduction

In section 1.3.2 we discussed the burden of fall related attendances in older people on the Emergency Department (E.D.), with an emphasis on the Australian population. Bell et al. reported that accidental falls and their consequences accounted for approximately 20% of E.D. attendances in a large university teaching hospital based in Sydney. (31) Over half of these attendances required overnight admission for further management. Larger population based studies using linked data have indicated that hospitalisations due to fall injuries constitute a significant proportion of the reasons for hospitalisation in people aged 65 years and older. (30, 37) Bradley et al. reported that fall injury hospitalisations of people aged 65 years and older accounted for 1,353,710 patient days in 2010-11 across all hospitals in Australia. (37) This figure represents 11% of all patient days for this age group and the data suggested an upward trend in hospitalisations between 1999 and 2011. This trend to increased fall related E.D. attendances and hospitalisations are also reported in North American populations. (130, 131) Orces et al. reported on projected figures for fall related injury E.D. up to 2030. Based on E.D. attendance rates and hospitalisation rates from 2001 to 2012 they deduced that there could be an increase in fall-related injuries of 43% by 2020 and 137% by 2030. (130) With the potential to cause such a significant burden on the healthcare system, it is important to understand more about the risk factors associated with these E.D. attendances and factors that are associated with increased propensity to further fall-related E.D. attendances.

Section 1.3.2 also discussed some of the characteristics of older people who have attended the E.D. with a fall in terms of the injuries sustained and the numbers requiring hospitalisation. Further discussion on the characteristics of and the risk factors for attendance at the E.D. with a fall-related injury is detailed in section 1.5.2. Davies and Kenny described the characteristics of 200 older people who attended an Accident and Emergency Department in the North of England with a fall. (66) The authors reported that 26% had cognitive impairment and that simple slip, trip and environmental causes for falls were common (29% of presentations). Further cross-sectional studies examined the circumstances of falls in terms of the mechanism of the fall (67) and how characteristics of the fall might determine functional decline in the short term. (132) Fewer studies however have examined outcomes following attendance at the E.D. with a fall. Close et al. reported that in an Australian cohort of older people aged 65 years and older who had attended the E.D. with a fall, a significant proportion had one or more E.D. presentations (35.4%) or one or more hospitalisations (20.3%) in the previous 12 months. (133) In a U.S. population of older people who attended a trauma centre E.D. with a fall or fall-related injury, 25.1% were found to have re-attended the E.D. for any reason over the following 12 months. (77) This study also reported a 1-year mortality rate of 15% in this cohort. These findings highlight the importance of developing strategies to predict those more likely to re-attend the E.D. with a fall.

Prospective cohort studies permit the examination of risk factors which might predict further falls in older people who have presented to the E.D. with a fall. A study of the non-intervention cohort of the PROFET trial (n = 213) found that an inability to get up after a fall and history of previous falls predicted falls in the future, when followed over 12 months. (69) A history of falls in the previous 12 months was also a significant risk factor for further falls in a study by Carpenter et al. (70) Similarly, Tiedemann et al. reported that recurrent falls in the previous 12 months was significantly associated with further falls in an E.D. population. (71) This study looked at a risk prediction model to identify those at greater risk of recurrent falls. These studies only examined the risk of further falls, rather than further falls-related

E.D. attendance. We argue that it is important to understand the risk factors associated with fall-related E.D. attendances, as this may highlight a cohort of older people who require more focussed attention in terms of falls prevention strategies. All of the above studies followed their respective cohorts for a maximum of 12 months. A community based study has reported that older people who have recurrent falls are at greater risk of mortality at 3 years following a fall (73), which suggests that outcome follow-up should be longer than 12 months. We hypothesise that risk for further falls-related E.D. presentations exists past 12 months of follow-up. Understanding the factors that predict further falls-related E.D. presentations past 12 months may alter the focus of interventions to target these risks.

A group of people aged 65 years and older who have presented to the Emergency Department with a fall or fall-related problem were identified with similar methodology to the studies discussed above and in section 1.5.2. Given the strong association between previous history of falls and future falls shown in the prospective cohort studies, we hypothesized that a proportion of this cohort of older people would indeed re-present to the E.D. with a fall or fall-related problem. In addition, we hypothesized that certain characteristics recorded at their index fall presentation might predict these re-presentations. The objectives of this study were to determine the proportion of this cohort who re-presented to the E.D. with a fall or fall-related problem over a 5-year period, and to examine the association between risk factors examined at the index fall and further E.D. attendance with a fall.

2.2 Methods

A previously reported study examined the characteristics of approximately 500 consecutive patients who were seen in the E.D. of Concord Hospital with a fall, fall-related problem or syncope. (134) This cross-sectional study examined the characteristics of these patients in terms of demographic details, details of the fall, injuries sustained and risk factors for falls. For this current prospective cohort study, we collected falls outcomes for this cohort over a 5-year period from the index fall presentation.

Subject identification

All patients aged 65 years or older presenting to the E.D. of Concord Hospital, a university teaching hospital in Sydney, were screened for inclusion in this study. Eligible subjects were those who were identified using the Emergency Department Information System (EDIS) database as having presented with a fall, fall-related problem or syncope over a 17-week period between 14th March 2005 and 8th July 2005. For the purposes of this study, a fall was defined using the PROFANE group definition: "an unexpected event in which a participant comes to rest on the ground, floor or lower level". (1) Falls due to excessive force, for example as a result of a motor vehicle accident or as a result of an alleged assault, were excluded.

The EDIS database includes demographic details and brief information on the reason for presentation to the E.D. Those patients who presented with a fall, fall-related problem, injury, fracture or syncope were identified. The information contained within the EDIS database is brief and in some instances, can be incomplete or unclear. In order to identify all cases of falls, medical records were also reviewed on any patient whose reason for presentation in the

EDIS was unclear, or the medical information suggested a fall may have occurred, for example presentations with a fracture or injury.

Data were collected on 513 consecutive attendances with a fall, fall-related problem or syncope within the study period in the initial cross-sectional study. Four hundred and ninety-eight subjects were responsible for these attendances and became the study group for the prospective cohort study.

Data collection

A standardised data collection form was used to collect information on socio-demographic details, risk factors for falls such as premorbid function, comorbidities, medication use and details of the index fall including injuries and outcomes following assessment in the E.D. at index presentation. A second standardised data collection form was used to collect information regarding subsequent presentations to the E.D. for falls, falls-related problems or syncope and are discussed further later. Information regarding the initial attendance at the E.D. was examined using the Electronic Medical Record (eMR) and the medical records chart (hard-copy) to confirm the reasons for presentation to the E.D. were related to a fall event.

Data extraction and collation was conducted for the baseline phase by an experienced Geriatrician as part of her Masters Treatise (LN). Data for the second phase of data collection was collected by the author of this thesis, who also has extensive experience in Geriatric Medicine. Therefore, in both phases of data collection, one researcher completed the data collection using electronic and hard-copy medical records. The clinical records reviewed were completed by a range of clinicians over the 5-year study period.

Baseline socio-demographic details

Baseline socio-demographic details collected at the time of index falls presentation included age, gender, place of residence and location of residence. Mobility, ability to manage activities of daily living (ADLs) and requirement of assistance from community services was recorded, based on information reported at the index fall presentation. A categorical variable for mobility prior to presentation at the E.D. was classified as walking unaided, walking with a mobility aid, or walking with physical assistance or immobile.

The participant's function prior to presentation to the E.D. was classified based on personal activities of daily living. Activities of daily living include toileting, continence, bathing, grooming and dressing, transferring from bed to chair and feeding. Recording of ADLs was based on self-report or carer report in the form of a simple question: "Requiring assistance or not requiring assistance with ADLs". A formal scale for assessment of functional dependence was not used in the initial data collection. If the subject required physical assistance, direction or supervision to perform at least one of these activities they were classified as "requiring assistance with ADLs".

Details on the use of any community services to assist a subject prior to presentation to the E.D. were also recorded. If a subject required any formal services provided by federal or state funded providers, they were classified as receiving services. This included the provision of assistance with activities of daily living, cleaning, shopping, transport or meal preparation including "meals on wheels".

Baseline fall risk factors

History of previous falls

A prior history of falls was determined by either a self-reported history documented in the participant's medical record or by identifying a prior attendance or admission to a hospital in

Sydney South West Area Health Service as a consequence of a fall, using the participant's eMR.

Comorbidities

Comorbidities were recorded using diagnoses recorded in the participant's eMR and hard-copy medical records. The accuracy is dependent on patient self-report and level of detail documented at each admission and discharge by the admitting medical and/or nursing staff. Comorbidities were classified into 11 categories as follows:

1. Cardiovascular diseases – including cardiac conditions such as ischaemic heart disease, coronary artery disease, arrhythmias such as atrial fibrillation, hypertension, hyperlipidaemia and peripheral vascular disease.
2. Respiratory disease – including chronic obstructive pulmonary disease, asthma, fibrotic lung disease, pulmonary embolism and pulmonary hypertension.
3. Gastrointestinal disease – including peptic ulcer disease, inflammatory bowel disease, diverticular disease, chronic liver disease and cholelithiasis.
4. Malignancy – including solid organ cancers, haematological malignancies and all skin cancers.
5. Endocrine disorders – including diabetes mellitus, thyroid disease and osteoporosis.
6. Neurological disorders – including stroke and transient ischaemic attacks (TIAs), Parkinson's disease and epilepsy.
7. Sensory impairment – including hearing loss or deafness, visual impairment due to cataracts, aged related macular degeneration, glaucoma or trauma.
8. Musculoskeletal disorders – including osteoarthritis, inflammatory arthropathies such as rheumatoid arthritis and gout, and prior trauma causing joint deformities.

9. Genitourinary disorders – including prostate disease such as benign prostatic hypertrophy and prostate cancer; recurrent urinary tract infections, urinary incontinence and chronic kidney disease.
10. Haematological disorders – including anaemia, myeloproliferative disorders and peripheral thromboembolic disease, but excluding haematological malignancies.
11. Psychiatric disorders – including depression, schizophrenia, and alcohol dependency.

Cognitive impairment and dementia were considered as a separate risk factor for falls and were not categorised with other medical co-morbidities. A subject was classified as having cognitive impairment if they satisfied one of the following conditions: there was a diagnosis of dementia or mild cognitive impairment (including short term memory loss), or there was a Mini-Mental State Examination (MMSE) score of 25 or below documented. Where there was no documentation about cognition, normal or abnormal, and no MMSE score recorded, the subject's cognition was classified as "unclear".

Medication use at index fall

All usual medications used both regularly and as required were recorded for each subject at their presentation to the E.D. with the index fall. The total number of medications used was recorded. Particular attention was paid to medications that have been shown to be associated with increased risk of falls - psychotropic agents, antihypertensives and diuretics.

Participants were categorised based on their use of psychotropic agents as a yes/no variable and the total number of psychotropic agents was also recorded as were the types of agents used. Psychotropic agents were classified as follows:

1. Antipsychotics – typical agents such as haloperidol; and atypical agents such as olanzapine and risperidone.
2. Antidepressants – such as tricyclic antidepressants (TCAs) and selective serotonin reuptake inhibitors (SSRIs).
3. Benzodiazepines (BZDs) – long, short and ultra-short acting agents and including the newer Z compounds such as zolpidem.
4. Anticonvulsants – older agents such as sodium valproate and newer agents such as gabapentin and lamotrigine.
5. Others – psychoactive medications not categorised above including antihistamines and cholinesterase inhibitors such as donepezil.

Participants were also categorised based on their use of antihypertensive medications as a yes/no variable. The total number of agents was also recorded and then individual agents were recorded as follows:

1. Angiotensin converting enzyme (ACE) inhibitors.
2. Angiotensin II receptor blockers (ARBs).
3. Beta (β) receptor blockers.
4. Calcium channel blockers.
5. Diuretics.
6. Antiarrhythmic agents with a blood pressure lowering effect such as sotalol.
7. Nitrates such as isosorbide mononitrate.

The use of alpha receptor blockers and centrally acting antihypertensives was recorded in the original cross-sectional study, but were not included in this analysis due to small numbers (less than 10 participants each). Medications which are prescribed for non-antihypertensive indications but may have a blood pressure lowering effect, such as those with anticholinergic effects or alpha blockers prescribed for urological conditions, were not included.

Medications used in the treatment of osteoporosis were recorded, and specifically, the agents used. The treatment was then re-categorised into the following two variables: calcium and vitamin D supplementation and specific osteoporosis treatment which included bisphosphonates, hormone replacement therapy and selective oestrogen receptor modulators (SERMs).

Details of the index fall

<u>Cause of falls classification</u>

The cause of falls was classified into 4 categories in keeping with definitions used by Campbell et al. (135) As discussed in chapter 1, falls may be the result of physiological changes and environmental factors combining to cause the fall, a "cold fall", such as a simple slip or trip. Falls may also be as a consequence of a precipitating event, such as an acute medical condition, for example a myocardial infarction or sepsis. This precipitating event may impact on physiological parameters, for example, muscle strength and balance, causing a "hot fall". The falls were characterised thus as we hypothesised that "hot falls" may be less likely to be associated with future falls and E.D. attendances with a fall or fall-related problem. The four categories of falls are as follows:

1. "Cold / external falls – a fall due to external factors with or without an underlying impairment in gait or balance. This included falls due to simple slips or trips, loss of balance or loss of support.
2. "Hot fall" – a fall precipitated by an acute medical condition, excluding a syncopal episode. Examples of medical conditions associated with falls include acute

myocardial infarction, infections, metabolic disturbances, adverse drug reactions and alcohol intoxication.

3. "Syncope" – a fall resulting from a transient loss of consciousness with spontaneous recovery. This includes conditions that cause cerebral hypoperfusion, most commonly due to cardiac arrhythmias and hypotension, but also including pulmonary embolism for example. For the purposes of this study syncope also includes seizures.
4. "Unclear" – any fall for which the cause of the fall could not be categorised in to one of the categories above, either because the details of the falls were not available, or the information available was insufficient to be able to clearly categorise into one of the three categories above.

Index fall injury

Any injury sustained at the time of the index fall was recorded. The most significant injury was categorised as either "no/minor" or "major". Minor injuries were defined as those not requiring specific medical intervention, such as suturing or regular dressings, and did not result in loss of function. This included bruising, abrasions and superficial lacerations. Major injuries included all other injuries not fitting into the minor classification and included fractures, soft tissue injuries affecting function, lacerations requiring suturing, abrasions or skin tears requiring regular dressings or skin grafting, and head injuries. Falls resulting in a long lie and consequently developing muscle injury, such as rhabdomyolysis, or dehydration were classified as a major injury. Falls due to acute medical conditions ("hot falls") which did not result in an injury were classified as "no/minor" injury. Fractures were classified into categories based on anatomical site as upper limb, lower limb (including neck of femur fractures) and pelvis, and vertebral and other fractures.

Outcome ascertainment – E.D. attendances with a fall, fall-related problem or syncope.

Following the index fall presentation all subsequent attendances to any E.D. in the Sydney South West Area Health Service (SSWAHS) were recorded. At the time of the study the SSWAHS included 8 public hospitals with an E.D. There were no private hospitals with E.D.'s within this area health service. The eMR provides information on E.D. attendances and admissions at all hospitals in the Sydney South West Area Health Service for individuals. The eMR for each participant was reviewed to identify attendances to an E.D. and admissions to hospital during the study period 14th March 2005 to 30th March 2010. Once the eMR identified an attendance at an E.D. or hospital admission, the record was reviewed to ascertain the nature of the visit and to identify those related to a fall, fall-related problem or syncope. These attendances or admissions were classified as a "fall attendance". All other E.D. attendances or hospital admissions were classified as a "non-fall attendance". If the information was unclear, a review of the medical record (hard-copy) was performed to verify the details of the attendance. This review was conducted at the study site (Concord Hospital) and 2 additional hospitals (Canterbury and Royal Prince Alfred Hospitals). The records of all participants were reviewed at Concord Hospital. A further 69 participants at Royal Prince Alfred Hospital and 39 participants at Canterbury Hospital had at least one attendance at each hospital requiring further clarification. Less than 1% of all attendances or admissions occurred in other hospitals in the SSWAHS, therefore hard-copy medical records were not reviewed at these sites. Information obtained from these sources included the date of the E.D. attendance and/or hospital admission and the reason for the attendance or admission in the study period.

Ethical approval

Both the initial cross-sectional study and this follow-up retrospective cohort study were reviewed and approved by the Human Research and Ethics Committee of Concord Hospital. A waiver of consent was granted by the overseeing Human Research and Ethics Committee.

Statistical analysis

Basic descriptive statistics were used to examine the baseline characteristics of the study cohort. Categorical data were summarised using number and percentages. Numerical data was summarised using means and standard deviations for normally distributed variables and medians and interquartile ranges for variables with skewed distribution. Continuous variables which demonstrated a non-linear relationship were re-classified into categorical variables as follows. The total number of comorbidities was dichotomised as ≤ 3 comorbidities and > 3 comorbidities to permit comparison across the studies in chapters 2, 3, 4 and 5. The total number of medications was recorded and the median number of medications was calculated, which determined that, for the purposes of this study that the use of 5 or more medications indicated polypharmacy, a definition which has been used in previous studies. (136, 137) The use of 4.5 regular medications had the highest predictive value for identification of falls using a receiver operator characteristics (ROC) curve in another community based cohort study. (138) A categorical variable was created as follows:

1. 0 – 4 medications.
2. >4 medications (polypharmacy).

The total number of psychoactive medications was also classified into a categorical variable as the use of no psychoactive medications, one psychoactive medication and two or more psychoactive medications. Previous studies have shown an association between increasing risk of falls with the using of increasing numbers of psychoactive medications. (56, 139)

The number of antihypertensives used was classified as a categorical variable as the use of no antihypertensive agents, one agent and 2 or more agents. Although no previous study has documented an association between increased risk of falling and increasing numbers of antihypertensives, we hypothesised that there may be an association with increased risk of E.D. re-attendance with a fall or fall-related problem when using more than one antihypertensive medication. Chi-square or Fisher's exact test statistics were used to determine if there was a significant difference between baseline variables in those who re-represented to the E.D. with a fall or fall-related problem, and those who did not.

Survival analyses were performed to look at predictors to first E.D. re-attendance with a fall for three different periods of follow up (1, 3 and 5 years), stratified for falls history at index fall presentation. The follow-up period was determined by time to first presentation to the E.D. with a fall or fall-related problem or death, or completion of the follow-up period to 14th March 2010. Logrank test for trend was performed to determine a relationship between prior falls history and re-attendance with fall or fall-related problems. Univariate analysis by Cox proportional hazards was used to examine the association between risk factors for falls identified at the index fall presentation and first subsequent E.D. presentation for falls. Multivariate analysis was then undertaken including variables with a p value of less than 0.2 in the univariate analysis. Important confounders such as age and sex were retained in the multivariate model regardless of statistical significance. Two multivariate models were used including and excluding prior history of falls within the analysis. Adjusted hazards ratios were reported for all variables retained in the multivariate analysis following backward stepwise elimination with significance set at the 5% level.
Data analysis was performed using SAS version 9.3 (SAS Institute, Inc., Cary, NC, USA).

2.3 Results

The initial baseline data collection identified 498 participants who had 513 attendances to the E.D. with a fall or fall-related problem during the baseline data collection period. Participants who usually resided interstate or overseas, and who had returned to this residence were excluded from the analysis (N = 5). Final analysis was conducted on 406 participants who had complete baseline characteristics recorded. Eighty-seven participants were excluded because there was extensive missing data in the baseline assessment for risk factors for falls. Of the 406 participants included in this analysis, 209 participants died in the 5-year follow-up period.

By the end of the follow-up period of up to 5 years, a total of 169 participants (41.6%) had fallen at least once and attended the E.D. for assessment and treatment, hereafter referred to as fallers. Table 2.1 shows the distribution of baseline characteristics of the cohort comparing those who re-attended the E.D. with a fall or fall-related problem and those who did not. Fallers were significantly older than non-fallers, with 73% of fallers aged 80 years or older compared with 55% of non-fallers. There was no significant association between gender and risk of re-attending the E.D. with a fall or fall-related problem, however, the cohort as a whole had a greater proportion of females to males. In terms of demographic risk factors, living at home alone and using community services were significantly associated with falling, in comparison to non-fallers who had a greater proportion residing in a Residential Aged Care Facility (RACF). There was no significant association demonstrated with cognition, however 59 participants (15% of the entire cohort) had an unclear categorisation of their cognitive status. Independence with activities of daily living showed a non-significant trend towards association with re-attendance at the E.D. with a fall or fall-related problem (fallers 78% vs non-fallers 52%).

A significant association was demonstrated between total number of comorbidities and E.D. re-presentations with a fall. The median number of comorbidities and the proportion or participants with more than 3 recorded comorbidities at index fall presentation, were significantly higher in those who were fallers. Specific comorbidities significantly associated with E.D. re-attendance with a fall were endocrine disorders (fallers 59% vs non-fallers 47%) and sensory impairment (fallers 49% vs non-fallers 35%).

Table 2.1 also shows that medications were not significantly associated with re-attendance at the E.D. with a fall or fall-related problem. There was no significant difference in the mean number of medications used between the groups. Polypharmacy, defined as taking more than 4 medications, was also not significantly increased in participants who re-attended the E.D. with a fall or fall-related problem. The proportion taking the specific classes or types of medications, which have been shown to increase the risk of falls in community based studies, were not significantly increased in the participants who fell (see Table 2.1).

The causes associated with the index fall and a participant's prior history of falls were both significantly associated with re-attendance. Index fall presentations which were due to multiple falls risk factors (multifactorial) (fallers 96% vs non-fallers 91%) and participants who self-reported a fall in the 12 months preceding the index fall presentation (fallers 74% vs non-fallers 57%) were more likely to re-present to the E.D. with a fall or fall-related problem.

Table 2.1: Baseline characteristics of subjects comparing subjects based on re-attendance at the Emergency Department with a fall.

Variable		Fallers N = 169 *N (%)*	Non-Fallers N = 237 *N (%)*	P Value
Age (years)	Median (IQR)	83 (IQR 79 - 88)	80 (IQR 75 -87)	0.001
Age group	65 – 79 years	46 (27.2)	106 (44.7)	0.0003
	≥ 80 years	123 (72.8)	131 (55.3)	
Gender	Male	57 (32.7)	92 (38.8)	0.29
	Female	112 (66.3)	145 (61.2)	
Residence	Home alone	67 (39.6)	68 (28.7)	0.01
	Home with others	76 (45.0)	108 (45.6)	
	RACF	26 (15.4)	61 (25.7)	
Cognition	Normal	81 (47.9)	99 (41.8)	0.45
	Unclear	24 (14.2)	35 (14.7)	
	Impaired	64 (37.9)	103 (43.5)	
Mobility	Independent no aid	82 (48.5)	120 (50.6)	0.29
	Independent with aid	81 (47.9)	101 (42.6)	
	Assisted	6 (3.5)	16 (6.8)	
ADLs	Independent	113 (66.9)	138 (58.2)	0.08
	Assisted	56 (33.1)	99 (41.8)	
Community services	No	88 (52.1)	124 (52.3)	0.01
	Yes	55 (32.5)	52 (21.9)	
	RACF	26 (15.4)	61 (25.7)	
Comorbidities	Mean (SD)	6.9 (SD 3.4)	6.1 (SD 3.5)	0.02
	≤ 3 comorbidities	26 (15.4)	66 (27.9)	0.003
	> 3 comorbidities	143 (84.6)	171 (72.2)	
	Cardiac	131 (77.5)	179 (75.5)	0.64
	Respiratory	53 (31.4)	64 (27.0)	0.34
	Gastrointestinal	70 (41.4)	79 (33.3)	0.10
	Malignancy	38 (22.5)	58 (24.5)	0.64
	Endocrine	99 (58.6)	112 (47.3)	0.02
	Neurological	66 (39.1)	89 (37.6)	0.76
	Sensory impairment	83 (49.1)	82 (34.6)	0.003
	Musculoskeletal	78 (46.2)	108 (45.6)	0.91
	Genitourinary	51 (30.2)	64 (27.0)	0.48
	Haematological	23 (13.6)	30 (12.7)	0.78
	Psychiatric	25 (14.8)	38 (16.0)	0.73

IQR – interquartile range; SD – standard deviation; RACF – Residential Aged Care Facility; E.D. – Emergency Department; ACE – angiotensin converting enzyme; ARB – angiotensin receptor blocker; CCB – calcium channel blocker; SERM – selective oestrogen receptor modulator;

Table 2.1: Baseline characteristics of subjects comparing subjects based on re-attendance at the Emergency Department with a fall. (Continued)

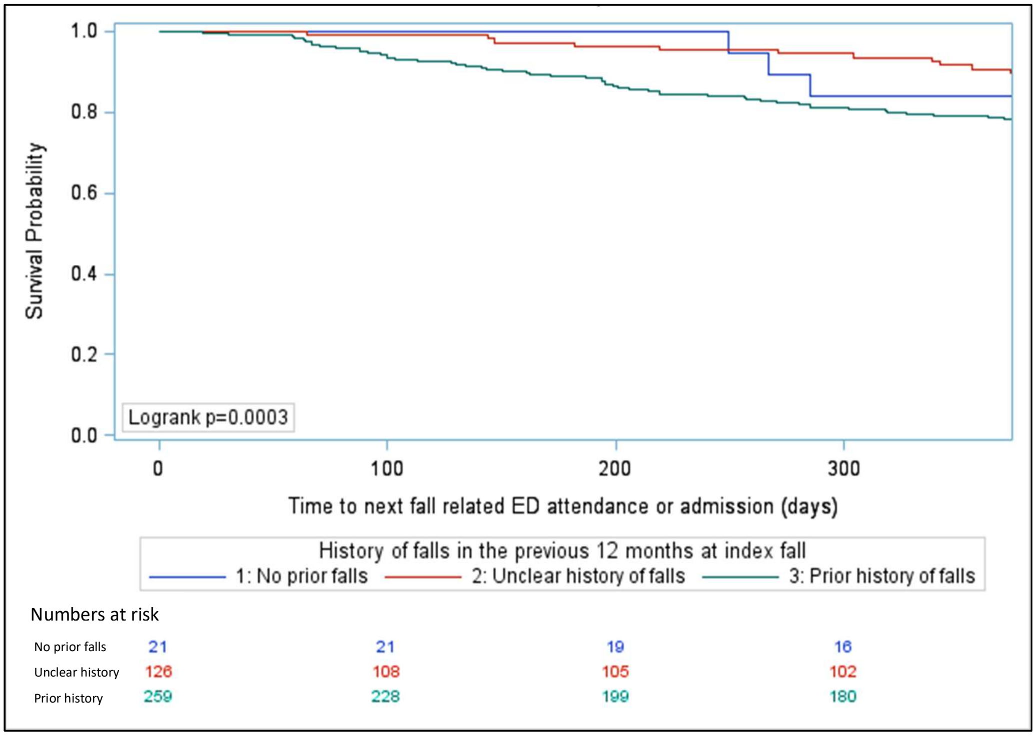
Variable		Fallers N = 169 *N (%)*	Non-Fallers N = 237 *N (%)*	P Value
Medications	Median (IQR)	6.0 (IQR 4 – 8)	5.0 (IQR 3 – 8)	0.95
Polypharmacy	≤ 4 medications	66 (39.1)	101 (42.6)	0.47
	> 4 medications	103 (61.0)	136 (57.4)	
CNS active medications	Psychotropics	68 (40.2)	93 (39.2)	0.84
	Antipsychotics	10 (6.0)	18 (7.6)	0.56
	Antidepressants	33 (19.5)	48 (20.3)	0.86
	Benzodiazepines	27 (16.0)	43 (18.1)	0.57
	Anticonvulsants	11 (6.5)	13 (5.5)	0.68
Antihypertensives	None	54 (32.0)	93 (39.2)	0.31
	1 agent	51 (30.2)	66 (27.9)	
	≥ 2 agents	64 (37.9)	78 (32.9)	
	Any antihypertensives	115 (68.1)	144 (60.8)	0.13
	ACE inhibitors	40 (23.7)	43 (18.1)	0.17
	ARBs	27 (16.0)	30 (12.7)	0.34
	Beta Blockers	38 (22.5)	43 (18.1)	0.28
	CCB	32 (18.9)	43 (18.1)	0.84
	Diuretics	52 (30.8)	59 (24.9)	0.19
	Nitrates	29 (17.2)	38 (16.0)	0.76
	Warfarin	15 (8.9)	26 (11.0)	0.51
Osteoporosis treatment	Bisphosphonates/SERM	25 (14.8)	35 (14.8)	0.99
	Vitamin D/Calcium	43 (25.4)	45 (19.0)	0.12
Index fall sequelae	Discharged from E.D.	57 (33.7)	75 (31.7)	0.66
	Admitted	112 (66.3)	162 (68.4)	
Reason for index fall	Cold fall	102 (60.4)	134 (56.5)	0.66
	Hot fall	37 (21.9)	55 (23.2)	
	Syncope	16 (9.5)	20 (8.4)	
	Unclear	14 (8.3)	28 (11.8)	
Cause of fall	Multifactorial	162 (95.9)	215 (90.7)	0.05
Falls in prior 12 months	No falls	35 (20.7)	91 (38.4)	0.0005
	Unclear history	9 (5.3)	12 (5.1)	
	Yes	125 (74.0)	134 (56.5)	
Index fall injuries	None / minor injuries	73 (43.2)	101 (42.6)	0.91
	Major injuries	96 (56.8)	136 (57.4)	
Fractures	Any fracture	70 (41.4)	104 (43.9)	0.62
	Upper limb	18 (10.7)	38 (16.0)	0.48
	Lower limb	27 (16.0)	34 (14.4)	
	Vertebral / non-limb	25 (14.8)	32 (13.5)	

IQR – interquartile range; SD – standard deviation; RACF – Residential Aged Care Facility; E.D. – Emergency Department; ACE – angiotensin converting enzyme; ARB – angiotensin receptor blocker; CCB – calcium channel blocker; SERM – selective oestrogen receptor modulator;

Analyses of the time to first re-presentation to the E.D. with a fall or fall related problem were performed examining the relationship between history of falls in the previous 12 months from index fall presentation and fall re-presentation. Figures 2.1 (a), (b) and (c) show the Kaplan Meier curves for time to first E.D. re-presentation with a fall or fall-related problem and history of falls at index fall presentation, at 1, 3 and 5 years of follow-up. The Logrank test for trend indicates a significant association between history of falls in the previous 12 months and a re-presentation with a fall during each follow-up period. The Kaplan Meier curves demonstrate at 1, 3 and 5 years of follow-up, those with a history of falls at the index fall presentation are at greater risk of re-presentation with a fall compared to those with no history of falls or those in whom the falls history is unclear. There were a small number of participants who are at risk in the group who do not have a documented history of falls at the index fall presentation.

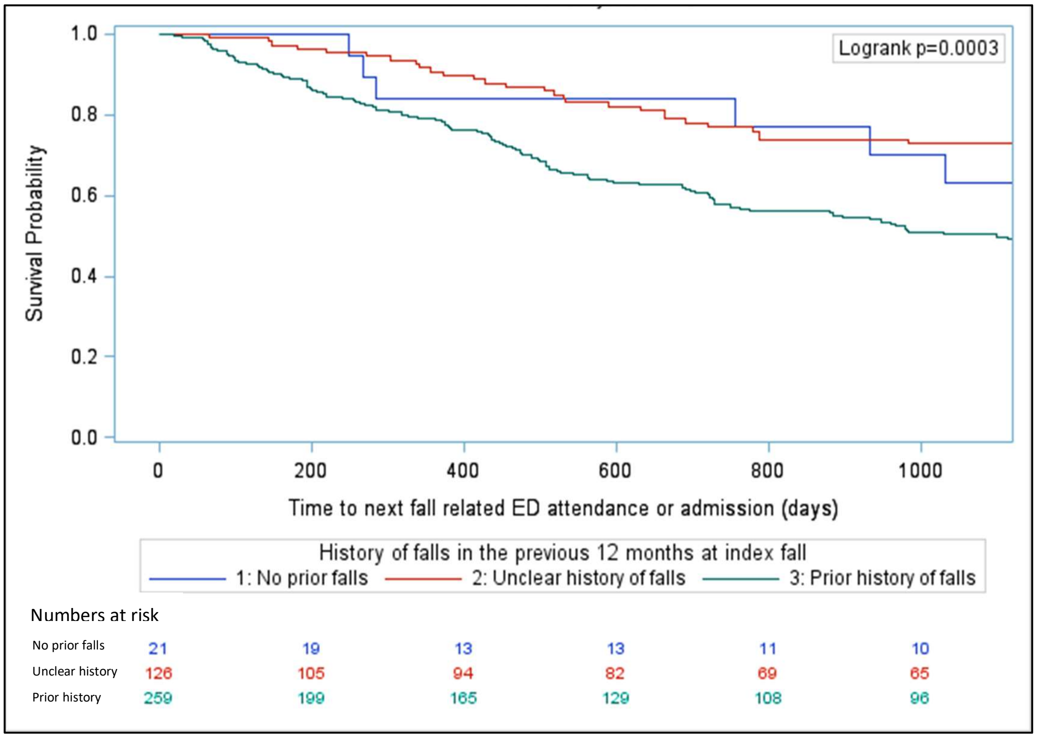
Figures 2.1: Kaplan Meier curves and Logrank test for trend for time to first E.D. re-presentation with a fall or fall-related injury stratified by history of falls at 1, 3 and 5 years.

(a) Year 1



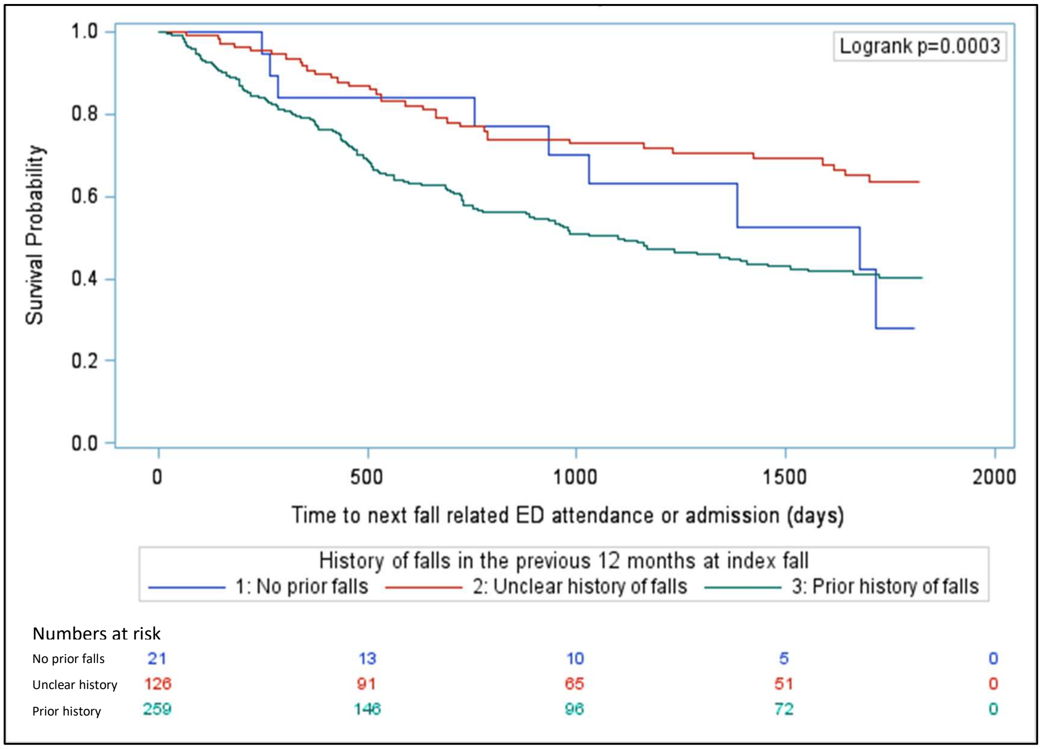
Figures 2.1: Kaplan Meier curves and Logrank test for trend for time to first E.D. re-presentation with a fall or fall-related injury stratified by history of falls at 1, 3 and 5 years. (Continued)

(b) Year 3



Figures 2.1: Kaplan Meier curves and Logrank test for trend for time to first E.D. re-presentation with a fall or fall-related injury stratified by history of falls at 1, 3 and 5 years (Continued).

(c) Year 5



Participants who re-attended the E.D. with a fall or fall-related problem were followed for median of 475 days (IQR 240 – 787days), which was significantly shorter follow-up than those who did not re-attend the E.D. (median 1492 days; IQR 314 – 1757 days). In the first year of follow-up 80 participants (20%) had at least one E.D. presentation with a fall or fall related problem.

Table 2.2 shows the results of the Cox proportional hazards univariate analysis examining the associations between risk factors identified at the index fall presentation to the ED and future re-attendance at the E.D. with a fall or fall-related problem at 1, 3, and 5 years of follow-up. Further discussion of the univariate analyses will focus on the risk factors for re-attendance at the E.D. for each of the time periods.

In the univariate analysis of the 1-year follow-up, a clear association between E.D. re-presentations with a fall and prior history of falls at the index fall presentation was not evident. If the group with a prior history of falls was compared to those who had an unclear history of falls, prior history of falls was associated with increased risk of the participant re-attending the E.D. with a fall or fall-related problem, but not when no history of falls was used as the referent group (results not shown).

Participants who were aged 80 years and older (HR 1.41; 95% C.I. 1.00 – 1.98), required assistance with activities of daily living (ADLs) (HR 1.57; 95% C.I. 1.13 – 2.16) and had sensory impairment (HR 1.35; 95% C.I. 1.00 – 1.82) were all at greater risk of re-attending the E.D. with a fall or fall-related problem. Being resident in a Residential Aged Care Facility (RACF) was protective against further E.D. presentations with falls when compared to being at home alone (HR 0.51; 95% C.I.0.32 – 0.80) or using community services (HR 0.60; 95% C.I. 0.38 – 0.92).

At 3 years following the initial fall E.D. presentation, 145 participants (36%) had at least one presentation to E.D with a fall or fall related problem, of which 65 participants had fallen and presented to the E.D. between years 2 and 3. The univariate analysis for 3 years of follow-up, shown in Table 2.2, demonstrated a significant association between place of residence, cognitive impairment, disability in activities of daily living requiring assistance and use of community services. A history of cognitive impairment at index fall presentation was associated with a 59% increased risk of re-presentation at the E.D. with a fall or fall-related problem. Being a resident in a RACF was associated with a reduced risk of re-presentation at the E.D. with a fall or fall-related problem when compared with living alone or participants who did not use community services. There was no significant association between further falls presentations to the E.D. and age, gender or prior history of falls in the follow-up period to 3 years.

By the end of the follow-up period of up to 5 years, a total of 169 participants (41.6%) had fallen at least once and attended the E.D. for assessment and treatment. Between 3 years and 5 years this amounted to an additional 24 participants attending the E.D. due to a fall or fall-related problem, more than 3 years after an index fall presentation. The univariate analysis in Table 2.2 shows the association between risk factors at the index fall presentation and further presentations to the E.D. with a fall or fall-related problem. Participants aged 80 years and older had a 2-fold increased risk of re-presentation to the E.D. with a fall (HR 2.11; 95% C.I. 1.50 – 2.97). Those who required the use of a walking aid to walk independently or who were in receipt of community services were at increased risk of fall re-presentation at the E.D., however there was no increased risk associated with disability in activities of daily living. Having more than 3 comorbidities at index fall presentation was associated with a 2-fold increased risk of re-presentation with a fall (HR 2.16; 95% C.I. 1.42 – 3.29). In terms of specific medical conditions, participants with endocrine disorders or sensory impairment were at increased risk of re-presentation. And at 5 years of follow-up, the use of more than 4 medications and specifically the use of diuretics also increased the risk of re-presentation at the E.D. with a fall. Participants who had multiple risk factors contributing to their index fall presentation had a 2.8-fold increased risk of a further fall re-presentation 5 years following their index fall E.D. attendance (HR 2.80; 95% C.I. 1.31 – 5.97).

Table 2.2: Cox proportional hazards univariate analysis of risk factors for falls based on re-attendance at the Emergency Department (E.D.) with a fall or fall-related problem at 1, 3 and 5 years

Variables		Year 1 Univariate HR (95% CI)	P value	Year 3 Univariate HR (95% CI)	P value	Year 5 Univariate HR (95% C.I.)	P value
Age 80 years or older		1.41 (1.00 – 1.98)	0.05	1.13 (0.80 – 1.58)	0.50	2.11 (1.50 – 2.97)	<0.0001
Female		1.24 (0.90 – 1.71)	0.18	1.18 (0.86 – 1.62)	0.32	1.04 (0.76 – 1.44)	0.79
Residence	Home alone	1.0	0.01	1.0	0.03	1.0	0.23
	Home with others	0.82 (0.59 – 1.14)		0.91 (0.65 – 1.26)		0.80 (0.57 – 1.11)	
	RACF	0.51 (0.32 – 0.80)		0.55 (0.35 – 0.86)		0.71 (0.45 – 1.11)	
Cognitive impairment	Normal	1.0	0.21	1.0	0.02	1.0	0.67
	Unclear	0.83 (0.53 – 1.31)		0.78 (0.49 – 1.23)		1.04 (0.66 – 1.65)	
	Impaired	0.75 (0.54 – 1.04)		1.59 (1.14 – 2.22)		1.16 (0.84 – 1.61)	
Mobility	Independent no aid	1.0	0.35	1.0	0.12	1.0	0.05
	Independent with aid	0.92 (0.68 – 1.26)		0.82 (0.60 – 1.12)		1.46 (1.07 – 1.99)	
	Assisted	0.55 (0.24 – 1.25)		0.46 (0.20 – 1.05)		1.08 (0.47 – 2.48)	
Activities of daily living	Assisted	1.57 (1.13 – 2.16)	0.0007	1.63 (1.18 – 2.25)	0.003	0.98 (0.65 – 1.24)	0.50
Community services	None	1.0	0.03	1.0	0.03	1.0	0.01
	Yes	1.12 (0.80 – 1.57)		0.91 (0.65 – 1.28)		1.63 (1.16 – 2.28)	
	RACF	0.60 (0.38 – 0.92)		0.56 (0.36 – 0.86)		0.95 (0.61 – 1.47)	

HR – Hazards ratio; C.I. – Confidence Intervals; E.D. – Emergency Department; RACF – Residential Aged Care facility;

Table 2.2: Cox proportional hazards univariate analysis of risk factors for falls based on re-attendance at the Emergency Department (E.D.) with a fall or fall-related problem at 1, 3 and 5 years (Continued).

Variables		Year 1 Univariate HR (95% CI)	P value	Year 3 Univariate HR (95% CI)	P value	Year 5 Univariate HR (95% C.I.)	P value
Comorbidities	> 3 comorbidities	1.41 (0.93 – 2.15)	0.11	1.03 (0.68 – 1.57)	0.89	2.16 (1.42 – 3.29)	0.0003
	Cardiac	1.00 (0.70 – 1.44)	0.99	1.02 (0.71 – 1.47)	0.90	1.13 (0.79 – 1.62)	0.51
	Respiratory	1.15 (0.83 – 1.59)	0.40	0.99 (0.71 – 1.36)	0.93	1.26 (0.91 – 1.75)	0.16
	Gastrointestinal	1.21 (0.89 – 1.64)	0.23	1.08 (0.80 – 1.47)	0.62	1.35 (0.99 – 1.83)	0.06
	Malignancy	0.78 (0.55 – 1.13)	0.19	0.78 (0.55 – 1.12)	0.18	1.16 (0.81 – 1.66)	0.42
	Endocrine	1.24 (0.91 – 1.68)	0.17	1.10 (0.81 – 1.50)	0.56	1.51 (1.11 – 2.05)	0.009
	Neurological	0.91 (0.67 – 1.24)	0.53	0.85 (0.63 – 1.16)	0.31	1.28 (0.94 – 1.74)	0.12
	Sensory impairment	1.35 (1.00 – 1.82)	0.05	1.16 (086 – 1.57)	0.33	1.63 (1.20 – 2.20)	0.002
	Musculoskeletal	1.07 (0.79 – 1.45)	0.65	0.98 (0.73 – 1.33)	0.92	0.99 (0.73 – 1.34)	0.95
	Genitourinary	0.01 (0.73 – 1.41)	0.94	0.95 (0.69 – 1.32)	0.76	1.25 (0.90 – 1.74)	0.19
	Haematological	0.85 (0.55 – 1.33)	0.48	0.83 (0.53 – 1.29)	0.40	1.43 (0.92 – 2.22)	0.11
	Psychiatric	0.90 (0.59 – 1.37)	0.61	0.87 (0.57 – 1.32)	0.50	1.03 (0.67 – 1.57_	0.90

HR – Hazards ratio; C.I. – Confidence Intervals; E.D. – Emergency Department;

Table 2.2: Cox proportional hazards univariate analysis of risk factors for falls based on re-attendance at the Emergency Department (E.D.) with a fall or fall-related problem at 1, 3 and 5 years (Continued).

Variables		Year 1 Univariate HR (95% CI)	P value	Year 3 Univariate HR (95% CI)	P value	Year 5 Univariate HR (95% C.I.)	P value
Polypharmacy	> 4 medications	0.94 (0.69 – 1.28)	0.70	0.84 (0.62 – 1.15)	0.27	1.38 (1.01 – 1.88)	0.04
CNS active medications	Psychotropics	0.96 (0.71 – 1.31)	0.81	0.86 (0.63 – 1.17)	0.35	1.16 (0.85 – 1.57)	0.37
	Antipsychotics	0.88 (0.46 – 1.67)	0.69	0.93 (0.49 – 1.77)	0.83	0.86 (0.45 – 1.63)	0.64
	Antidepressants	0.89 (0.61 – 1.31)	0.55	0.90 (0.62 – 1.32)	0.31	0.98 (0.65 – 1.48)	0.92
	Benzodiazepines	0.93 (0.61 – 1.40)	0.72	0.81 (0.54 – 1.22)	0.31	0.98 (0.65 – 1.48)	0.92
Antihypertensives	Any antihypertensives	1.17 (0.85 – 1.62)	0.34	1.13 (0.82 – 1.56)	0.47	1.25 (0.90 – 1.72)	0.18
	ACE inhibitors	1.10 (0.77 – 1.57)	0.60	1.02 (0.71 – 1.45)	0.94	1.41 (0.99 – 2.01)	0.06
	ARBs	1.21 (0.81 – 1.03)	0.36	1.23 (0.82 – 1.86)	0.32	1.08 (0.71 – 1.62)	0.73
	Beta Blockers	1.26 (0.88 – 1.81)	0.21	1.15 (0.80 – 1.64)	0.32	1.10 (0.77 – 1.58)	0.61
	CCB	1.23 (0.83 – 1.81)	0.30	1.21 (0.83 – 1.78)	0.32	0.86 (0.58 – 1.26)	0.43
	Diuretics	1.11 (0.80 – 1.53)	0.55	0.92 (0.67 – 1.28)	0.63	1.45 (1.05 – 2.02)	0.03
	Nitrates	0.89 (0.59 – 1.32)	0.56	0.79 (0.53 – 1.18)	0.26	1.46 (0.98 – 2.18)	0.07
	Warfarin	0.81 (0.48 – 1.37)	0.43	0.82 (0.48 – 1.39)	0.46	0.94 (0.56 – 1.60)	0.83
Osteoporosis treatment	Bisphosphonates/SERM	1.02 (0.66 – 1.55)	0.94	0.94 (0.62 – 1.44)	0.78	1.03 (0.67 – 1.57)	0.91
	Vitamin D/Calcium	1.36 (0.96 – 1.92)	0.08	1.06 (0.75 – 1.50)	0.73	1.27 (0.90 – 1.80)	0.18

HR – Hazards ratio; C.I. – Confidence Intervals; E.D. – Emergency Department; ACE – angiotensin converting enzyme; ARB – angiotensin receptor blocker; CCB – calcium channel blocker; SERM – selective oestrogen receptor modulator;

Table 2.2: Cox proportional hazards univariate analysis of risk factors for falls based on re-attendance at the Emergency Department (E.D.) with a fall or fall-related problem at 1, 3 and 5 years (Continued).

Variables		Year 1 Univariate HR (95% CI)	P value	Year 3 Univariate HR (95% CI)	P value	Year 5 Univariate HR (95% C.I.)	P value
Index fall sequelae	Discharged from E.D.	1.0	0.20	1.0	0.23	1.0	0.42
	Admitted	0.81 (0.59 – 1.12)		0.82 (0.60 – 1.13)		1.14 (0.83 – 1.57)	
Reason for index fall	Cold fall	1.0	0.22	1.0	0.31	1.0	0.76
	Hot fall	0.73 (0.50 – 1.07)		0.79 (0.54 – 1.15)		1.19 (0.82 – 1.73)	
	Syncope	1.18 (0.70 – 2.01)		1.03 (0.61 – 1.74)		0.94 (0.56 – 1.59)	
	Unclear	0.73 (0.42 – 1.28)		0.64 (0.37 – 1.12)		0.92 (0.52 – 1.60)	
Cause of fall	Multifactorial	1.32 (0.62 – 2.81)	0.48	0.86 (0.40 – 1.83)	0.87	2.80 (1.31 – 5.97)	0.008
Falls in prior 12 months	No falls	1.0	0.09	1.0	0.17	1.0	0.0004
	Unclear history	0.73 (0.35 – 1.52)		0.71 (0.34 – 1.49)		0.59 (0.28 – 1.23)	
	Yes	1.11 (0.57 – 2.19)		1.02 (0.52 – 2.01)		1.25 (0.64 – 2.47)	
Index fall injuries	None / minor injuries	1.0	0.87	1.0	0.83	1.0	0.92
	Major injuries	0.97 (0.72 – 1.32)		1.03 (0.75 – 1.38)		0.98 (0.73 – 1.33)	
Fractures (Compared with no fracture)	Any fracture	1.01 (0.75 – 1.38)	0.93	0.98 (0.72 – 1.33)	0.90	0.91 (0.67 – 1.23)	0.53
	Upper limb	0.75 (0.45 – 1.24)	0.45	0.75 (0.46 – 1.25)	0.60	0.96 (0.62 – 1.46)	0.85
	Lower limb	1.21 (0.79 – 1.86)		1.09 (0.71 – 1.67)		0.96 (0.62 – 1.46)	
	Vertebral / non-limb	1.10 (0.71 – 1.71)		1.10 (0.71 – 1.70)		0.95 (0.61 – 1.47)	

HR – Hazards ratio; C.I. – Confidence Intervals; E.D. – Emergency Department; RACF – Residential Aged Care facility;

Table 2.3 (a), (b) and (c) show the results of the multivariate Cox proportional hazards models for re-presentations to the E.D. with a fall or fall-related problem at 1, 3 and 5 years of follow-up. Two models were used – model 1 included adjustment for age and sex only, and model 2 included adjustments for age, sex and history of falls at index fall presentation. As previously shown, the Kaplan Meier curves and the Logrank test for trend demonstrated a significant association between prior history of falls at index fall presentation and time to first re-presentation to the E.D. with a fall (see Figures 2.1 (a), (b) and (c)), but the univariate Cox proportional hazards analysis did not show a significant association. Therefore, the final 2 models were designed to explore the impact history of falls on the multivariate analyses.

At 1-year follow-up, age 80 years and older and requiring assistance in at least one activity of daily living were both associated with increased risk of re-presenting to the E.D. with a fall or fall-related problem, even when history of falls was included in the multivariate model. When followed to 3 years from the index admission, only disability in activities of daily living was associated with increased risk of re-presentation at the E.D with a fall or fall-related problem, with a 70% increased risk when adjusted for age, sex and history of falls. At 5 years, disability in activities of daily living was no longer retained in the model. Participants aged 80 years or older were at 2-fold increased risk and those with more than 3 comorbidities at index fall presentation had a 61% increased risk of re-presentation to the E.D. with a fall or fall-related problem. In the 5-year multivariate analysis, diuretic or nitrate medication use were associated with increased risk of a fall-related re-presentation when substituted for number of comorbidities in the fully adjusted model. Diuretic use was associated with 43% increased risk (HR 1.43; 95% C.I. 1.02 – 1.99) and nitrates with 54% increased (HR 1.54; 95% C.I. 1.03 – 2.32) risk of re-presentation to the E.D. with a fall or fall-related problem.

Table 2.3: Predictors of E.D. re-presentations with a fall or fall –related problem – multivariate Cox regression at 1, 3 and 5 years

1. Year 1

Year 1 Analysis	Adjusted HR (95% C.I.) Model 1	P value	Adjusted HR (95% C.I.) Model 2	P value
Age 80 years and older	1.54 (1.09 – 2.17)	0.01	1.47 (1.04 – 2.09)	0.03
Female	1.31 (0.95 – 1.80)	0.10	1.31 (0.95 – 1.81)	0.10
Disability in ADLs	1.71 (1.23 – 2.38)	0.001	1.78 (1.26–2.44)	0.0007

2. Year 3

Year 3 Analysis	Adjusted HR (95% C.I.) Model 1	P Value	Adjusted HR (95% C.I.) Model 2	P Value
Age 80 years and older	1.18 (0.84 – 1.67)	0.33	1.15 (0.81 – 1.62)	0.46
Female	1.22 (0.88 – 1.67)	0.23	1.22 (0.89 – 1.69)	0.22
Disability in ADLs	1.67 (1.21 – 2.31)	0.002	1.70 (1.23 – 2.36)	0.001

3. Year 5

Year 5 Analysis	Adjusted HR (95% C.I.) Model 1	P Value	Adjusted HR (95% C.I.) Model 2	P value
Age 80 years and older	1.92 (1.36 – 2.71)	0.0002	2.00 (1.42 – 2.82)	<0.0001
Female	0.97 (0.71 – 1.34)	0.87	0.97 (0.71 – 1.39)	0.86
Greater than 3 comorbidities	1.89 (1.24 – 2.90)	0.003	1.61 (1.04 – 2.50)	0.03

HR – hazards ratio; C.I. – confidence intervals; ADL – activities of daily living;
Model 1 adjusted for age and sex.
Model 2 adjusted for age, sex and history of falls at index fall presentation. At year 5 the use of diuretics or nitrates could be interchanged for number of comorbidities in the analysis.

2.4 Discussion

This retrospective cohort study demonstrates that older people who have fallen and required assessment and treatment in the Emergency Department (E.D.) remain at risk for further presentations to the E.D. due to a fall or fall-related problem, up to 5 years after the index fall presentation. There was a 50% attrition rate due to death in this cohort of people aged 65 years and older during the 5 years of follow-up. Despite this, 41% of this cohort had a further attendance at the E.D. with a fall, with the majority of falls re-presentations occurring in the first 3 years. Risk factors which increased the risk of further presentations included having a disability in activities in daily living which increased the risk of re-presenting with a fall in the first year and at 3 years. Participants who were aged 80 years and older were also at increased risk in the first year and had an overall 2-fold increased risk of re-presenting with a fall or fall-related problem to the E.D. up to 5 years after the index presentation. At 5 years of follow-up participants with more than 3 comorbidities were at increased risk of further falls presentations to the E.D. A history of falls in the previous 12 months at index presentation was not significantly associated with re-presentation to the E.D. with a fall or fall-related problem in the Cox multivariate analyses.

In the first year of follow-up our study reported that 20% of the cohort had re-presented to the E.D. with a further fall or fall-related problem. Some care is required in comparing this figure to previously reported E.D. cohort studies. A substantially smaller percentage of re-presentations were reported by Castro et al. in a retrospective study of people aged 40 years and older who had fallen and attended the E.D. of 2 hospitals in the United States (U.S.). (140) Nine per cent of the cohort re-presented with a fall or fall-related problem at 1 year and this increased to 13% at 2 years. This cohort included all people over the age of 40 compared to older people aged 65 years and older in our study. Since age was associated with increased risk of fall re-presentation, this could account for the difference in results between the two studies. In another retrospective cohort study in the U.S., Liu et al. reported on re-attendances to the E.D. over a 1 year period by people aged 65 years and older who had attended with an index fall. (77) At 1 year 25% of this cohort had returned to the E.D. for treatment – this was not specifically with a fall or fall-related problem, but it is closer to the estimate we obtained. Close et al. reported that of 3,220 older people who presented to the E.D. of a metropolitan teaching hospital in Sydney Australia with a fall, 35% had one or more E.D. presentations or hospital admissions in the previous year. (133) This study does not differentiate between falls and non-falls attendances.

Our study was unable to find a significant association between history of falls in the 12 months prior to the index fall presentation and re-presentations to the E.D. with a fall or fall-related problem in the adjusted analyses, although the initial log-rank analyses did show a significant trend between history of falls and time to first fall re-presentation. This is counter to what has been described previously in a range of studies. Close et al. reported that history of falls in the previous 12 months was a significant predictor of future falls in the control arm of the PROFET trial. (69) The participants in this trial where recruited from the E.D. after attending with a fall or fall injury, which is similar to the recruitment strategy for our study. Tiedemann et al. were also able to demonstrate a significant association between history of falls and future falls in an E.D population recruited in Australia. (71) Importantly, history of falls and taking 6 or more medications was used prospectively in order to predict future falls in a cohort recruited from a second E.D. Tiedemann et al. prosecuted the case for using a simple 2 question screening tool in the E.D. to be able to target falls prevention interventions. It is important to note that in the Kaplan Meier curve examining the relationship between history of falls and re-presentation to the E.D., there appears to be a significant association between history of falls, with those with a prior fall at index fall presentation more likely to have a re-presentation at 1, 3 and 5 years. Those who have an unclear history of falls at the index fall presentation are less likely to re-present to the E.D. When analysed with unclear history as the referent group, history of falls is associated with a significant increased risk of further falls re-presentation. The participants with an unclear history of falls have a significant effect on the analysis, even though the number of participants "at risk" in this group are smaller than in the other 2 groups. Therefore, a smaller number of events appeared to be influencing the statistical analysis. It could still be argued that in assessing older people who have attended the E.D. with a fall, asking about history of falls in the previous 12 months should prompt referral to falls prevention interventions on discharge.

We have been unable to find a previous study of older people attending the E.D. with a fall which reports an association between requiring assistance with activities of daily living and future fall re-presentations. Russell et al. did examine the effect that a presentation to the E.D. with a fall had on function in older people living in the community. (132) The authors showed that pre-index fall functional impairment, as described by the need for assistance with ADLs, was associated with reduced score on Human Activity Profile - Adjusted Activity score (HAP-AAS score) at 12 months, indicating further loss of function and impaired activity. Frailty scores have also included a measure of functional impairment. Fried et al. have previously described a frailty phenotype including exhaustion, weight loss, low activity, slow walking speed and reduced grip strength, which has then been associated with increased risk of hospitalisation rather than E.D. attendance. In those who were "frail" the risk of hospitalisation over 3 years of follow-up was increased by 29% compared with those who were not frail (HR 1.29; 95% CI 1.09 – 1.54). Therefore, targeting interventions which might both reduce the effect of frailty and falls is appropriate in those who require assistance with their ADLs.

There were a range of limitations associated with our study. Baseline characteristics such as the prior history of falls are based on patient recall, and therefore can be an under-representation of the risk as discussed previously. (10) Sander et al. did also discuss how participants in their study over-reported falls, although the percentage returning falls diaries with "no falls" recorded and then reporting at 12 months a fall was 15%. (11) Information recorded in this study with respect to history of falls, was based on both self-report on the part of the participant, and the accuracy of reporting on the part of the clinical team in the E.D. recording the details in the medical record. The outcome of fall E.D. presentation or hospitalisation focuses on the admissions to hospitals within an Area Health Service, and has the potential to miss admissions to private hospitals and those to other Area Health Services. Using data linkage to large databases, such as the New South Wales Emergency Department Data Collection administered by the Centre for Health Record Linkage, could overcome this limitation.

Information on the baseline risk factors were gathered from clinical documents and not collected by professionals trained in the assessment of falls risk. Therefore, there can be an under-reporting of the baseline risks. Specifically, limitations in mobility were not reported using physical tests of balance and strength such as the "Timed Up and Go Test" or Berg Balance Scale, nor were these measures assessed by a physiotherapist routinely. Impaired function was not quantified using a standardised assessment tools, such as the Barthel Index. It is also important to recognise the degree of uncertainty introduced into analyses when variables have categories like "unclear". Both history of falls and cognitive impairment contained “unclear” categories, which had the potential to significantly diminish the effect of the presence or absence of prior falls and cognitive impairment on any analyses. And finally, the strength of association more distant to the index fall may be affected by the development of risk factors in subjects who did not have the risk factor recorded at the index presentation. Therefore, this reduces the effect of the association at year 3 and year 5.

2.5 Conclusion

Older people sustaining a fall requiring attendance at an Emergency Department have been shown to have further presentation to the E.D. with a fall or fall-related problem, even up to 5 years following an initial presentation with a fall. In a cohort of older people attending the E.D. with a fall, the greatest proportion fell within the first year following the initial attendance to the E.D. People aged 80 years and older and those who require assistance with activities of daily living are at greatest risk. This then suggests that people aged 80 years and older, living in the community and who need assistance with ADLs, warrant particular focus in terms of falls prevention interventions.

Chapter 3: Predictors of mortality in older people who have attended an Emergency Department with a fall or fall related problem.

3.1 Introduction

Population based data from Australia, Europe and North America have shown that accidental falls account for a significant proportion of deaths in older people as discussed in section 1.6. The Australian Institute for Health and Welfare has reported that accidental falls account for 32.2% of all deaths due to injuries in Australia. (72) Data derived from the National Death Index demonstrates that in the Australian population deaths due to accidental falls are more likely to occur in older people aged 65 years and older. Studies which have used population based data have also demonstrated trends for increased rates of deaths due to accidental falls since the 1970's. (30, 141, 142) Older people aged 85 years and older are at particular risk. (30, 142)

In section 1.6.1 mortality related to accidental falls in terms of community based studies was discussed. Donald and Bulpitt examined the long-term consequences of falls in community-dwelling older people from 19 General Practices in the United Kingdom. (73) Mortality was increased in those subjects who had a history of more than one fall in the 12 months prior to recruitment. Compared with older people who did not fall, recurrent fallers were 2.6 times more likely to die in the 1st year of follow-up (OR 2.6; 95% C.I. 1.4 - 4.7), and had sustained increased risk of death at 3 years of follow-up (OR 1.9; 95% C.I. 1.2 – 3.0) when adjusted for age and gender. This provides some estimate for the risk of death in people who are fallers, but will have included a large proportion of older people who have fallen and not sustained an injury as a result of the fall. It may be more important to examine the association between mortality and falls in older people who have had an injurious fall, particularly those who have required assessment and treatment at the Emergency Department (E.D.).

Close et al. have previously published a mixed method study on the outcomes for older people who have attended the E.D. with a fall in a large teaching hospital in Sydney Australia. (143) Accidental falls accounted for 3,220 attendances (35.4%) of 18,902 all-cause E.D. attendances for older people aged 70 years and older in a 2-year period. Of this cohort 0.3% died during the index fall presentation, whereas 5.5% of the original cohort died within 1 year from the index fall presentation. No further data was provided on the characteristics of the older people who fell and died.

Three more recent studies have attempted to provide more details on the characteristics of older people who have died following an E.D. attendance due to a fall. Both Liu et al. and Ayong-Chee et al. used data from trauma registries to provide some detail on the characteristics and mortality of the older people who fell and attended the E.D. (77, 78) The 1-year mortality rates in both studies were 15% and 33% respectively, with Ayoung-Chee et al. attributing a higher mortality rate to the severity of injuries sustained. Yu et al. reported a 10% 1 year mortality rate following an E.D. attendance with a fall, determining that the discharge destination and sustaining a traumatic brain injury at the time of the index fall as predictors of death at 1 year. (79) The limitations of these studies were that by using trauma registries as the source of information on the characteristics of the patients, important information on falls specific risk factors were not available. In older people who have presented to the E.D. after a fall, this information is important as it may be used to guide the selection of older people who should receive specific falls prevention strategies. Alternatively, examining the risk factors for mortality following an E.D. presentation due to a fall or fall-related problem, may highlight a group of older people for whom advanced care planning and symptom management are more important.

The aim of this study was to examine mortality rates and risk factors for death following a fall-related E.D. attendance at 1, 3 and 5 years, based on information gathered at the time of their index fall presentation. We hypothesised that the risk predictors for mortality would vary over time and would differ from risk factors associated with re-presentation to the E.D. with a fall or fall-related problem as identified in chapter 2.

3.2 Methods

The methodology for the subject identification and the baseline characteristics of these subjects has been described in chapter 2. In brief a cross-sectional study previously identified 498 subjects who attended an Emergency Department with a fall, fall-related injury or syncope. Their baseline sociodemographic details were recorded including their comorbidities, medication use, physical and functional limitations, and the specific details of the index fall event and the outcomes in terms of injury and hospitalisation.

Mortality determined from data linkage with the National Death Index.

The National Death Index (NDI) is a database which is administered by the Australian Institute of Health and Welfare. The database includes records of all deaths occurring in Australia since 1980. The data is obtained from the Registrars of Births, Death and Marriages in each State and Territory. The database is designed for use in medical research.

The NDI database comprises the following variables for each deceased person: name, date of birth, age at death, sex, date of death, State/Territory of registration and registration number. The underlying cause of death is available for all records with those from 1997 onwards also containing information on all other causes of death recorded on the death certificate.

Data linkage was performed using the original cohort to establish whether the subject has died or not and date of death for those who had died during the study period 1st March 2005 and 30th March 2010 (i.e. a follow-up period of 5 years). There is a delay in the recording of the cause of death in the National Death Index due to the database being updated with the raw data from the Registers of Birth Death and Marriages and National Coronial Information System once per calendar year. The information was incomplete in the data linkage for those deaths in 2009 and 2010. Therefore, cause of death information is not included in this analysis. Ongoing updating of the data linkage information was not requested at the outset of this study, and was not requested at a later stage due to financial constraints. The following details were submitted to the National Death Index for matching: surname, first and additional names, date of birth, gender, date of last contact and Australian state or territory. The linked data was then reviewed for each returned record to ensure accuracy of linkage before the study database was linked to the date of death and cause of death (if known). For each participant all supplied details were compared for matching, but importantly, surname, first name, date of birth, and gender were all considered essential for matching accuracy.

Ethical approval

Both the initial cross-sectional study and this prospective cohort study were reviewed and approved by the Human Research and Ethics Committee of Concord Hospital. A waiver of consent was granted by the supervising Human Research and Ethics Committee. Additional consent was obtained and was approved by the Australian Institute of Health and Welfare for data linked to the National Death Index

Statistical analysis

Baseline descriptive statistics were used to examine the baseline characteristics of the cohort comparing those who had died to those who had survived over the 5-year follow-up period. Continuous variables were re-categorised as dichotomous or categorical variables based on distribution characteristics or using accepted cut-points as described in chapter 2.2. Chi-squared and Fisher's exact test were used to compare dichotomous and categorical variables for differences in baseline characteristics. Survival analyses were then performed to examine the relationship between age and mortality at the 1, 3 and 5-year time points. The follow-up period was determined by date of death as determined by data from the National Death Index or completion of follow-up to 14th March 2010. Logrank test for trend was also performed to further test the strength of association between age and mortality at 1, 3 and 5 years. Univariate analysis by Cox proportional hazards was used to examine the association between risk factors for falls identified at the index fall presentation and mortality. Multivariate analysis was then undertaken including variables with a p value of less than 0.2 in the univariate analysis. Important confounders such as age and sex were retained in the multivariate model regardless of statistical significance. Adjusted hazards ratios were reported for all variables retained in the multivariate analysis following backward stepwise elimination with significance set at the 5% level.

Data analysis was performed using SAS version 9.3 (SAS Institute, Inc., Cary, NC, USA).

3.3 Results

In the 12 months following the index fall and presentation to the Emergency Department, 78 subjects (19.2%) had died. By year 3 a further 77 participants had died with another 54 participants by year 5 – 155 deaths (38.2%) by year 3 and 209 deaths (51.5%) by year 5.

The baseline characteristics of the participants are shown in Table 3.1 comparing those who had died to those who had survived. The median age of participants who died in the 5 years of follow-up was significantly greater than those who had survived (median age 85 years vs 79 years). Other factors significantly associated with dying in the 5-year follow-up period included being male, being resident in a Residential Aged Care Facility (RACF), using community services, impaired cognition, impaired mobility either by needing a mobility aid or physical assistance, and requiring assistance with ADLs.

The number of comorbidities was also significantly associated with death in the 5 years of follow-up, with this association persisting when categorised into up to 3 comorbidities and more than 3 comorbidities (see Table 3.1). Neurological, genitourinary and haematological conditions were all more commonly reported in participants who died. Increasing numbers of medication and polypharmacy as defined by the use of more than 4 medications were more frequently reported in participants who died. Angiotensin converting enzyme inhibitors, diuretics and nitrates were prescribed more commonly in participants who died, whereas angiotensin receptor blockers and calcium channel blockers were more commonly prescribed in those who survived to 5 years of follow-up.

The characteristics of the index fall event were also significantly associated with death in the 5 years of follow-up. Hospitalisation due to the index fall, an index fall which was due to multiple risk factors and the type of fracture sustained at the index fall were all significantly associated with death at 5 years (see Table 3.1). Falls which were termed "hot" falls and those where the aetiology was unclear were also significantly associated with death, compared with those falls which were termed "cold" falls or syncope.

Table 3.1: Baseline characteristics of participants at index fall presentation to the Emergency Department (E.D.) based on survival

Variable		Dead N = 209 *N (%)*	Alive N = 197 *N (%)*	P Value
Age (years)	Median (IQR)	85 (IQR 79 - 90)	79 (IQR 72 -85)	<0.0001
Age group	65 – 79 years	53 (25.4)	99 (50.3)	<0.0001
	≥ 80 years	156 (74.6)	98 (49.8)	
Gender	Male	89 (42.6)	60 (30.5)	0.01
	Female	120 (57.4)	137 (69.5)	
Residence	Home alone	61 (29.2)	74 (37.6)	<0.0001
	Home with others	81 (38.8)	103 (52.3)	
	RACF	67 (32.1)	20 (10.2)	
Cognition	Normal	66 (31.6)	114 (57.9)	<0.0001
	Unclear	25 (12.0)	34 (17.3)	
	Impaired	118 (56.5)	49 (24.9)	
Mobility	Independent no aid	77 (36.8)	125 (63.5)	<0.0001
	Independent with aid	113 (54.1)	69 (35.0)	
	Assisted	19 (9.1)	3 (1.5)	
ADLs	Independent	96 (45.9)	155 (76.7)	<0.0001
	Assisted	113 (54.1)	42 (21.3)	
Community services	No	83 (39.7)	129 (65.5)	<0.0001
	Yes	67 (32.1)	20 (10.2)	
	RACF	59 (28.2)	48 (24.4)	
Comorbidities	Mean (SD)	7.0 (SD 3.5)	5.9 (SD 3.4)	0.003
	≤ 3 comorbidities	39 (18.7)	53 (26.9)	0.05
	> 3 comorbidities	170 (81.3)	144 (73.1)	
	Cardiac	156 (74.6)	154 (78.2)	0.40
	Respiratory	62 (29.7)	55 (27.9)	0.70
	Gastrointestinal	79 (37.8)	70 (35.5)	0.64
	Malignancy	57 (27.3)	39 (19.8)	0.08
	Endocrine	110 (52.6)	101 (51.3)	0.78
	Neurological	93 (44.5)	62 (31.5)	0.007
	Sensory impairment	90 (43.1)	75 (38.1)	0.31
	Musculoskeletal	89 (42.6)	97 (49.2)	0.18
	Genitourinary	68 (32.5)	47 (23.9)	0.05
	Haematological	34 (16.3)	19 (9.6)	0.05
	Psychiatric	39 (18.7)	24 (12.2)	0.07

IQR – interquartile range; SD – standard deviation; RACF – residential aged care facility;

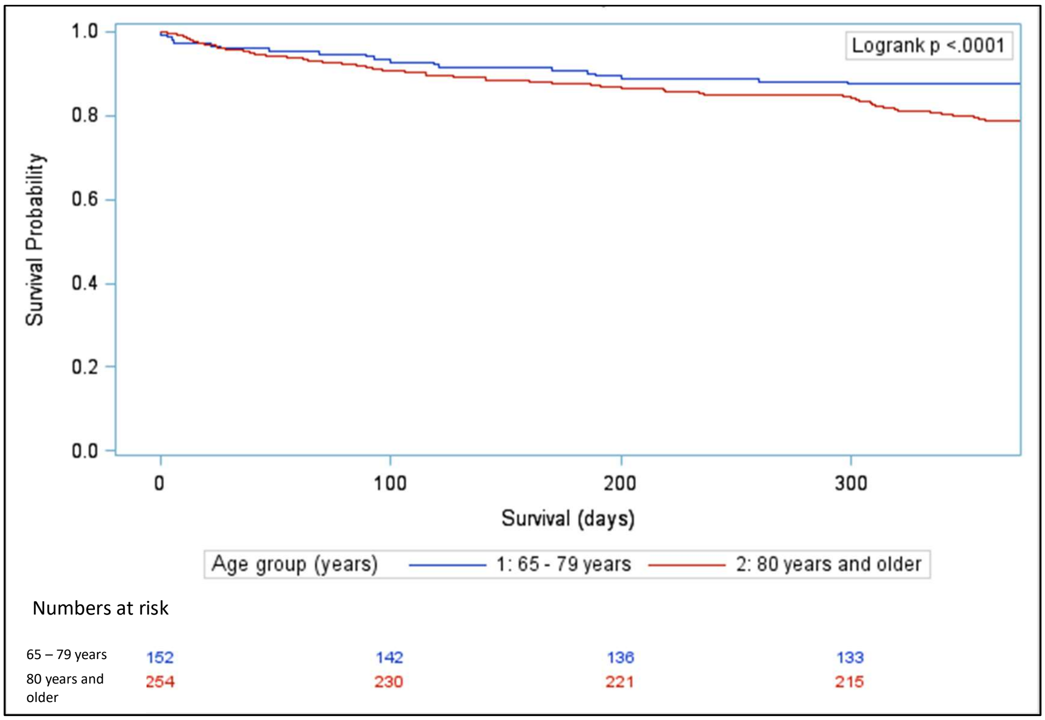
Table 3.1: Baseline characteristics of participants at index fall presentation to the Emergency Department (E.D.) based on survival (Continued)

Variable		**Fallers** **N = 209** ***N (%)***	**Non-Fallers** **N = 197** ***N (%)***	**P Value**
Medications	Median (IQR)	6.0 (IQR 4 – 8)	5.0 (IQR 3 – 7)	0.0008
Polypharmacy	≤ 4 medications	73 (34.9)	94 (47.7)	0.0009
	> 4 medications	136 (65.1)	103 (52.3)	
CNS active medications	Psychotropics	89 (42.6)	72 (36.6)	0.21
	Antipsychotics	19 (9.1)	9 (4.6)	0.08
	Antidepressants	42 (20.1)	39 (19.8)	0.94
	Benzodiazepines	42 (20.1)	28 (14.2)	0.12
	Anticonvulsants	12 (5.7)	12 (6.1)	1.00
Antihypertensives	None	54 (32.0)	93 (39.2)	0.31
	1 agent	51 (30.2)	66 (27.9)	
	≥ 2 agents	64 (37.9)	78 (32.9)	
	Any antihypertensives	129 (61.7)	130 (66.0)	0.37
	ACE inhibitors	51 (24.4)	32 (16.2)	0.04
	ARBs	18 (8.6)	39 (19.8)	0.002
	Beta Blockers	41 (19.6)	40 (20.3)	0.90
	CCB	27 (12.9)	48 (24.4)	0.003
	Diuretics	68 (32.5)	43 (21.8)	0.02
	Nitrates	44 (21.1)	23 (11.7)	0.01
	Warfarin	20 (9.6)	21 (10.7)	0.72
Osteoporosis treatment	Bisphosphonates/SERM	29 (13.9)	31 (15.7)	0.60
	Vitamin D/Calcium	48 (23.0)	40 (20.3)	0.52
Index fall sequelae	Discharged from E.D.	54 (25.8)	78 (39.6)	0.003
	Admitted	155 (74.2)	119 (60.4)	
Reason for index fall	Cold fall	116 (55.5)	120 (60.9)	0.005
	Hot fall	54 (25.8)	38 (19.3)	
	Syncope	11 (5.3)	25 (12.7)	
	Unclear	28 (13.4)	14 (7.1)	
Cause of fall	Multifactorial	201 (96.2)	176 (89.3)	0.01
Falls in prior 12 months	No falls	13 (6.2)	8 (4.1)	0.57
	Unclear history	62 (29.7)	64 (32.5)	
	Yes	134 (64.1)	125 (63.5)	
Index fall injuries	None / minor injuries	82 (39.2)	92 (46.7)	0.13
	Major injuries	127 (60.8)	105 (53.3)	
Fractures	Any fracture	76 (38.6)	98 (49.7)	0.09
	Upper limb	39 (18.7)	17 (8.6)	0.03
	Lower limb	31 (14.8)	30 (15.2)	
	Vertebral / non-limb	28 (13.4)	29 (14.7)	

IQR – interquartile range; SD – standard deviation; E.D. – Emergency Department; ACE – angiotensin converting enzyme; ARB – angiotensin receptor blocker; CCB – calcium channel blocker; SERM – selective oestrogen receptor modulator;

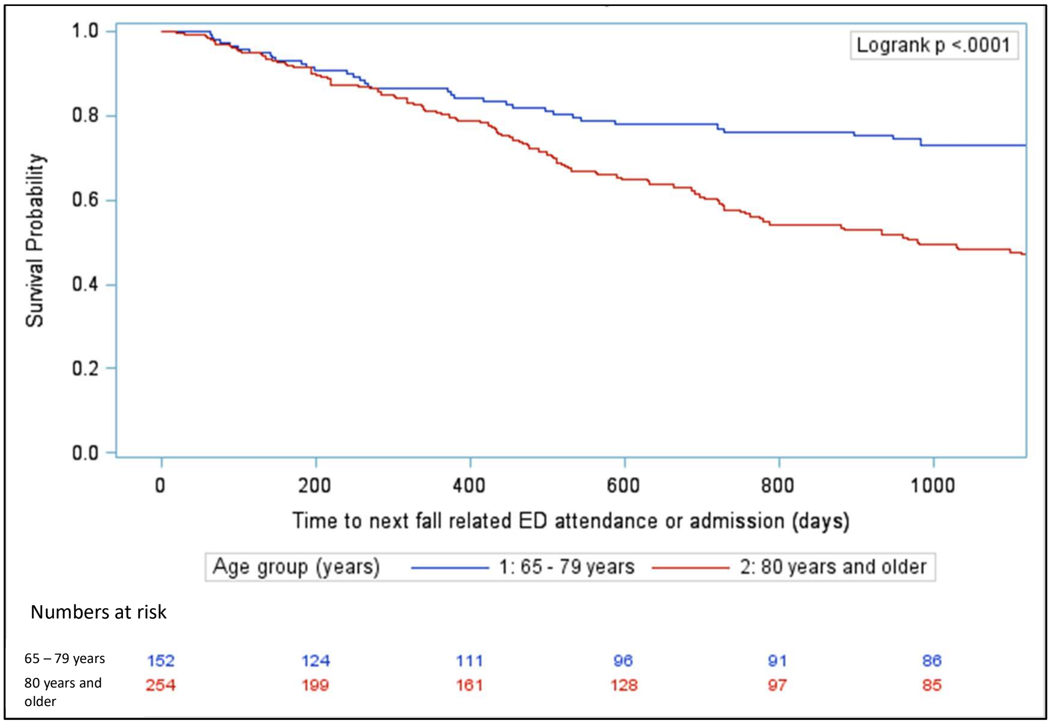
Figures 3.1: Kaplan Meier curves and Logrank test for trend for survival following an index fall presentation to the E.D. stratified by age group for 1, 3 and 5 years.

(a) Year 1



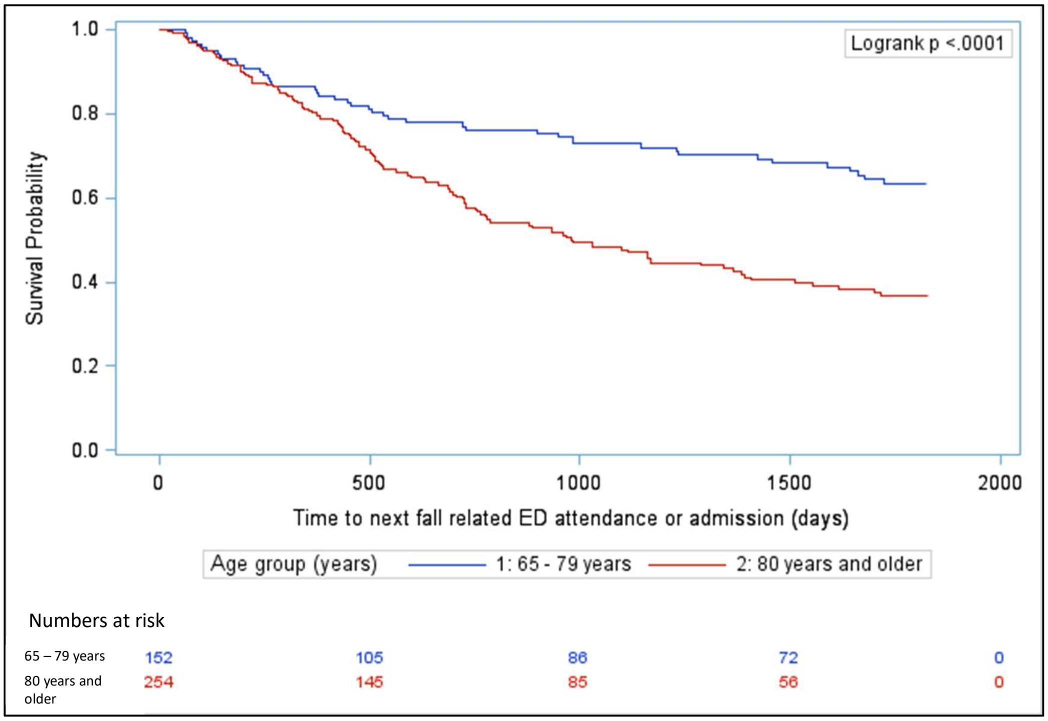
Figures 3.1: Kaplan Meier curves and Logrank test for trend for survival following an index fall presentation to the E.D. stratified by age group for 1, 3 and 5 years.

(b) Year 3



Figures 3.1: Kaplan Meier curves and Logrank test for trend for survival following an index fall presentation to the E.D. stratified by age group (continued)

(c) Year 5



Analyses were then performed to examine the relationship between age and mortality, by categorising participants into two age groups - those aged 65 – 79 years and those aged 80 years and older and mortality. Figures 3.1 (a), (b) and (c) show the Kaplan Meier curves for survival time at 1, 3 and 5years, stratified by age group. The Logrank test for trend shows a significant association between age and mortality, with age 80 years and older significantly associated with increased risk of death at 1, 3 and 5 years. In terms of duration of survival, participants who died had a median survival time of 668 days (IQR 219 – 1150 days) which ranged from death on the day of index fall presentation to 1711 days.

Univariate analyses by Cox proportional hazards were performed using the baseline characteristics to examine the association between these risk factors and mortality at 1, 3 and 5 years and are shown in Table 3.2.

Participants aged 80 years and older had a 49% increased risk of death at 1 year compared to those who were aged 65 – 79 years. Cognition was also associated with increased mortality, with participants who had cognitive impairment at 54% increased risk of death in year 1. Participants who required assistance with activities of daily living and those in receipt of community services were also more likely to die in the first year of follow-up. Polypharmacy, defined as the use of more than 4 medications, was also associated with increased risk of mortality in the first year (HR 1.52; 95% C.I. 1.14 – 2.02), but no specific medication had a significant association with mortality. More than 3 comorbidities, specific medical conditions and the characteristics of the index fall presentation were not significantly associated with increased risk of mortality in year 1 of follow-up.

There was variation in the statistical association between baseline characteristics and mortality when the univariate analysis was repeated for 3 and 5-year follow-up periods. Table 3.2 shows that age was no longer significantly associated with mortality at year 3. Participants who were resident in a residential aged care facility had a 2-fold increased risk of mortality at year 3 (HR 2.08; 95% C.I. 1.32 – 3.33). Participants who had other measures of physical decline, such as those who required assistance with activities of daily living and those who required community services, were also at increased risk of death at year 3. Impaired cognition was associated with increased risk of mortality at year 3. The total number of comorbidities was no longer associated with mortality, however participants with sensory impairment were at increased risk of death at year 3 (HR 1.36; 95% C.I. 1.01 – 1.84).

At 5 years from the index fall presentation, a wide range of baseline risk factors were significantly associated with increased mortality (see Table 3.2) Age 80 years and older, being resident in a RACF, impaired cognition, impaired mobility, requiring assistance with ADLs and use of community services were all significantly associated with death at 5 years. Females had a 32% reduction in the risk of death at 5 years compared with males.

Medical conditions were more strongly associated with mortality at 5 years in the univariate analysis. Participants who reported more than 3 comorbidities at their index fall presentation had a 45% increased risk of mortality at 5 years. Participants who reported histories of malignancy, neurological, genitourinary haematological and psychiatric conditions were all associated with increased risk of death at 5 years (see Table 3.2). The use of diuretics and nitrates increased the risk of death, whereas angiotensin receptor blockers and calcium channel blockers were associated with a reduction in the risk of death. Participants who were admitted to hospital as a result of their index fall presentation were at higher risk of death at 5 years. The specific reason for in the index fall was also important – participants who had "hot" falls, which are falls precipitated by medical events, and those who had an unclear reason for falling were at increased risk of death at 5 years. Participants who had multiple risk factors for falls had a 2-fold increased risk of death (HR 2.35; 95% C.I. 1.16 – 4.76) and those who sustained an upper limb fracture were also at increased risk (HR 1.65; 95% C.I. 1.15 – 2.38).

Table 3.2: Cox proportional hazards univariate analysis of risk factors for falls associated with mortality at 1, 3 and 5 years

Variables		Year 1 Univariate HR (95% CI)	P value	Year 3 Univariate HR (95% CI)	P value	Year 5 Univariate HR (95% C.I.)	P value
Age 80 years or older		1.49 (1.09 – 2.03)	0.01	1.34 (0.96 – 1.89)	0.09	2.13 (1.56 – 2.91)	<0.0001
Female		0.89 (0.67 – 1.17)	0.39	1.23 (0.91 – 1.73)	0.16	0.68 (0.52 – 0.89)	0.006
Residence	Home alone	1.0	0.12	1.0	0.007	1.0	<0.0001
	Home with others	0.94 (0.68 – 1.31)		0.83 (0.60 – 1.15)		0.99 (0.71 – 1.39)	
	RACF	1.31 (0.92 – 1.86)		2.08 (1.32 – 3.33)		2.34 (1.65 – 3.31)	
Cognitive impairment	Normal	1.0	0.006	1.0	0.04	1.0	<0.0001
	Unclear	0.95 (0.60 – 1.50)		0.81 (0.51 – 1.27)		1.31 (0.83 – 2.08)	
	Impaired	1.54 (1.14 – 2.09)		1.53 (1.10 – 2.13)		2.63 (1.94 – 3.56)	
Mobility	Independent no aid	1.0	0.08	1.0	0.21	1.0	<0.0001
	Independent with aid	1.28 (0.95 – 1.71)		0.88 (0.65 – 1.21)		2.06 (1.54 – 2.75)	
	Assisted	1.69 (1.02 – 2.80)		2.08 (0.90 – 4.76)		3.72 (2.24 – 6.16)	
Activities of daily living	Assisted	1.41 (1.07 – 1.86)	0.02	1.61 (1.16 – 2.22)	0.004	2.67 (2.03 – 3.50)	<0.0001
Community services	None	1.0	0.04	1.0	0.01	1.0	<0.0001
	Yes	1.51 (1.09 – 2.08)		1.81 (1.16 – 2.85)		2.77 (2.01 – 3.83)	
	RACF	1.30 (0.93 – 1.82)		1.09 (0.78 – 1.53)		1.58 (1.13 – 2.20)	

HR – Hazards ratio; C.I. – Confidence Intervals; E.D. – Emergency Department; RACF – Residential Aged Care facility;

Table 3.2: Cox proportional hazards univariate analysis of risk factors for falls associated with mortality at 1, 3 and 5 years (Continued).

Variables		Year 1 Univariate HR (95% CI)	P value	Year 3 Univariate HR (95% CI)	P value	Year 5 Univariate HR (95% C.I.)	P value
Comorbidities	> 3 comorbidities	1.09 (0.77 – 1.55)	0.62	1.41 (0.93 – 2.15)	0.11	1.45 (1.03 – 2.06)	0.04
	Cardiac	0.88 (0.65 – 1.20)	0.43	1.10 (0.77 – 1.58)	0.59	0.88 (0.65 – 1.20)	0.43
	Respiratory	1.00 (0.74 – 1.34)	0.98	1.08 (0.78 – 1.50)	0.63	1.10 (0.82 – 1.48)	0.54
	Gastrointestinal	0.96 (0.73 – 1.27)	0.79	1.13 (0.83 – 1.53)	0.45	1.11 (0.84 – 1.47)	0.45
	Malignancy	0.93 (0.68 – 1.26)	0.63	0.81 (0.56 – 1.16)	0.25	1.47 (1.09 – 2.00)	0.01
	Endocrine	1.05 (0.80 – 1.37)	0.75	1.25 (0.92 – 1.70)	0.16	1.07 (0.81 – 1.40)	0.64
	Neurological	1.13 (0.86 – 1.48)	0.39	0.95 (0.70 – 1.30)	0.76	1.47 (1.11 – 1.93)	0.006
	Sensory impairment	1.12 (0.85 – 1.47)	0.42	1.36 (1.01 – 1.84)	0.04	1.12 (0.85 – 1.47)	0.42
	Musculoskeletal	0.96 (0.73 – 1.26)	0.75	1.05 (0.78 – 1.42)	0.75	0.82 (0.62 – 1.08)	0.16
	Genitourinary	1.08 (0.81 – 1.44)	0.60	1.00 (0.72 – 1.39)	1.00	1.37 (1.02 – 1.82)	0.04
	Haematological	0.94 (0.65 – 1.36)	0.74	0.89 (0.58 – 1.39)	0.62	1.60 (1.11 – 2.31)	0.01
	Psychiatric	0.94 (0.65 – 1.36)	0.74	0.89 (0.58 – 1.39)	0.62	1.60 (1.11 – 2.31)	0.01

HR – Hazards ratio; C.I. – Confidence Intervals; E.D. – Emergency Department;

Table 3.2: Cox proportional hazards univariate analysis of risk factors for falls associated with mortality at 1, 3 and 5 years (Continued).

Variables		Year 1 Univariate HR (95% CI)	P value	Year 3 Univariate HR (95% CI)	P value	Year 5 Univariate HR (95% C.I.)	P value
Polypharmacy	> 4 medications	1.52 (1.14 – 2.02)	0.004	0.95 (0.70 – 1.30)	0.77	1.06 (0.80 – 1.42)	0.67
CNS active medications	Psychotropics	1.11 (0.84 – 1.45)	0.47	0.94 (0.69 – 1.27)	0.67	1.23 (0.94 – 1.62)	0.11
	Antipsychotics	1.46 (0.91 – 2.34)	0.11	1.23 (0.69 – 2.33)	0.52	1.47 (0.92 – 2.30)	0.11
	Antidepressants	1.06 (0.75 – 1.48)	0.74	0.93 (0.64 – 1.36)	0.71	1.04 (0.75 – 1.47)	0.80
	Benzodiazepines	1.15 (0.82 – 1.62)	0.41	0.80 (0.53 – 1.20)	0.28	1.39 (0.99 – 1.95)	0.06
Antihypertensives	Any antihypertensives	0.93 (0.70 – 1.22)	0.59	1.23 (0.89 – 1.70)	0.22	0.88 (0.67 – 1.17)	0.38
	ACE inhibitors	1.18 (0.86 – 1.62)	0.30	1.14 (0.80 – 1.62)	0.48	1.35 (0.99 – 1.86)	0.06
	ARBs	0.66 (0.41 – 1.07)	0.09	0.73 (0.48 – 1.21)	0.14	0.49 (0.30 – 0.79)	0.003
	Beta Blockers	1.13 (0.80 – 1.59)	0.48	1.22 (0.85 – 1.75)	0.28	0.91 (0.65 – 1.29)	0.60
	CCB	0.85 (0.56 – 1.27)	0.42	0.85 (0.58 – 1.27)	0.44	0.55 (0.37 – 0.83)	0.004
	Diuretics	1.11 (0.83 – 1.49)	0.47	1.06 (0.77 – 1.47)	0.72	1.47 (1.10 – 1.96)	0.009
	Nitrates	1.02 (0.73 – 1.42)	0.92	1.11 (0.75 – 1.67)	0.59	1.71 (1.23 – 2.39)	0.002
	Warfarin	0.87 (0.55 – 1.38)	0.54	0.88 (0.52 – 1.49)	0.63	0.60 (0.60 – 1.51)	0.83
Osteoporosis treatment	Bisphosphonates/SERM	1.00 (0.67 – 1.48)	0.98	1.00 (0.65 – 1.52)	0.98	0.89 (0.60 – 1.32)	0.57
	Vitamin D/Calcium	1.21 (0.87 – 1.67)	0.26	1.16 (0.82 – 1.64)	0.40	1.09 (0.79 – 1.50)	0.61

HR – Hazards ratio; C.I. – Confidence Intervals; E.D. – Emergency Department; ACE – angiotensin converting enzyme; ARB – angiotensin receptor blocker; CCB – calcium channel blocker; SERM – selective oestrogen receptor modulator;

Table 3.2: Cox proportional hazards univariate analysis of risk factors for falls associated with mortality at 1, 3 and 5 years (Continued).

Variables		Year 1 Univariate HR (95% CI)	P value	Year 3 Univariate HR (95% CI)	P value	Year 5 Univariate HR (95% C.I.)	P value
Index fall sequelae	Discharged from E.D.	1.0	0.73	1.0	0.29	1.0	0.003
	Admitted	1.06 (0.27 – 1.45)		0.84 (0.61 – 1.16)		1.61 (1.18 – 2.20)	
Reason for index fall	Cold fall	1.0	0.78	1.0	0.36	1.0	0.002
	Hot fall	0.95 (0.69 – 1.32)		0.81 (0.56 – 1.18)		1.43 (1.04 – 1.98)	
	Syncope	0.77 (0.41 – 1.43)		0.91 (0.53 – 1.51)		0.55 (0.30 – 1.02)	
	Unclear	1.70 (0.73 – 1.67)		1.49 (0.85 – 2.63)		1.68 (1.11 – 2.54)	
Cause of fall	Multifactorial	1.50 (0.74 – 3.04)	0.27	1.50 (0.71 – 3.21)	0.29	2.35 (1.16 – 4.76)	0.02
Falls in prior 12 months	No falls	1.0	0.83	1.0	0.02	1.0	0.78
	Unclear history	0.83 (0.46 – 1.51)		0.63 (0.30 – 1.30)		0.81 (0.44 – 1.47)	
	Yes	0.84 (0.48 – 1.49)		1.08 (0.58 – 2.12)		0.86 (0.48 – 1.51)	
Index fall injuries	None / minor injuries	1.0	0.38	1.0	0.86	1.0	0.25
	Major injuries	1.13 (0.86 – 1.50)		0.97 (0.72 – 1.32)		1.18 (0.89 – 1.56)	
Fractures (Compared with no fracture)	Any fracture	1.18 (0.90 – 1.55)	0.22	0.93 (0.69 – 1.27)	0.65	1.18 (0.90 – 1.55)	0.22
	Upper limb	1.25 (0.87 – 1.80)	0.59	0.70 (0.42 – 1.15)	0.49	1.65 (1.15 – 2.38)	0.05
	Lower limb	1.22 (0.82 – 1.82)		1.06 (0.69 – 1.63)		1.02 (0.69 – 1.52)	
	Vertebral / non-limb	1.08 (0.71 – 1.63)		1.05 (0.67 – 1.62)		0.97 (0.64 – 1.47)	

HR – Hazards ratio; C.I. – Confidence Intervals; E.D. – Emergency Department; RACF – Residential Aged Care facility;

Table 3.3 shows the Cox proportional hazards multivariate analyses for mortality at 1, 3 and 5 years adjusted for age and sex. Years 1 and 3 have similar models, with age more than 80 years old and requiring assistance with activities of daily living both increasing the risk of death. Females were not more likely than males to die at years 1 and 3. The model was re-analysed exchanging the variable assistance with activities of daily living with cognitive impairment, as both variables appeared to have a similar effect on the multivariate model. Participants who had a history of cognitive impairment were at increased risk of death at year 1 (HR 1.45; 95% C.I. 1.06 – 1.98), and at year 3 (HR 1.65; 95% C.I. 1.18 – 2.31) when adjusted for age and sex (not reported in the Table 3.3).

At 5 years from the index fall presentation over half the participants had died and a wider range of baseline risk factors influenced survival and were retained in the multivariate analysis model. As previously seen at 1 and 3 years, participants who were aged 80 years and older were at increased risk of death at 5 years (HR 1.54; 95% C.I. 1.09 – 2.19). Participants who had a history of cognitive impairment, those who required assistance to mobilise or assistance with activities of daily living were at increased risk of death by 5 years. In terms of comorbidities, only malignancy was significantly associated with death at 5 years in the adjusted model (HR 1.58; 95% 1.15 – 2.17). Participants who were taking diuretics and those taking nitrates had increased risk of death at 5 years. Females were at a significantly reduced risk of dying at 5 years compared with males (HR 0.62; 95% C.I. 0.47 – 0.83). Participants who were taking calcium channel blockers were more likely to survive to 5 years (HR 0.61; 95% C.I 0.40 – 0.93). Participants who presented with a fall due to syncope were also more likely to survive to 5 years (HR 0.44; 95% C.I. 0.23 – 0.82) compared to those who had a “cold” fall (usually a simple slip or trip).

Table 3.3: Multivariate analysis of the predictors of mortality in older people who have attended the ED with a fall at 1, 3 and 5 years adjusted for age and sex.

Variable		**Year 1**		**Year 3**		**Year 5**	
		Multivariate HR (95% CI)	**P value**	**Multivariate** HR (95% CI)	**P value**	**Multivariate** HR (95% C.I.)	**P value**
Deaths *n* (%)		78 (19.2%)		155 (38.2%)		209 (51.5%)	
Age group (years)	Age 80 years and older	1.41 (1.03 – 1.94)	0.03	1.45 (1.03 – 2.05)	0.03	1.54 (1.09 – 2.19)	0.01
Sex	Female	0.87 (0.66 – 1.14)	0.30	1.32 (0.96 – 1.82)	0.09	0.62 (0.47 – 0.83)	0.001
Cognitive impairment	Normal cognition	…	…	…	…	1.0	0.01
	Unclear history	…		…		1.24 (0.77 – 1.99)	
	Cognitive impairment	…		…		1.74 (1.20 – 2.52)	
Mobility	Unaided	…	…	…	…	1.0	0.03
	Use of mobility aid	…		…		1.33 (0.95 – 1.87)	
	Assisted mobility or immobile	…		…		2.10 (1.19 – 3.69)	
Activities of daily living	Assisted	1.36 (1.02 – 1.80)	0.03	1.73 (1.25 – 2.41)	0.001	1.55 (1.07 – 2.24)	0.02
Comorbidities	Malignancy	…		…		1.58 (1.15 – 2.17)	0.005
Medications	Calcium Channel Blockers	…		…		0.61 (0.40 – 0.93)	0.02
	Diuretics	…		…		1.44 (1.05 – 1.98)	0.02
	Nitrates	…		…		1.60 (1.11 – 2.31)	0.01
Reason for index fall	Cold	…		…		1.0	0.01
	Hot	…		…		1.19 (0.86 – 1.66)	
	Syncope	…		…		0.44 (0.23 – 0.82)	
	Unclear	…		…		1.33 (0.86 – 2.06)	

HR – hazards ratio; C.I. – confidence interval;

3.4 Discussion

In this retrospective study of older people who have attended an Emergency Department (E.D.) with a fall or fall-related injury, over 19% of participants died within 1 year of their E.D. attendance and by 5 years that proportion had increased to over 50%. The risk factors which were associated with mortality at year 1 and year 3 were different to the factors associated with mortality at year 5. Age and requiring assistance with activities of daily living (ADLs) were associated with reduced survival at year 1 and year 3 when adjusted for sex. In year 1, cognitive impairment was also significantly associated with increased mortality when adjusted for age and sex, but was eliminated from the model when assistance with ADLs was retained. At 5 years a much wider variety of risk factors were associated with mortality, including age 80 years and older, impaired cognition and mobility, requiring assistance with ADLs, having a history of malignancy and the use of nitrates and diuretics at index fall presentation. Being female, using calcium channel blockers and having a syncopal episode as the cause for the index fall were associated with lower mortality at 5 years.

At 1 year following an attendance at the E.D with a fall or fall related problem, 19% of the cohort had died. Liu et al. reported a 15% one year mortality in their study of 21,340 patients aged 65 years and older who attended an E.D. with a fall and our data is consistent with this. (77) Yu et al. reported that 10% of their cohort died at 1 year, but included only community dwelling older people rather than all E.D. attenders. (79) The mean age of our cohort was 81.9 years which is higher than the 78.6 years and this may account for the higher mortality in our study cohort. At 3 years 38% of the cohort had died. Donald and Bulpitt reported a mortality rate of 25% at 3 years of follow-up in a community based cohort who had fallen derived from G.P. practice registers. (144) The higher rate of falls at 3 years in our cohort most likely reflects the fact the residents from an RACF were also included in our cohort as opposed to the community living sample by Donald and Bulpitt. In addition, the cohort derived from the E.D. may represent a larger cohort of injurious falls than that reported in a community based cohort. There are no studies with which to compare our 5-year mortality data.

The increasing mortality with time from the index fall presentation does raise the question of who should receive falls prevention interventions and for how long. It may be useful to examine the risk factors that predict mortality in order to either concentrate resources and intervention on this group to improve their overall survival. Or alternatively it may inform the clinician on the frailty of the older person who has fallen and attended the E.D. and permit a more supportive approach rather than aggressive intervention approach.

In terms of the risk predictors for mortality following a presentation to the E.D. with a fall or fall-related problem it is interesting to note that the model of predictor for mortality at 1 and 3 years is the same. The difference lies in the magnitude of effect of these risk predictors. Age was retained in the multivariate analysis regardless of the level of significance of effect, but it did prove to significantly increase the risk of mortality at 1 and 3 years. Other studies have found a significant but weaker associated with age. (77, 79)

Requiring assistance with ADLs was associated with increased risk of death at 1 year and 3 years. No comparison with the studies by Liu et al. (77) and Ayoung-Chee et al. (78) can be made as the trauma registries used for these retrospective cohort studies did not record this information. Yu et al. did report on changes in ADLs based on assessment by a trained research nurse, but this was not reported as a risk factor for mortality. (79) Impairment in function as demonstrated by the need for assistance in ADLs has been reported to be associated with frailty and specific frailty indices can predict loss of function over time. (145) Frailty indices and functional decline have been shown to be associated with mortality in the MrOS study. (146) This finding was largely replicated in a cohort of community dwelling older women, where an association between frailty, falls, increased disability and death was shown after up to 9 years of follow-up. (75)

By 5 years over 50% of the cohort had died and the risk predictors associated with mortality were more varied. Impaired mobility and disability in ADLs were both associated with mortality at 5 years, with a 2-fold increased risk associated with requiring assistance to mobilise or being dependent. As previously discussed the frailty indices reported in a large cohort study of men and women showed that measures of impairment in mobility were associated with increased mortality in males and females. (75, 146)

Cognitive impairment was associated with increased risk of death at 5years. The E.D. based retrospective cohort studies reviewing hospital trauma registries previously discussed, did not include measures of cognition in their analyses. (77, 78) Yu et al. did provide a measure of cognition, with the research nurse recording the results of the Short Portable Mental Status Questionnaire (SPMSQ). (79) Cognitive impairment as defined by score of greater than 3 errors on SPMSQ was more prevalent in older people who had sustained a traumatic brain injury at their index fall presentation. Yu et al. then demonstrated an increased mortality associated with traumatic brain injury, reporting a 3-fold increased risk of mortality at 1 year. It is more likely that the performance on SPMSQ is a measure of the severity of the traumatic brain injury rather than an independent predictor. Cognitive impairment has been associated with increased risk of hospitalisation due to a serious fall injury in a study of 5356 older people participating in the Cardiovascular Health Study. (147) Welmerink et al. demonstrated increased risk with both mild cognitive impairment and dementia based on scores of the Modified Mini-Mental State Examination (3MS). Hospitalised fallers were also more likely to be female and have at least one impairment in ADLs. All these findings suggest that older people with cognitive impairment are at increased risk of falling and requiring hospitalisation and death, and perhaps should not be excluded from falls prevention interventions or should have interventions tailored to their requirements.

Malignancy at baseline assessment was associated with increased risk of death at 5 years. It is difficult to ascertain the reason for this association as the baseline data collection did not differentiate between active disease and previous disease. Cancer is a well-established cause of mortality in the general population with mortality rates increasing with increasing age. (148) Medications associated with cardiovascular disease and hypertension had a mixed association with mortality and likely reflected the prescribing pattern for the medications. Calcium channel blockers were associated with a reduction in mortality at 5 years. Calcium channel blockers are more commonly prescribed for the management of hypertension and have been demonstrated to reduce the risk of stroke and all-cause mortality. (149) Diuretic and nitrate medications were associated with increased mortality at 5 years. These medications are most commonly prescribed for the symptomatic management of heart failure and ischaemic coronary artery disease rather than providing survival benefit. Syncope as a cause for the index fall was protective as it was associated with a reduction in mortality at 5 years. A cross-sectional study in the U.S. did find a low mortality rate in all hospital admissions due to syncope compared with other causes of hospital admissions in older people. (150)

This study provides an assessment of baseline falls risk factors and their association with mortality. It permits assessment of risk prediction for mortality following a fall or fall-related E.D. presentation. Many of the E.D. based cohort studies have used trauma registries which are not designed to collect falls specific risk factors. In addition, the assessment of survival over 5 years provides a comparison to the mortality outcomes to community based studies in a cohort of older people sustaining a serious injurious fall necessitating E.D. assessment and management. It lends weight to the argument that older people attending the E.D. with a fall should receive falls prevention interventions as a priority to prevent re-attendance at the E.D. as reported in chapter 2 and to improve mortality.

In terms of limitations, this study looks at the risk of mortality over 5 years in older people who have presented to the Emergency Department (ED) with a fall. The consequences of further falls and their effect on the subject's health cannot be determined. Older people who have fallen are at 3-fold increased risk of having a further fall in one year. (151) The baseline assessment was dependent upon the clinical records reviewed for each patient and were not collected by staff trained in the assessment of older people who fall. Therefore, the importance of some risk factors at baseline may have been overlooked and could not be ascertained. Baseline characteristics, such as use of community services and cognition, are not routinely assessed or confirmed by the Emergency Department staff that perform the initial clinical assessments. Therefore, the influence of some of these variables may have not been significant due to the fact that a proportion of subjects were categorised as "unclear" for some of the factors examined.

3.5 Conclusions

In a cohort of older people who have presented with a fall or fall-related problem to an Emergency Department, 19% of the cohort had died by 1 year and by 5 years that proportion had increased to over 50%. In the first 3 years requiring assistance with ADLs was the strongest predictor of mortality when adjusted for age and sex. Cognitive impairment was also associated with increased mortality at 1 year when replacing ADL disability in the adjusted model. Impaired mobility, history of malignancy and medications associated with the management of heart failure are associated with mortality at 5 years.

This suggests that there is a group of older people who are seen in the E.D. with a fall or fall related injury, who are more likely to survive long term who may benefit from long term falls prevention strategies. Alternatively, there is a group of older people with poor mobility, poor cognition and serious medical illnesses who are at high risk of death, in whom it may be more important to focus on strategies to manage their disability, and their cognitive and medical problems.

Chapter 4: Risk predictors for future falls in community dwelling older men – The Concord Health and Ageing in Men Project (CHAMP)

4.1 Introduction

In chapter 2 we found that 20% of a cohort of 405 older people, who had previously attended an Emergency Department (E.D.) with a fall or fall-related problem, re-attended an E.D. with a fall within 1 year. These older people continued to fall and require attendance at the E.D. up to 5 years after the initial attendance. Although the multivariate analysis included sex, males were not less likely than females to re-attend. In chapter 3, we examined the mortality for this cohort and found that by year five 52% of the cohort had died, with 78 dead in the first year and a further 78 by year three. In the multivariate analysis males were at greater risk of death than females. These findings highlight the importance of preventing falls in older men. To have a better understanding of how falls could be prevented in older men, there would be value in knowing more about the risk factors for falls in older men.

As discussed in section 1.7.1 of the literature review, a systematic review and meta-analysis by Deandrea et al. has collated the information from prospective cohort studies to provide an estimate of the effect of these risk factors on experiencing any fall and recurrent falls. (12) In the main, the cohorts of the studies included in this meta-analysis were either exclusively female or had a high proportion of females, i.e. greater than 50% of the subjects were females. Only 6 studies included in the meta-analysis had male only cohorts and 3 of the published studies were on the same male cohort. (52-56, 152) The size of these studies ranged from 217 to 5,995 men. The mean age of participants in these studies was approximately 74 years. One of the limitations of these studies is that the participants in these cohorts were not a representative sample of older men. Duncan et al. (55) and Weiner et al. (56) drew their samples from a Veteran population in the United States (U.S.) and the MrOS cohort (52-54) was derived from volunteer participants. One of the stated outcomes of interest in the MrOS study was to examine the influence of falls on risk of osteoporotic fractures, rather than to examine the risk factors for falls as an objective in its own right. (153) This is then reflected in the design and analyses of data in Mr OS, for example measures of static and dynamic balance were not included in the study's original design. It is also important to note that all of these studies recruited from populations living in the United States of America, Sweden or Hong Kong. Regional differences in risk factor profiles have previously been demonstrated, therefore there is value in knowing what the risk factor profile for falls is in Australian men. (154)

Prospective cohort studies with male and female participants have previously demonstrated a difference between the sexes in terms of risk of falling. Female sex is frequently associated with increased risk of falling compared with males in multivariate analyses, when the cohort is analysed as a whole. For example, Tinetti et al. reported in multivariate analyses that female sex was a significant risk factor for injurious falls in a prospective study of a cohort of 1,103 people that included 298 men. (60) However, many studies assume this difference exists and adjusts the multivariate analyses for sex irrespective of the significance of sex in the analysis, and therefore have not looked at the specific risk factors for falls in male and females. Few studies with male and female subjects have performed subgroup analyses to look for sex differences in predictors of falls (see section 1.7.2 of thesis literature review). In a cohort of 761 community-dwelling older people living in New Zealand, Campbell et al. reported on the differences in factors associated with falls between males and females (39) The age adjusted multivariate analysis in males demonstrated increased risk of falling in those who had difficulty rising from a chair, signs of knee arthritis and demonstrated body sway. In comparison, the age adjusted multivariate analysis in females found that these same factors were also significantly associated with falls, but in addition an association with polypharmacy, psychotropic medications, stroke and grip strength was also seen. The authors postulated that the smaller size of the male cohort may have been the reason they did not find a significant association between medications and falls in males. A Finnish cohort study of 979 people, that included 377 men, found sex differences in the factors associated with injurious falls. (63) In this study a variety of measures of gait and balance were undertaken. In men gait disturbance, using a scale by Tinetti (155), was associated with falls (OR 3.5; 95% C.I. 1.40 – 8.77). A different measure of gait impairment was shown to be associated with falls in females (short step length). In addition, calcium channel blocker medications were associated with increased risk of falling in women, but not in men. The authors also reported on minor falls and major falls. The risk factors associated with minor injuries were similar to that seen for all injurious falls, with the same difference between the sexes in factors associated with falls. When major injurious falls were considered the risk profile changed, and again there were differences in the risk factors associated with falls between the sexes. There was a significant increase in the risk of a major injurious fall in those men with absent quadriceps reflex, but the association between gait impairment, based on Tinetti score, and falls was no longer significant. The multivariate analysis for women did not demonstrate a significant association between any measures of gait or balance and major injurious falls. The use of long-acting benzodiazepines was associated with major injurious falls in female but not in males.

With few prospective studies looking at falls risk factors in representative male cohorts, there is a need for more data on the risk predictors for future falls in community-dwelling older men. Assumptions are made that falls risks are similar between the sexes but we hypothesize that this is not true. The aim of this study was to determine the risk factors for falls in a representative cohort of community dwelling older men. Knowledge of the specific risk factors associated with falls in older men may provide knowledge that can be used to determine if the approach to falls prevention in men should be any different from women.

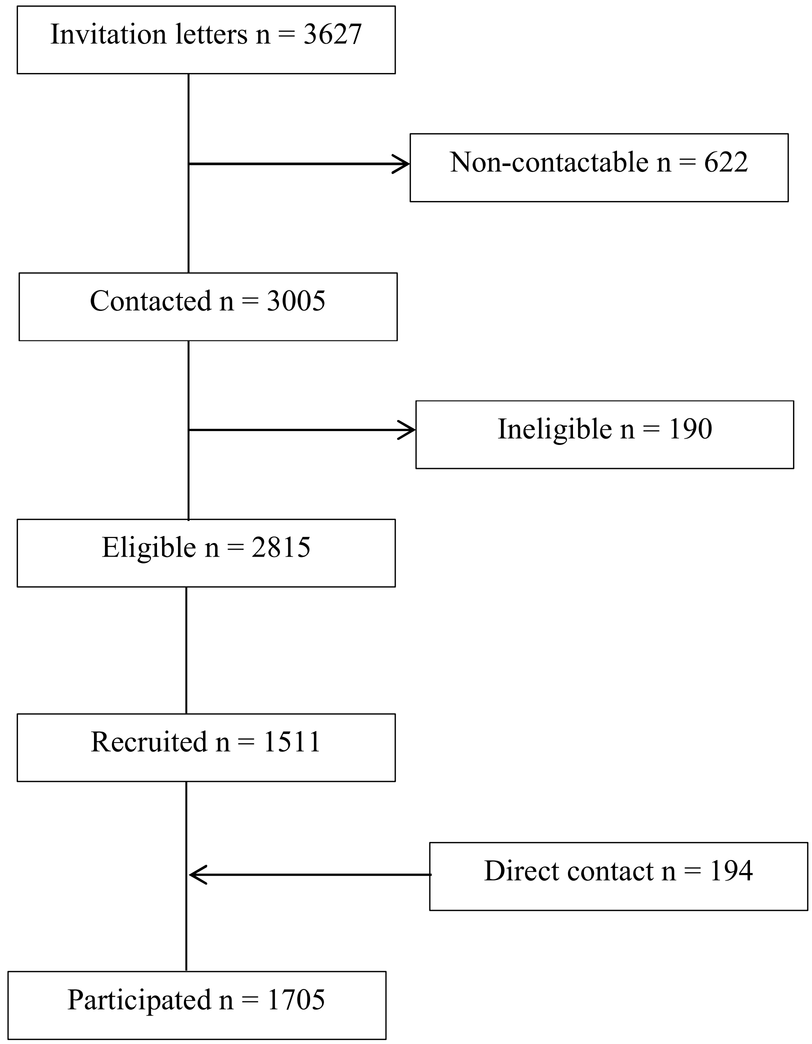
4.2 Methods

The Concord Health and Ageing in Men Project is a National Health and Medical Research Council (NHMRC) funded prospective cohort study designed to examine the health of older men living in the community. The methodology and baseline characteristics of the participants have been reported previously, and are discussed in brief here. (156) This study was designed to examine the causes and consequences of geriatric syndromes such as frailty, falls, bone health and fractures, dementia and cognitive decline, and urinary problems.

Cohort selection

A representative sample of men aged 70 years and older was identified using the New South Wales electoral register as the sampling frame. The men were all resident in the local government areas of Burwood, Canada Bay and Strathfield. Registration on the Electoral Roll is compulsory for all Australian citizens, therefore ensuring a representative sample. Only those residents in a Residential Aged Care facility were excluded. Eligible men were invited by letter to participate in the study and were contacted by telephone after one week to determine if they were interested in taking part in the study.

Figure 4.1: CHAMP recruitment



Recruitment occurred from January 2005 to June 2007. Figure 4.1 describes the recruitment process. Of 3,627 men invited, 622 were unable to be contacted and 190 men were deemed ineligible due to their place or location of residence. An additional 194 eligible men living in the study area heard about the study from friends or the local media and were recruited after contacting the study investigators prior to being identified through electoral rolls. Participation rate is, therefore, calculated as (1,511 from invitation letter system +194 volunteers) / (3627 invitations sent +194 volunteers -190 ineligibles) = 47%.

Baseline data collection

Participants completed a self-report questionnaire which included details on their family history, medical history, personal history, sun exposure, physical activity, lifestyle, depression and pain. This questionnaire was estimated to take 45 minutes to complete. Participants then attended Concord Hospital to complete an assessment with a trained assessor over approximately 3 hours. The assessor used a standardised data collection process to obtain information on a range of socio-demographic, health status and physical performance measures and including fasting blood samples. Data entry was standardized and performed by a single qualified data-entry clerk. The quality of the data was checked using standard procedures of data management (i.e. data examination, data cleaning, and data analysis).

Socio-demographic measures

The baseline demographic details collected included age, country of birth, marital status and living arrangements. Socioeconomic details were also reported including years of education, occupation, source of income and home ownership. The Duke Social Support index was used to quantify satisfaction with social interactions. (157)

Health status measures

Medical conditions were assessed using a standardized questionnaire in which participants reported if a doctor had ever told them that they had diabetes, thyroid dysfunction, osteoporosis, Paget's disease, stroke, Parkinson's Disease, kidney stones, dementia, depression, epilepsy, hypertension, myocardial infarction, angina, congestive heart failure, intermittent claudication, chronic respiratory disease, liver disease, chronic kidney disease, arthritis or gout, and cancer. This data was used to determine the total number of comorbidities and was used as a measure of health. Self-rated health was determined by using the question "compared to other people your own age, how would you rate your overall health?" Participants were then dichotomised as those who perceive their health to be very poor, poor or fair compared to those who rated their health good or very good. A self-reported history of dizziness or prior history of falls was also recorded. The 15 point Geriatric Depression Scale was used to determine symptoms suggestive of depression. (158)

The Mini-Mental State Examination (MMSE) (159) and the Addenbrooke's Cognitive Examination (ACE) (160) were used to assess cognition. Further screening for cognitive impairment and psychiatric conditions was performed by interviewing a nominated informant using the Neuropsychiatric Inventory (NPI) (161) and the Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE). (162) Men who scored 26 or below on MMSE or 3.6 or higher on the IQCODE were invited to undergo a detailed face-to-face assessment by a geriatrician. Additional testing with the Rowland Universal Dementia Assessment Score (RUDAS) (163) was performed in those men scoring poorly on MMSE whose first language was not English. A consensus diagnosis of dementia, mild cognitive impairment or normal cognition was reached between a geriatrician, a neurologist and neuropsychologist who had access to all available information.

Disability was measured using the Katz Activities of Daily Living Scale. (164) Physical activity was measured using the Physical Activity Scale for the Elderly (PASE). (165) In the PASE participants are asked about outdoors walking and/or light, moderate or strenuous sports, and the duration of each activity. A score was derived for each question based on the time spent on each activity weighted for its intensity.

Participants were asked about symptoms of urinary incontinence including frequency of urination and frequency of incontinence. Men answered questions on urinary symptoms based on the International Prostate Symptom Score (IPSS) (166) and International Consultation on Incontinence Questionnaire (ICIQ) (167). Men were then categorised into 3 categories based on frequency of incontinence symptoms: no incontinence, non-urge incontinence and urge incontinence based on self-reported symptoms of leakage > 1 day per week, with urge incontinence determined by the presence or absence of leakage on the way to the toilet.

Participants brought medications that they had been taking daily or almost daily, for at least the past month to the clinic visit for medication inventory. Polypharmacy for the purposes of this study was defined as taking more than 4 different regular medications, based on a previous analysis of this cohort identifying 4.5 medications as the highest predictive value for identification of falls using a receiver operator characteristics (ROC) curve. (138) Men were also categorised according to their use of psychotropic medications (benzodiazepines, narcotic analgesics, non-benzodiazepine anticonvulsants, selective serotonin reuptake inhibitors, and tricyclics) using the Iowa Drug Information System Coding System. (168) Alcohol use was also self-reported and men were then dichotomised as a current drinker versus non-drinker.

Corrected visual acuity was assessed using the Bailey-Lovie chart. (169) Men with corrected visual acuity 20/40 or worse were considered to have poor visual acuity and visual acuity was dichotomised as normal and poor. Contrast sensitivity was assessed using the Pelli-Robson test. (170) A score of less than 36 letters recognised is consistent with a log contrast sensitivity of 1.5 below which is considered impaired contrast sensitivity. Stereopsis or depth perception was assessed using the Frisby Stereo test. (171) Depth perception was assessed as poor if the participant cannot see the depth cue on the maximum thickness plate.

Physical performance measures

During the clinic based assessment a range of physical performance measures were undertaken as follows:

Grip strength

Muscle strength was assessed using a test of grip strength (kg) measured twice using a hand dynometer. Grip strength was dichotomised as poor strength and normal strength using the lowest quintile of measurements of the cohort based on the assessment of muscle strength by Fried et al. (145)

Chair stand test

The timed chair-stand test or sit-to-stand test is a complex measure of lower limb strength and balance. Participants were seated in a standard height (43cm) armed chair and asked to stand up, without using their arms, as fast as possible 5 times. Performance was measured, in seconds, as the time from the initial seated position to the final seated position after completing 5 stands. A categorical variable with yes/no response was also recorded for the participant's ability to complete the test.

The 6m walk test

The 6m walk test was used as a measure of gait speed. Impaired gait specifically in terms of speed is a recognised risk factor for falls and also associated with frailty and disability. From a standing position, the participant was timed and asked to walk at their usual pace between 2 lines marked on the floor 6m apart. Gait speed was calculated as the average of 2 trials (m/seconds). The variable was dichotomised at the lowest quintile into fast speed and slow speed/unable. (145)

Narrow walk test

The narrow walk test was an additional assessment of gait and balance. Participants were asked to repeat the 6m walk test, but to attempt to keep their feet within 2 lines of tape placed 20cm apart on the floor. Up to 3 trials were allowed and the test was deemed successful if 2 trials were completed without the participant walking on or outside of the lines. The walk was timed and the results dichotomised using the lowest quintile into fast speed and slow speed/unable.

Postural sway

Postural sway is a measure of static balance and was performed on both firm floor and foam platform. Using the Lord sway-meter, the participant was instructed to stand on the floor or a 10cm thick foam platform with their eyes open. (172) The participant's movement was recorded by the movement of the pen on the paper, with the score derived by multiplying the width by the height of the number of markings on the paper (in mm^2). Higher scores indicated poorer balance. The variable was dichotomised into those who had a good performance and those who had a poor performance or were unable to perform the test, based on the highest quartile score (worst performance). Participants who declined to perform the test or were unable to perform for non-physical reasons were considered missing for the purpose of analysis.

Coordinated stability test

Dynamic balance was measured using the coordinated stability test – or race-track test. With the Lord sway-meter attached around the waist of the participant with the rod facing anteriorly, participants were asked to trace a pen around a race track that is on a piece of paper and stay within the lines of the track. The participants were instructed to move their bodies to move the pen around the track, without moving their feet. A score was given for each breech of the line with a higher score given for breeches when at the corners. Higher scores indicated poor performance. The variable was dichotomised into those who had a good performance and those who had a poor performance, based on the highest quartile score (worst performance), or were unable to complete the test. Again, participants who declined to perform the test or were unable to perform for non-physical reasons were considered missing for the purpose of analysis.

Falls ascertainment

Participants were followed using phone calls every 4 months to the participant or their nominated informant. Outcome measures recorded included falls occurring in the previous 4 months, fractures and hospitalisations. Only falls outcomes are reported in this study. Details were also provided during these follow-up phone calls on participants who had been admitted to residential aged care facilities and who had died in the preceding 4 months. The NSW Registry of Births, Deaths and Marriages was used to confirm deaths of participants. For the purposes of this study, only outcome data up to the 2-year review are included to allow comparison with other prospective cohort studies. CHAMP data collection commenced in 2005 with ongoing follow-up assessments at 2 years, 5 years and 8 years.

Ethical approval

This prospective cohort study was reviewed and approved by the Human Research and Ethics Committee of Concord Hospital. All participants gave informed consent.

Statistical analysis

Initial data analysis examined the relationship between the baseline characteristics of the participants and a prior history of falls, because we hypothesised that if baseline characteristics differed greatly between those who had a history of falls compared to those who did not, history of falls should be accounted for in the further analysis. Analysis of the risk predictors of further falls was performed in those who had valid falls outcome data. A total of 15 participants were excluded as outliers as they had more than 10 falls per year, which was outside the interquartile range for number of falls (or greater than 2 standard deviations from the mean number of falls). The analyses examined the risk of having a single fall, recurrent falls and any falls, by calculating odds ratio using logistic regression, and incident rate ratios (IRR) using negative binomial regression. Previous studies have demonstrated that there is a stronger association between risk predictors and recurrent falls compared to one or more falls. The PRoFaNe group advise that the most appropriate analysis of falls risk is using negative binomial regression. (1) Negative binomial regression enables the adjustment for different follow-up lengths and analysis or recurrent events, such as falls, which are not independent of one another. All these methods were used to allow comparison with earlier studies.

Multivariate analysis using negative binomial regression was carried out including all variables with a P value less than 0.2 in the univariate analysis. Continuous variables such as age, BMI and education in years were dichotomised when preliminary analysis revealed a non-linear relationship. Urinary incontinence was also dichotomised after initial analysis as there was a clear relationship between both types of incontinence and falls. Backward stepwise elimination was used to eliminate non-significant variables. Any important confounders were retained in the model regardless of statistical significance. Since we found that the risk profile at baseline was different between the group with and without a history of falls, the multivariate analysis models were analysed including and excluding the history of falls variable. This permitted us to examine both a predictive model to identify risk factors that predict further falls (including previous falls history), and a causal model to identify risk factors for falls (excluding previous falls history) in community dwelling older men. Multivariate analysis was also performed excluding risk factors which may have been on the same causal pathway, such as disability in ADLs, which may reduce the size of the effect of measures of strength, balance and mobility on future falls (over-adjustment).

Data analysis was performed using SAS version 9.3 (SAS Institute, Inc., Cary, NC, USA).

4.3 Results

The baseline characteristics of those men who had a self-reported history of falls in the year prior to recruitment compared to those who had not fallen in this time period is shown in Table 4.1. In terms of the demographic characteristics a history of prior falls was significantly associated with increasing age, being single, one or more disabilities in activities of daily living and low satisfaction in social support based on the Duke Social Support satisfaction score. Participants who were still employed compared to those who were retired, and those who drank any alcohol compared with non-drinkers, were significantly less likely to report a history of falls in the 12 months prior to recruitment. Significant associations with prior history of falls were also seen in a variety of measures of health. Increasing number of comorbidities, self-reported dizziness, depression (GDS score >5), urinary incontinence and low physical activity were all strongly associated with self-reported history of falls. Polypharmacy and the use of psychotropic medications were also associated with a history of falls. The categorical variable cognitive impairment showed a significant association with a history of falls, with a greater proportion of fallers having a diagnosis of dementia than non-fallers. There were similar proportions of fallers and non-fallers with a diagnosis of mild cognitive impairment. A non-linear relationship was seen between body mass index (BMI) and falls, but the median BMI was not significantly different between fallers and non-fallers. The proportion of fallers with a BMI score ≤ 24.9kg/m² was greater than non-fallers, but the association was not significant. The measures of gait, balance and strength and the 3 tests of vision all demonstrated a significant association with a prior history of falls, with the poor/unable or slow category performances associated with history of fall. Poor grip strength was also significantly associated with a history of falls.

Table 4.1: Comparison of baseline characteristics between men who had a history of falling in the preceding 12 months and those who did not.

Variable		Fallers N= 320 N (%)	Non-fallers N= 1383 N (%)	P value
Age (years)	70-74	88 (27.5)	585 (42.3)	<0.0001
	75-79	90 (28.1)	446 (32.2)	
	80 years or more	142 (44.4)	352 (25.5)	
Marital status	Living with a partner	220 (68.8)	1088 (78.7)	0.0002
	Single	100 (31.3)	295 (21.3)	
Accommodation	Owner occupier	281 (87.8)	1240 (89.7)	0.28
	Rental	29 (9.1)	92 (6.7)	
	Other	8 (2.5)	27 (2.0)	
Employment	No	307 (95.9)	1252 (90.5)	0.007
	Yes	13 (4.1)	116 (8.4)	
Income	Aged pension	131 (40.9)	537 (38.8)	0.27
	Part Aged Pension	58 (18.1)	212 (15.3)	
	Self-funded	128 (40.017.3)	612 (44.7)	
Years of education	1-14 years	110 (34.4)	513 (37.1)	0.47
	>14 years	196 (61.3)	832 (60.2)	
Country of birth	Australian or English language countries	217 (67.8)	729 (52.7)	<0.0001
	Non-English speaking	103 (32.2)	654 (47.3)	
Smoking	Non-smoker	127 (39.7)	532 (38.5)	0.91
	Ex-smoker	175 (54.7)	768 (55.5)	
	Current smoker	18 (5.6)	83 (6.0)	
Average number of alcoholic drinks per week	Mean (SD)	6.8 (8.53)	7.9 (8.26)	0.03
	Non-drinker	102 (31.9)	324 (23.4)	0.001
	Drinker	216 (67.5)	1057 (76.4)	
ADL Disability	No	259 (80.9)	1301 (94.1)	<0.0001
	Yes	61 (19.1)	79 (5.8)	
Duke satisfaction score	High satisfaction >=19	225 (70.3)	1068 (77.2)	0.002
	Low satisfaction <19	94 (29.4)	293 (21.2)	

SD – standard deviation; ADL – Activities of Daily Living.
Some column percentages do not total 100% due to rounding and missing data.

Table 4.1: Comparison of baseline characteristics between men who had a history of falling in the preceding 12 months and those who did not. (Continued)

Variable		Fallers N = 320 N (%)	Non-fallers N = 1383 N (%)	P value
Number of comorbidities	<=3	207 (64.7)	1076 (77.8)	<0.0001
	>3	113 (35.3)	290 (21.0)	
Dizziness	No	183 (57.2)	1036 (74.9)	<0.0001
	Yes	136 (42.5)	324 (23.4)	
Depression	No	237 (74.1)	1197 (86.6)	<0.0001
	Yes	81 (25.3)	164 (11.9)	
Cognitive function	Normal	265 (82.8)	1226 (88.6)	<0.0001
	Mild cognitive impairment	22 (6.9)	98 (7.1)	
	Dementia	33 (10.3)	59 (4.3)	
Urinary incontinence	Continent	235 (73.4)	1191 (86.1)	<0.0001
	Incontinent	82 (25.6)	165 (11.9)	
BMI	Mean (SD)	27.4 (4.10)	27.8 (3.68)	0.11
	<=24.9	84 (26.3)	311 (22.5)	0.06
	>24.9	214 (66.9)	1038 (75.1)	
PASE	>=85	184 (57.5)	1045 (75.6)	<0.0001
	<85	136 (42.5)	319 (23.1)	
Self-rated health	Excellent / very good / good	201 (62.8)	974 (70.4)	0.002
	Fair / poor / very poor	119 (37.2)	387 (28.0)	
Polypharmacy	<=4 medications	167 (52.2)	888 (64.2)	<0.0001
	>4 medications	153 (47.8)	486 (35.1)	
Psychotropic medications	No	273 (85.3)	1289 (93.2)	<0.0001
	Yes	47 (14.7)	94 (6.8)	
Physical measures				
Visual acuity	Good vision (20/40 or better)	239 (74.7)	1117 (80.8)	0.005
	Poor vision / unable to test	69 (21.6)	208 (15.0)	
Contrast sensitivity	Good	155 (48.4)	876 (63.3)	<0.0001
	Poor / unable to test	124 (38.8)	448 (32.4)	
Stereopsis	Good	192 (60.0)	1024 (74.0)	<0.0001
	Poor / unable to test	128 (40.0)	359 (26.0)	

SD – standard deviation; BMI – Body Mass Index; PASE – Physical Activity Scale in the Elderly.

Table 4.1: Comparison of baseline characteristics between men who had a history of falling in the preceding 12 months and those who did not. (Continued)

Variable		**Fallers N = 320 N (%)**	**Non-fallers N = 1383 N (%)**	**P value**
Walking speed	Fast	183 (57.2)	1116 (80.7)	<0.0001
	Slow	101 (31.6)	226 (16.3)	
Narrow walking speed	Fast	110 (34.4)	842 (60.9)	<0.0001
	Slow	61 (19.1)	184 (13.3)	
Chair stand test	Good performance	258 (80.6)	1305 (94.4)	<0.0001
	Unable to perform	60 (18.8)	74 (5.4)	
Floor sway test	Good performance	283 (88.4)	1336 (96.6)	<0.0001
	Unable to perform	37 (11.6)	44 (3.2)	
Foam sway test	Good performance	233 (72.8)	1269 (91.8)	<0.0001
	Unable to perform	87 (27.2)	87 (6.3)	
Racetrack test	Good performance	246 (76.9)	1294 (93.6)	<0.0001
	Unable to perform	74 (23.1)	87 (6.3)	
Grip strength	Median (range)	37 (9 – 495)	39 (12 – 555)	0.73
	Good	182 (56.9)	1016 (73.5)	<0.0001
	Poor	89 (27.8)	245 (17.7)	

SD – standard deviation.
Some column percentages do not total 100% due to rounding and missing data.
5 subjects removed due to excessive alcohol intake (outliers); 4 subjects removed due to outlying BMI (Body Mass Index).

As explained above, because of the significant association between prior history of falls and all of the variables discussed and shown in Table 4.1, this guided the modelling of the multivariate analyses including and excluding prior history of falls. Four hundred and seventy-six men (27.9%) had a total of 1,511 falls in the 2-year follow-up period – 246 men (14.4%) had a single fall and 230 men (13.5%) had 2 or more falls. Table 4.2 shows the results of the univariate analyses of baseline risk factors for all falls, single fallers and men with 2 or more falls in the 2-year follow-up.

Table 4.2: Predictors of having a single fall or recurrent falls over 2 years of follow-up from initial assessment – Univariate analyses

Variable		Single fall Odds Ratio (OR) (95% CI)	P value	2 or more falls Odds Ratio (OR) (95% CI)	P value	Incident rate ratios for all falls (IRR) (95% CI)	P value
<u>**Demographics**</u>							
Age (years)	80 years or more	1.42 (1.05 – 1.90)	0.02	2.38 (1.78 – 3.19)	<0.0001	1.78 (1.47 – 2.23)	<0.0001
Marital status	Single	1.47 (1.08 – 2.01)	0.02	1.87 (1.37 – 2.54)	0.0001	1.50 (1.18 – 1.92)	0.0009
Accommodation	Owner occupier	1.00	0.74	1.00	0.60	1.00	0.73
	Rental	1.02 (0.60 – 1.73)		0.83 (0.46 – 1.48)		0.98 (0.65 – 1.49)	
	Other	1.42 (0.60 – 3.31)		0.63 (0.19 – 2.11)		0.72 (0.32 – 1.60)	
Employment	Yes	0.83 (0.49 – 1.41)	0.48	0.56 (0.30 – 1.07)	0.06	0.56 (0.36 – 0.88)	0.01
Income	Aged pension	1.00	0.83	1.00	0.004	1.00	0.01
	Part Aged Pension	1.13 (0.75 – 1.70)		1.88 (1.28 – 2.76)		1.49 (1.10 – 2.02)	
	Self-funded	1.00 (0.75 – 1.37)		1.04 (0.75 – 1.44)		0.98 (0.77 – 1.24)	
Years of education	<15 years	1.12 (0.84 – 1.49)	0.45	1.22 (0.90 – 1.66)	0.21	0.91 (0.73 – 1.14)	0.43
Country of birth	Non-English speaking	0.63 (0.47 – 0.83)	0.001	0.41 (0.30 – 0.56)	<0.0001	0.58 (0.47 – 0.72)	<0.0001
Smoking	Non-smoker	1.00	0.41	1.00	0.19	1.00	0.14
	Ex-smoker	0.82 (0.62 – 1.10)		0.95(0.71 – 1.28)		0.87 (0.70 – 1.08)	
	Current smoker	0.86 (0.47 – 1.55)		0.52 (0.24 – 1.11)		0.63 (0.38 – 1.04)	
Alcohol intake	Drinker	0.95 (0.69 – 1.30)	0.13	0.57 (0.42 – 0.77)	0.0003	0.64 (0.50 – 0.81)	0.0002
ADL Disability	Yes	1.49 (0.91 – 2.44)	0.13	3.48 (2.32 – 5.22)	<0.0001	2.26 (1.58 – 3.21)	<0.0001
Duke satisfaction score	Low satisfaction <19	1.27 (0.92 – 1.75)	0.16	1.92 (1.41 – 2.62)	<0.0001	1.53 (1.20 – 1.96)	0.0006

SD – standard deviation; ADL – activities of daily living.

Table 4.2: Predictors of having a single fall or recurrent falls over 2 years of follow-up from initial assessment – Univariate analyses (continued)

Variable		Single fall Odds Ratio (OR) (95% CI)	P value	2 or more falls Odds Ratio (OR) (95% CI)	P value	Incident rate ratios for all falls (IRR) (95% CI)	P value
Number of comorbidities	>3	1.44 (1.05 – 1.98)	0.02	2.33 (1.73 – 3.15)	<0.0001	1.59 (1.25 – 2.03)	0.0001
History of falls in past 12 months	Yes	2.13 (1.51 – 3.01)	<0.0001	7.94 (5.87 – 10.83)	<0.0001	3.75 (2.91 – 4.71)	<0.0001
Dizziness	Yes	0.96 (0.70 – 1.31)	0.78	1.60 (1.18 – 2.16)	0.003	1.29 (1.01 – 1.63)	0.04
Depression	Yes	1.49 (1.02 – 2.16)	0.04	2.16 (1.52 – 3.07)	<0.0001	1.68 (1.26 – 2.24)	0.0004
Cognitive function	Normal	1.00	0.38	1.00	0.0005	1.00	<0.0001
	Mild cognitive impairment	1.31 (0.79 – 2.16)		1.12 (0.64 – 1.96)		1.02 (0.67 – 1.55)	
	Dementia	1.37 (0.75 – 2.51)		2.85 (1.74 – 4.67)		2.51 (1.65 – 3.83)	
Urinary incontinence	Incontinent	0.95 (0.63 – 1.42)	0.79	1.59 (1.11 – 2.29)	0.01	1.35 (1.00 – 1.81)	0.05
BMI	<=24.9	1.0	0.16	1.00	0.16	1.0	0.11
	>24.9	0.79 (0.58 – 1.09)		1.26 (0.92 – 1.73)		0.81 (0.63 – 1.04)	
PASE	<85	1.09 (0.80 – 1.49)	0.59	1.74 (1.29 – 2.34)	0.0004	1.44 (1.14 – 1.83)	0.002
Self-rated health	Poor / very poor	1.26 (0.94 – 1.69)	0.13	1.50 (1.11 – 2.01)	0.009	1.36 (1.08 – 1.71)	0.009
Polypharmacy	>4 medications	1.57 (1.19 – 2.92)	0.002	1.83 (1.37 – 2.43)	<0.0001	1.45 (1.17 – 1.80)	0.0008
Psychotropic medications	Yes	1.87 (1.19 – 2.92)	0.009	2.10 (1.35 – 3.27)	0.002	1.63 (1.13 – 2.35)	0.007

SD – standard deviation; BMI – Body Mass Index; PASE – Physical Activity Scale in the Elderly.

Table 4.2: Predictors of having a single fall or recurrent falls over 2 years of follow-up from initial assessment – Univariate analyses (continued)

Variable		Single fall Odds Ratio (OR) (95% CI)	P value	2 or more falls Odds Ratio (OR) (95% CI)	P value	Incident rate ratios for all falls (IRR) (95% CI)	P value
Visual acuity	Poor vision / unable to test	1.31 (0.91 – 1.88)	0.15	1.80 (1.28 – 2.55)	0.001	1.86 (1.42 – 2.43)	<0.0001
Contrast sensitivity	Poor / unable to test	1.35 (1.01 – 1.79)	0.04	1.79 (1.34 – 2.39)	<0.0001	1.75 (1.40 – 2.17)	<0.0001
Stereopsis	Poor / unable to test	1.30 (0.97 – 1.75)	0.08	1.71 (1.27 – 2.29)	0.0005	1.65 (1.32 – 2.07)	<0.0001
Walking speed	Slow	1.57 (1.13 – 2.18)	0.009	1.87 (1.33 – 2.63)	0.0004	1.67 (1.29 – 2.16)	<0.0001
Narrow walking speed	Slow	1.18 (0.78 – 1.42)	0.45	1.91 (1.25 – 2.91)	0.004	1.53 (1.11 – 2.11)	0.009
Chair stand test	Unable to perform	1.43 (0.85 – 2.39)	0.19	3.58 (2.37 – 5.39)	<0.0001	2.58 (1.81 – 3.67)	<0.0001
Floor sway test	Unable to perform	1.88 (1.02 – 3.44)	0.05	3.68 (2.20 – 6.15)	<0.0001	2.16 (1.36 – 3.45)	0.0006
Foam sway test	Unable to perform	1.34 (0.88 – 2.06)	0.19	2.91 (2.03 – 4.18)	<0.0001	2.00 (1.47 – 2.72)	<0.0001
Racetrack test	Unable to perform	1.46 (0.92 – 2.34)	0.12	3.50 (2.39 – 5.14)	<0.0001	2.25 (1.61 – 3.14)	<0.0001
Grip strength	Weak or unable to perform	1.29 (0.91 – 1.81)	0.16	1.59 (1.13 – 2.24)	0.009	1.58 (1.21 – 2.06)	0.0006

SD – standard deviation; BMI – Body Mass Index; PASE – Physical Activity Scale in the Elderly.

In those who sustained only one fall in the 2-year follow-up period a prior history of falling was associated with 2-fold increased odds of falling (OR 2.13; 95% CI 1.51 – 3.01). Socio-demographic factors associated with increased risk of a single fall were age 80 years and older, and being single. Being born in a non-English speaking country was protective against falling. The presence of more than 3 comorbidities and high depression score, pre-defined as a GDS score of more than 5, were also associated with an increased risk of falling once. Vision related factors and physical measures associated with increased risk of falling included impaired contrast sensitivity, impaired depth perception, slow walking speed and impaired static balance based on performance on the floor sway test.

The results of the univariate analysis of the factors associated with risk of recurrent falls (2 or more falls in 2 years), are also shown in Table 4.2. In general, the strength of associations between the baseline risk factors and having more than one fall was greater than that seen for men who experienced only a single fall. A previous history of falls was associated with a 7-fold increase in the odds of 2 or more falls. The odds of falling was also increased 3-fold or more in those with a disability in activities of daily living, and impaired static and dynamic balance. Age ≥ 80 years, being single and having a poor score on the Duke social support satisfaction score were all associated with increased odds of falling. More than 3 comorbidities and depression were associated with falling, as too were self-reported dizziness, urinary incontinence, low score on the Physical Activity Scale in the Elderly (PASE) and poor or very poor self-reported health. All tests of vision and physical measures of walking speed, static and dynamic balance and strength measured at the baseline assessment were associated with increased odds of having more than one fall. Drinking any alcohol and coming from a non-English speaking country were both protective against having recurrent falls.

Incident rate ratios were also calculated using negative binomial regression using the total count of all falls in the 2-year follow-up as the outcome measure (see Table 4.2). Again, the greatest increased risk was seen with the prior history of falls, with 3-fold increase in risk of falling. The patterns of association were similar to what was seen for the outcome of 2 or more falls.

Table 4.3 shows the results of the negative binomial multivariate analysis. As discussed, a prior history of falls was significantly associated with further falls, and the strength of association was thought to mask the potential influence of other risk factors. Therefore 2 models of multivariate analysis were run; Model 1 was a fully adjusted model for all variables with a significance level of 0.2 or below in the univariate analysis, excluding "history of falls in the 12 months prior" variable and Model 2 was the same multivariate analysis but included the history of falls variable. Variables which were considered to measure the same physical parameters were reduced to a single variable based on the strength of the association in the univariate analysis and reproducibility of the parameter in a clinical setting. The chair stand test was included as a test of both strength and balance, and the foam sway test was included as a test of static balance. Visual acuity was used as the measure of impaired vision as more participants completed this assessment, and there was collinearity with impaired contrast sensitivity and depth perception.

In model 1, impairment in ADLs was associated with a 1.67-fold increase in the risk of falling (IRR 1.67; 95% CI 1.15 – 2.43), but dropped out as a significant variable in model 2. Being single was significantly associated with falls in model 1, but was not significantly associated with further falls when prior history of falls was included in the model (model 2).

Dementia was associated with increased risk of falling in both models, whereas mild cognitive impairment had a non-significant association with risk of falling. Poor visual acuity and age ≥ 80 years old were associated with risk of falling in both models. Income was also a significant predictor of further falls with the increased risk associated with being a part funded pensioner and no significant association with being a self-funded retiree. When history of falls in the previous 12 months was included in the multivariate analysis it remained the most significant risk factor associated with falls, with a 3-fold adjusted increased risk of falling (IRR 3.12; 95% CI 2.49 – 3.91). A low score on the Duke Social Satisfaction score and polypharmacy were only significantly associated with increased risk of falls in the model including adjustment for history of falls. Men with more than 3 comorbidities at baseline assessment were only significantly associated with risk of falls when history of falls was omitted from the model. However, having more than 3 comorbidities was included as a variable in the model 2 analysis as a significant confounder ($p = 0.07$). As was seen in the univariate analyses, being born in a non-English speaking country (model 2 IRR 0.58; 95% CI 0.46 – 0.73) and current alcohol use (model 2 IRR 0.74; 95% CI 0.59 – 0.93) were associated with lower risk of falls when adjusted for previous history of falls.

All physical measures of strength and balance were eliminated from the models in the process of backwards stepwise regression. This may have been due to the effect of some of the demographic variables masking the effect of the association with these physical parameters. Therefore, further analyses were performed to look at the association between physical parameters, including measures of vision on the risk of falling (data not shown in the Tables). Two models were performed adjusted for age and including and excluding history of falls in the previous 12 months. When history of falls was not included in the model, poor performance on the chair stand test (IRR 2.2; 95% C.I. 1.54 – 3.19), poor visual acuity (IRR 1.52; 95% C.I. 1.17 – 1.99) and poor performance on tests of stereopsis (IRR 1.46; 95% C.I. 1.15 – 1.84) were significantly associated with increased risk of falling, adjusted for age. In the model which retained age and history of falls in the analysis, poor performance on chair stand test (IRR 1.57; 95% C.I. 1.11 – 2.23) and poor visual acuity (IRR 1.64; 95% 1.28 – 2.10) remained significantly associated with increased risk of falling.

Multiple regression analysis was also performed examining the associations between risk factors and recurrent falls in the 2 years of follow-up (Table 4.3). Again, two models were used as described for the negative binomial models: Model 3 was a fully adjusted model excluding the variable "history of falls in the previous 12 months", and Model 4 was a fully adjusted model including prior falls variable. As with the previous analyses (models 1 and 2), impairment in ADLs was associated with a 2-fold increased risk of more than 1 fall in 2 years when adjusted for age, but not history of falls (OR 2.16; 95% C.I. 1.31 – 3.57). When history of falls was included in the analysis (model 4), the association between impairment in ADLs and falls was no longer significant, and impairment in ADLs was eliminated from the multivariate model.

In the analysis which did not include prior history of falls, single marital status was significantly associated with increased risk of 2 or more falls at 2 years (OR 1.45; 95% C.I. 1.03 – 2.06). When prior history of falls was included in model 4, marital status was no longer significantly associated with recurrent falls. Age 80 years or older, low score on Duke social satisfaction score, more than 3 comorbidities and poor visual acuity were all associated with increased risk of falling 2 or more times in 2 years with and without history of falls in the model. Table 4.3 also shows that being born in a non-English speaking country and current alcohol use were associated with decreased risk of 2 or more falls irrespective of inclusion of history of falls in the analysis.

The analyses were repeated examining the association between the physical parameters and 2 or more falls in 2 years, as only poor visual acuity was retained in the final models shown in Table 4.3. When adjusted for age only, poor performance on chair stand test and poor visual acuity were the only physical parameters associated with recurrent falls. In the model without history of falls as a variable, poor performance on chair stand test was associated with a 2.8-fold increased risk (OR 2.79; 95% C.I. 1.77 – 4.40) and poor visual acuity was associated with a 1.6-fold increased risk (OR 1.62; 95% C.I. 1.13 – 2.33) of recurrent falls at 2 years. When adjusted for history of falls, the magnitude of association was reduced – poor performance on chair stand test (OR 1.69; 95% C.I. 1.02 – 2.79), and poor visual acuity (OR 1.51; 95% C.I. 1.02 – 2.22).

Table 4.3: Multivariate analysis of predictors of risk of falling at 2 years – incident rate ratios for all falls and odds ratios for two or more falls

Variable	All falls				Two or more falls			
	Adjusted IRR (95% CI) Model 1	P value	Adjusted IRR (95% CI) Model 2	P value	Adjusted OR (95% CI) Model 3	P value	Adjusted OR (95% CI) Model 4	P value
Age ≥ 80 years	1.36 (1.08 – 1.72)	0.009	1.26 (1.01 – 1.57)	0.04	1.51 (1.08 – 2.11)	0.02	1.41 (1.00 – 2.00)	0.05
Single marital status	1.37 (1.07 – 1.75)	0.01	…	…	1.45 (1.03 – 2.06)	0.04	…	…
Income								
Aged pension	1.00	0.003	1.0	0.007	…	…	…	…
Part Aged Pension	1.50 (1.10 – 2.05)		1.44 (1.07 – 1.93)					
Self-funded	0.91 (0.71 – 1.16)		0.92 (0.73 – 1.17)					
Non-English-speaking country of birth	0.55 (0.43 – 0.70)	<0.0001	0.58 (0.46 – 0.73)	<0.0001	0.42 (0.29 – 0.60)	<0.0001	0.45 (0.32 – 0.65)	<0.0001
Low Duke Social Satisfaction Score	…	…	1.36 (1.07 – 1.72)	0.01	1.71(1.19 – 2.44)	0.004	1.65 (1.14 – 2.39)	0.01
Alcohol drinker	0.72 (0.57 – 0.91)	0.007	0.74 (0.59 – 0.93)	0.009	0.63 (0.45 – 0.88)	0.008	0.67 (0.47 – 0.96)	0.03
Presence of ADL disability	1.67 (1.15 – 2.43)	0.007	…	…	2.16 (1.31 – 3.57)	0.009	…	…
>3 comorbidities	1.42 (1.10 – 1.84)	0.008	1.26 (0.98 – 1.62)	0.07	1.83 (1.31 – 2.57)	0.0006	1.75 (1.23 – 2.50)	0.002
History of falls in the past 12 months	…	,…	3.12 (2.49 – 3.91)	<0.0001	…	…	5.85 (4.17 – 8.22)	<0.0001
Cognitive function								
Normal	1.00	0.001	1.0	0.002	…	…	…	…
Mild cognitive impairment	1.22 (0.81 – 1.86)		1.36 (0.91 – 2.02)					
Dementia	2.19 (1.42 – 3.39)		1.95 (1.30 – 2.94)					
Polypharmacy	1.20 (0.94 – 1.31)	0.14	1.26 (1.00 – 1.58)	0.05	…	…	…	…
Poor visual acuity	1.56 (1.18 – 2.03)	0.002	1.59 (1.22 – 2.07)	0.0005	1.66 (1.13 – 2.44)	0.01	1.61 (1.07 – 2.42)	0.02

IRR – incident rate ratio; OR – Odds Ratio; ADL – Activities of Daily Living.

Explanation for models using in negative binomial and logistic regression analyses (Table 4.3).

Model 1: Fully adjusted negative binomial model excluding history of falls.

Model 2: Fully adjusted negative binomial model including history of falls.

Model 3: Fully adjusted logistic regression model excluding history of falls.

Model 4: Fully adjusted logistic regression model including history of falls.

4.4 Discussion

This study on a cohort of men living in a major metropolitan centre in Australia, builds on the evidence that already exists on the risk predictors for falls in community dwelling older men. A history of falling within the 12 months prior to enrolment in the study was the most significant risk predictor for future falls. Additional risk factors for falls were age ≥ 80 years, being single, impaired function, impaired cognition, more than 3 comorbidities and poor visual acuity.

The association of falls in the preceding 12 months and further falls has previously been reported in the MrOS study by Cawthon et al., with falls in the preceding 12 months associated with a 2.6-fold increased risk of further falls. (53) The 3-fold increased risk reported in our study is also consistent with the meta-analysis by Deandrea et al. (12) In both the meta-analysis of risk predictors of single and recurrent falls, there was a 3-fold increase in the risk of falling in those with a prior history of falls. This suggests that asking about falls in the previous 12 months is one of the most important risk assessments in both males and females. It is interesting to note that retaining history of falls in the multivariate model did not have the effect on the level of associations of factors associated with falls to the extent that one might expect. Presence of a disability in activities of daily living (ADL) and number of comorbidities were no longer significantly associated with risk of falls in the multivariate analysis which included a history of falls. This is probably explained by the fact that there is a significant association between disability in ADL and number of comorbidities, and having fallen in the previous 12 months.

Being aged 80 years and older was associated with a modest increased risk of falling ranging from 26% to 36% depending on whether or not history of falls was included in the multivariate analysis. Again this is consistent with the findings of the meta-analysis by Deandrea et al., with risk increasing by 12% for every 5 years increased age. (12) The association between increased age and falls was also demonstrated in a group of 217 veterans by Duncan et al. (55) The association between age and increased risk of falls may also account for the lack of association between the measures of gait, balance and strength and further falls in our study. The prevalence of frailty has been demonstrated to increase with age, in a study by Fried et al., using a model which included measures of muscle strength, physical activity, walking speed and self-reported exhaustion. (145) The association between age, disability in ADLs and increased risk of falls in multivariate model 1 and age, history of previous falls and increased risk of falls in multivariate model 2, may account for the lack of association with physical measures in the multivariate analysis, as they may be proxy measures of frailty. Deandrea et al. were unable to measure the association of physical measures of balance and strength with falls so included only the variable "gait problems" in the meta-analysis as there was wide range of physical measures of balance, mobility and strength used in studies included. (12)

To further examine the association between physical parameters and falls in our cohort of community living older men, we performed analyses adjusted for age only, and explored the association between physical measures of strength and balance and measures of vision and falls. In these analyses, poor performance in the chair stand test was associated with increased risk of falling in models with and without the history of falls variable. The chair stand test measures lower limb strength and balance. Orwoll et al. examined the association between testosterone, physical performance measures and falls in the MrOS cohort. (54) Poor grip strength or inability to perform the test of grip strength was associated with increased risk of falls compared to those who had grip strength in the highest quartile for strength (RR 1.7; 95% C.I. 1.4 – 2.1). Reduced leg power, and inability to perform the narrow walk test were associated with increase in falls risk, but the exact magnitude of the associations was not reported. The MrOS study also performed the chair stand test as part of their battery of physical measures, but this was not reported to be associated with increased risk of falls. The lack of association between physical parameters and falls in our cohort, when included in models with risk factors such as falls history and disability in activities of daily life, raises the possibility that perhaps measures of mobility, strength and balance are not as important in falls risk assessment as was previously thought. In older men, perhaps the only measure of strength or balance required is the chair stand test, when assessing falls risk particularly with a view to implementation of falls prevention strategies. In a randomised controlled trial of an intervention to reduce the risk of falls, with allocation of intervention determined by a participant's score on the physiological profile assessment (PPA), no effect was seen on the risk of falling or rate of falls. (103) The lack of effect on falls was reported, even though the intervention was able to demonstrate an improvement in the scores of balance and lower limb strength on completion of the study. This might suggest that addressing physical parameters alone may not ameliorate the risk of further falls, without addressing non-physical parameters.

Dementia was significantly associated with risk of falling in this study, with a 2-fold increased risk of falling seen in those with a diagnosis of dementia, regardless of whether or not a history of falls was included in the analysis. No other prospective cohort study with a male population has reported on a significant association between dementia and falls. Surprisingly we did not find an association between dementia and recurrent falls. This could be because the inclusion of ADL disability in one model and history of falls in another eliminates dementia from the final model. A study on older male veterans in the USA found an association between reduced score on MMSE (Mini Mental State Examination) and recurrent falls. (55) In the meta-analysis by Deandrea et al., cognitive impairment was associated with increased risk of one or more falls (OR 1.36; 95% C.I. 1.12 – 1.65). (12) In our study the association with mild cognitive impairment was not significant (IRR 1.36; 95% C.I. 0.91 – 2.02). This suggests that dementia, rather than tests of cognition, such as the MMSE score, is the more important predictor of falls in older men.

Our study demonstrated that polypharmacy was associated with a 26% increased risk of falls, but only in the multivariate analysis model that included history of falls in the past 12 months. None of the prospective male only cohort studies previously discussed reported on an association between polypharmacy and risk of falls. (52-56) Weiner et al. did report that CNS (central nervous system) – active medications were associated with an increased risk of falls, but did not report on an association with polypharmacy. (56) In a mixed sex cohort study, Campbell et al. demonstrated an association in females and not males, and postulated that perhaps this was related to the smaller number of males than females in the cohort. (39)

In contrast, in a Dutch based study, a mixed gender cohort of 1,722 subjects including 705 men, did report an increased risk in all fallers (OR 1.3; 95% C.I. 1.0-1.7) and recurrent falls (OR 1.5; 95% C.I. 1.0 – 2.3), but the definition of polypharmacy use was 4 or more medications rather than more than 4 medications. (15) We did not find an association between psychotropic medications specifically and falls in multivariate analyses. This could be because this is not as strong a risk factor for falls in males as it has been shown in females, or it reflects that a lower proportion of males were taking at least one psychotropic (8.3%) compared to what has been found in female populations of similar age. (39)

Poor vision based on visual acuity score worse than 20/40 using the Bailey-Lovie chart was the only physical measure that was significantly associated with increased risk of falls in the multivariate models. The Blue Mountains Eye study and the EPIC-Norfolk Eye study are 2 large cross-sectional studies, with sizeable male cohorts, which reported on the association between visual acuity and falls. (173, 174) Ivers et al. showed that poor visual acuity, impaired contrast sensitivity and impaired visual field were all associated with increased risk of recurrent falls. (173) Yip et al. in 2014, did show that measured rather than reported impaired visual acuity was associated with a modest 24% increased risk of one or more falls in the previous 12 months, after adjustment for a range of confounders including polypharmacy, grip strength and physical activity. (174) Neither of these studies looked at whether there were any gender differences in the association between measures of vision and falls. In prospective cohort studies, Nevitt et al. and Lord et al. have both reported associations between visual impairment and falls, but with cohorts with small proportions of male subjects. (175, 176) Only 59 men (18% of the cohort) were included in the study by Nevitt et al., which found that impaired visual acuity was associated with 3 or more falls in the multivariate analysis. Lord et al. in 2001, showed an association between poor vision and falls in a mixed cohort study of 156 community living men (n = 57) and women (n = 99). (176) Poor vision as determined by visual acuity and other parameters, such as contrast sensitivity, depth perception and stereopsis, and all were significantly associated with increased risk of multiple falls when adjusted for age only. Our study found no association between contrast sensitivity and stereopsis and risk of falls in the analysis including only physical parameters. The effect of these measures of vision may be masked by the strength of association with visual acuity, which was significantly associated with falls even in the fully adjusted model. Perhaps only tests of visual acuity are required to assess risk in community dwelling older men, when considering falls prevention interventions.

In our study, factors associated with decreased risk of falls included current alcohol use and being born in a non-English speaking country. In the analysis of the MrOS study, Cawthon et al. also reported a reduction in the risk of recurrent falls with light alcohol intake (RR 0.77; 95% CI 0.65 – 0.92). (53) It is possible that this is association is more complex than drinker versus non-drinker, as is reported here. The study participants ranged in their reported country of birth, including from non-English-speaking countries whose use of alcohol is more modest. There may also be a link with social satisfaction and reduced access to alcohol. Low social satisfaction, based on the Dukes social satisfaction scale, was also associated with increased risk of falling in analyses where prior history of falls was included. Fairhall et al. also reported in this cohort, a progressive reduction in participation in life activities, that is work and leisure activities, over the same 2-year period. (177) This reduction in participation was also linked with baseline characteristics, which have also linked to increased risk of fall: increasing age, cognitive impairment and dementia, muscle weakness, slowed gait speed and functional impairment. Therefore, reduced social satisfaction may be a proxy for physical and functional decline and their association with social isolation and falls.

With regards to the finding that country of birth was associated with reduced falls risk, Stanaway et al. have previously reported that the risk for falls is lower in Italian men compared to Australian born men in the CHAMP cohort. (178) In this study we extended the analyses to the entire cohort. We compared those who were born in an English-speaking country or Australia with those who were not. It is likely that the association with country of birth is driven by the Italian sub-group, who make up the largest group not born in Australia or an English-speaking country, such as the United Kingdom. Chu et al. have previously postulated that there is variation in falls risks between countries. They have reported a reduced falls incident rate in a cohort study of a Chinese population of older people in Hong Kong, compared to rates reported in the U.S.A. (16)It is

There are inherent limitations in our cohort study recruiting from the community with a recruitment rate of 47%. This raises the question of the representativeness of the men included in the cohort. However, as previously reported by the CHAMP investigators, the recruitment rate is comparable to other community based studies. (156) In addition, the baseline characteristics of the CHAMP cohort in terms of medical conditions, and specifically the rates of cardiovascular disease, were similar to that reported in the MATeS study published in 2005. (179) This was an Australian national telephone survey of nearly 6000 men with 915 men aged 70 years and older, with a 78% participation rate. The MATeS study reported that in the men aged 70 years and older, the prevalence of stroke was 11% (CHAMP cohort 9%), diabetes 13% (CHAMP cohort 18%) and hypertension 47% (CHAMP cohort 46%). In terms of self-rated health, in the MATeS study men aged 70 years and older 73% rated their health as good or excellent and in the CHAMP men the prevalence of good or excellent self-rated health was 70%. These findings suggest that the men in the CHAMP study are a representative sample of a group of community dwelling, older Australian men. This also infers that the risk factors for falls can only be applied to “relatively healthy” community dwelling older men, as men living in residential care were not included in the CHAMP study. An additional limitation of this study is how fall events were ascertained. By only collecting data on fall events using 4 monthly phone calls, this introduces the possibility of recall bias. The “gold standard” approach would be to have monthly returns of falls calendars or diaries (1).

The comprehensive baseline and follow-up assessments are both strengths of this study. The clinic-based assessment provides a range of physiological measures of vision, strength and balance to allow comprehensive assessment of falls risk factors. In addition, the assessment of cognition that includes assessment by a trained specialist with neuropsychological testing if necessary, and a diagnosis reached by consensus, provide a measure of certainty to the assessment of cognition. We were therefore able to look at not only the association between dementia and falls, but also mild cognitive impairment and falls. Most prospective studies used crude measures of cognition such as MMSE or similar cognitive screens to account for cognition in their analyses of risk factors for falls.

4.5 Conclusion

This is the largest study to provide an analysis of risk factors for falls in a representative sample of community dwelling older men. A history of falls in the past year remains the strongest predictor of future falls in older men living in the community. Age ≥ 80 years, along with impairments in vision, cognition and function were found to increase the risk of further falls by over 50%. When a history of falls is included in the analysis, the effects of other measures of frailty lose their significance. Being born in a non-English speaking country was found to be associated with lower risk of falls and the reasons for this warrant further investigation. The risk factors associated with falls in this cohort of older men are similar to those reported in other male only cohorts and studies with predominantly female or all female cohorts. This study does raise the question of whether specific measures of strength, balance and mobility are needed to assess the risk of future falls or whether a simpler approach would suffice by asking about previous falls, medication use and function, assessing for the presence of dementia and measuring visual acuity. Our study suggest that the one important measure of strength and balance is the chair stand test, which is inexpensive and less resource intensive than other physiological tests of strength and balance.

Chapter 5: Risk factors for hospitalisations due to falls injury in community dwelling older men – The Concord Health and Ageing in Men Project (CHAMP)

5.1 Introduction

As has been stated earlier in this thesis, accidental falls account for a large proportion of Emergency Department (E.D.) attendances in people aged 65 years and older. There is also evidence that rates of hospitalisation for fall related injuries are increasing and this is true for both males and females. (37) Females are reported to be at greater risk of falls and fractures, but population based data also reports an increased rate of traumatic brain injuries due to falls in men. (12, 37) Chapter 3 examined the risk factors associated with re-presentation to the E.D. with a fall in a cohort of people aged 65 years and older who had previously attended the E.D. with a fall. The study utilised the information that had been recorded as part of the clinical encounter rather than specific fall risk factors collected by trained researchers. Therefore, some pertinent information on falls risk factors was not available or inaccurate.

Bradley has examined the trend in falls injury hospitalisations between 1999-2000 and 2010-11 in Australia (see section 1.4.3). (37) In the study period the age standardised rates of falls injury hospitalisations increased by 2.3% per year (95% CI 2.0-2.6), with the rate of increase greater in men than women (3.3% vs 2.1% increase respectively). This increase in rate of injury accounts for an estimated 25,000 extra falls injury hospitalisations in those 65 years and older in 2010-11, than if the age standardised rates remained unchanged. The author of this study described a methodology for identifying falls injury hospitalisations that could be replicated in a cohort study such as CHAMP, where there was linkage to hospital admissions data. This linked data could be used to determine the fall risk factors that are associated with fall injury hospitalisations. There is a lot of interest in how to prevent fall injury hospitalisations and to do this it is important to understand these risk factors. In particular we were interested in examining the differences in the risk factors for hospitalisations due to falls injury and E.D. attendances due to falls with or without injury (chapter 2) or falls that do not necessarily result in injury or hospitalisation (chapter 4).

The Concord Health and Ageing in Men Project (CHAMP) has been described in chapter 4. This prospective study on a community-dwelling cohort of men aged 70 years and older collected baseline information on risk factors for falls. It was possible for us to link the CHAMP data to data on acute hospital admissions. The aim of this study was to examine the risk factors that are associated with hospitalisations due to fall injury.

5.2 Methods

The cohort for this study are men recruited to the Concord Health and Ageing in Men Project a prospective cohort study designed to examine the health of older men living in the community. The methodology and baseline characteristics of the participants, have been reported previously (156) and discussed in chapter 4. Two methods were used to determine the outcome of hospitalisations in CHAMP: 4 monthly phone calls to participants and linkage to data on hospital admissions collected by the New South Wales (NSW) Health department. For the purposes of this study the linked data was analysed as a more robust method of determining hospitalisations linked to specific disease codes and is outlined below.

<u>Data linkage with NSW Health Admitted Patient Data Collection</u>

The NSW Admitted Patient Data Collection (APDC) records all inpatient separations (discharges, transfers and deaths) from all public, private, psychiatric and repatriation hospitals in NSW, including public multi-purpose services, private day procedure centres and public nursing homes. Clinical information is coded for each separation according to the

International Classification of Diseases 10th revision Australian Modification (ICD-10-AM). For each separation the principal cause of hospitalisation is allocated to a diagnosis group and is allocated a diagnosis code based on the principle diagnosis. An additional variable, the external cause category, is recorded where an external cause is present, such as injury, accident or poisoning.

Data linkage was requested from the Centre for Health Record Linkage (CHeReL), a dedicated data linkage unit managed by the NSW Ministry of Health, to link CHAMP participants with the NSW Admitted Patient Data Collection (APDC) to obtain information for each participant on hospitalisations and principal and secondary diagnoses. For the purposes of this study, only fall injury hospitalisations were selected. Using the methodology described by Bradley et al. (37), fall injury cases were defined using the following criteria:

- the principal diagnosis was in the range S00-T75 or T79, which accounts for injuries due to an external cause.
- the first reported external cause code was in the range W00-W19 Falls – falls due to slips, trip and other accidental causes but not including assault, falls from animals, vehicles, machinery or self-inflicted.
- the mode of admission was not a transfer from another hospital.

The principal diagnosis is the condition primarily responsible for requiring admitted patient care. We examined data on first fall injury hospitalisations from the date of enrolment of each subject until death or 30th June 2014. CHAMP data collection commenced in 2005.

Statistical analysis

Initial data analysis examined the relationship between the baseline characteristics of the participants and fall injury hospitalisation. A Kaplan-Meier curve was produced with Logrank test for trend to determine if there was an association between a history of falls in the past 12 months and time to first fall injury hospitalisation. Univariate analysis using Cox proportional hazards regression was performed to examine the relationship between the risk factors variables and first fall injury hospitalisation in those who had valid outcome data. Multivariate Cox regression was then undertaken including variables with p value less than 0.2 in the univariate analysis. Continuous variables such as age, BMI and education in years were dichotomised when preliminary analysis revealed a non-linear relationship as in chapter 4. Backward stepwise elimination was used to eliminate non-significant variables. Two multivariate analyses were performed with model 1 adjusted analysis including all variables except a history of falls in the preceding 12 months and model 2 a fully adjusted analysis including this variable. As in the analysis in chapter 4 it was hypothesised that prior falls history would have a strong association with the risk of fall injury hospitalisation and may mask the effect of other variables. The analyses outlined were then repeated censoring data at 2 years to examine the relationship between the risk factors and fall injury hospitalisations in the first 2 years of follow-up. This analysis was to account for any change to the falls risk profile which may have occurred in the intervening years, and to allow for comparison with other prospective cohort studies.

Data analysis was performed using SAS version 9.3 (SAS Institute, Inc., Cary, NC, USA).

5.3 Results

Data on falls related injury hospitalisations were examined for 1,690 men from the original 1,706 cohort. Over the entire follow-up period, 284 men were hospitalised due to a fall related injury. The mean duration of follow-up was 2,543 days for men who were not hospitalised and 1,680 days for men who were hospitalised.

Table 5.1 details the distribution of baseline characteristics between men who were hospitalised due to a fall injury and those who were not. A significantly greater number of men were hospitalised due to a fall injury if they were aged 80 years and older or had a disability in at least one activities of daily living (ADL). There were also an increased proportion of men who reported low satisfaction with community support, based on Duke social satisfaction score, who had a fall injury hospitalisation. Fewer men who were in employment experienced a fall injury hospitalisation. Significantly fewer men who were born in a non-English speaking country had a fall injury hospitalisation when compared with men born in Australia, or the U.K. or Ireland. Men who drank any alcohol were less likely to be hospitalised due to a fall injury compared with men who were non-drinkers. In terms of comorbidities and specific medical illnesses, the following characteristics were significantly associated with fall injury hospitalisations: having more than 3 comorbidities, depression based on a score greater than 5 on the Geriatric Depression Scale (GDS), and impaired cognitive function. Men who reported low physical activity based on the Physical Activity Score in the Elderly (PASE) were more likely to be hospitalised with a fall injury hospitalisation. A greater proportion of men using more than 4 medications (polypharmacy) and those taking psychotropic medications had a fall injury hospitalisation.

Table 5.1: Comparison of the baseline characteristics of men in the CHAMP study by fall injury hospitalisation

Variable		Fall injury hospital admission N = 284 *N (%)*	No fall injury hospital admission N = 1406 *N (%)*	P value
Age (years)	<80 years	160(56.3)	1045 (74.3)	<0.0001
	>=80 years	124 (43.7)	361 (25.7)	
Marital status	Living with a partner	200 (70.4)	1097 (78.0)	0.006
	Single	84 (29.6)	309 (22.0)	
Accommodation	Owner occupier	252 (88.7)	1256 (89.3)	0.75
	Rental	23 (8.1)	98 (7.0)	
	Other	5 (1.8)	30 (2.1)	
Employment	No	274 (96.5)	1273 (90.5)	0.0003
	Yes	8 (2.8)	120 (8.5)	
Income	Aged pension	109 (38.4)	556 (39.5)	0.16
	Part Aged Pension	55 (19.4)	211 (15.0)	
	Self-funded	115 (40.5)	619 (44.0)	
Years of education	1-14 years	166 (58.5)	863 (61.4)	0.37
	>14 years	111 (39.1)	512 (36.4)	
Country of birth	Australian or English language countries	198 (69.7)	740 (52.6)	<0.0001
	Non-English-speaking countries	86 (30.3)	666 (47.4)	
Smoking	Non-smoker	112 (39.4)	545 (38.8)	0.39
	Ex-smoker	160 (56.3)	772 (54.9)	
	Current smoker	12 (4.2)	89 (6.3)	
Alcohol intake	Non-drinker	78 (27.5)	343 (24.4)	0.20
	Drinker	203(71.5)	1061 (75.5)	
ADL Disability	No	250 (88.0)	1304 (92.7)	0.005
	Yes	34 (12.0)	99 (7.0)	
Duke satisfaction score	High satisfaction >=19	200 (70.4)	1086 (77.2)	0.006
	Low satisfaction <19	82 (28.9)	299 (21.3)	
Number of comorbidities	<=3	197 (69.4)	1085 (77.2)	0.003
	>3	85 (29.9)	306 (21.8)	
Dizziness	No	197 (69.4)	1020 (72.5)	0.31
	Yes	82 (28.9)	366 (26.0)	
Depression	No	224 (78.9)	1206 (85.8)	0.001
	Yes	57 (20.1)	180 (12.8)	
Cognitive function	Normal	232 (81.7)	1251 (89.0)	<0.0001
	MCI	21 (7.4)	97 (6.9)	
	Dementia	31 (10.9)	58 (4.1)	

ADL – Activities of daily living; MCI – mild cognitive impairment; BMI – body mass index; PASE – physical activity score in the elderly;
Some percentages may not equal 100% due to rounding and missing data.

Table 5.1: Comparison of the baseline characteristics of men in the CHAMP study by hospitalisation due to falls injury. (Continued)

Variable		Fall injury hospital admission N = 284 *N (%)*	No fall injury hospital admission N = 1406 *N (%)*	P value
Urinary continence	Continent	236 (83.1)	1185 (84.3)	0.40
	Incontinent	45 (15.8)	194 (13.8)	
BMI	<=24.9 kg/m²	74 (26.1)	321 (22.8)	0.24
	>24.9 kg/m²	203 (71.5)	1051 (74.8)	
PASE	>=85	191 (67.3)	1034 (73.5)	0.02
	<85	91 (32.0)	355 (25.2)	
Self-rated health	Very good / good	186 (65.5)	985 (70.1)	0.13
	Poor / very poor	94 (33.1)	402 (28.6)	
Polypharmacy	≤4 medications	147 (51.8)	906 (64.4)	<0.0001
	>4 medications	135 (47.5)	493 (35.1)	
Psychotropic medications	No	249 (87.7)	1304 (92.7)	0.004
	Yes	35 (12.3)	102 (7.3)	
Visual acuity	Good vision (20/40 or better)	211 (74.3)	1135 (80.7)	0.002
	Poor vision / unable to test	65 (22.9)	211 (15.0)	
Contrast sensitivity	Good	136 (47.9)	888 (63.2)	<0.0001
	Poor / unable to test	140 (49.3)	457 (32.5)	
Stereopsis	Good	180 (63.4)	1028 (73.1)	0.001
	Poor / unable to test	104 (36.6)	104 (7.4)	
Walking speed	Fast	181 (63.7)	1114 (79.2)	<0.0001
	Slow	86 (30.3)	237 (16.9)	
Narrow walking speed	Fast	104 (36.6)	848 (60.3)	<0.0001
	Slow	52 (18.3)	190 (13.5)	
Chair stand test	Good performance	248 (87.3)	1307 (93.0)	0.0005
	Unable to perform	36 (12.7)	93 (6.6)	
Floor sway test	Good performance	269 (94.7)	1342 (95.4)	0.49
	Unable to perform	15 (5.3)	61 (4.3)	
Foam sway test	Good performance	236 (83.1)	1260 (89.6)	0.002
	Unable to perform	47 (16.5)	143 (10.2)	
Racetrack test	Good performance	254 (89.4)	1281 (91.1)	0.33
	Unable to perform	30 (10.6)	123 (8.7)	
Grip strength	Good	165 (58.1)	1025 (72.9)	<0.0001
	Poor	87 (30.6)	244 (17.4)	

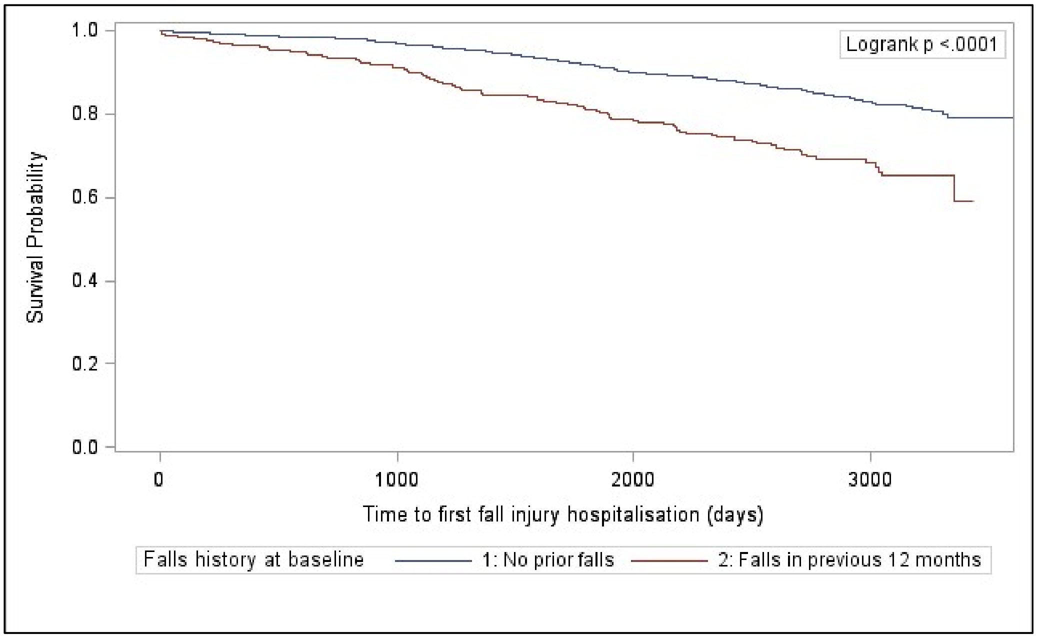
ADL – Activities of daily living; MCI – mild cognitive impairment; BMI – body mass index; PASE – physical activity score in the elderly;
Some percentages may not equal 100% due to rounding and missing data.

Poor performances in all measures of vision were significantly associated with fall injury hospitalisations. Some physical measures of gait, balance and strength were also associated with fall injury hospitalisation, specifically slow walking speed and slow narrow walking speed, and poor performances on the chair stand and foam sway tests. As discussed in chapter 4, 496 men had missing data for a timed narrow walking speed, with a greater proportion of those men in the hospitalised group (128 [45.1%] men fall injury hospitalised group vs 368 [26.1%] men non-hospitalised group).

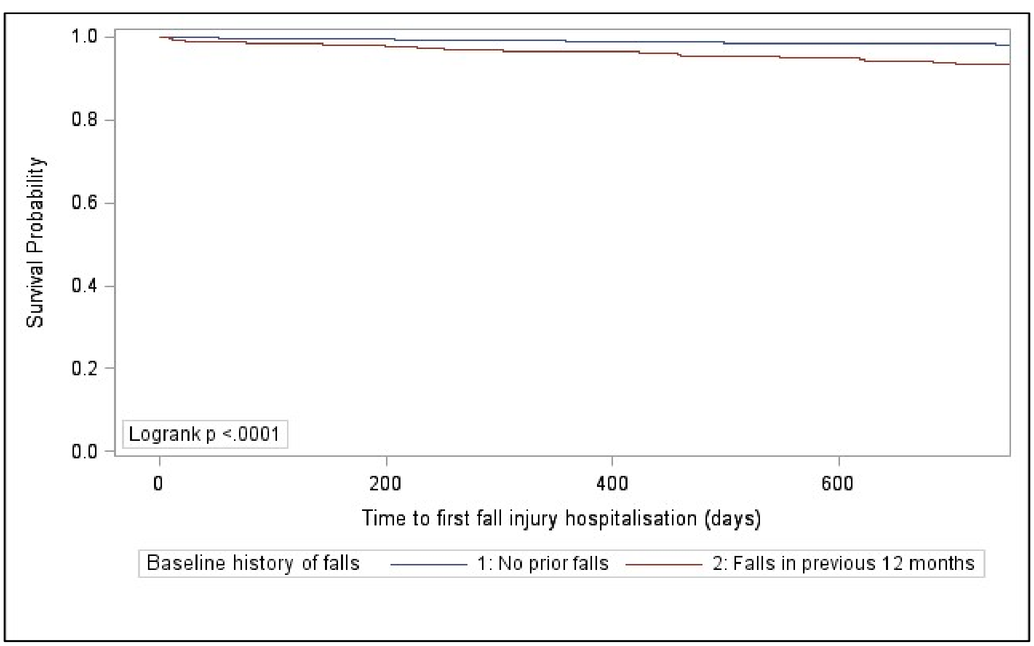
Figures 5.1 (a) and (b) show the Kaplan Meier curves for time to fall injury hospitalisation, with (a) showing the entire follow-up period and (b) showing the first 2 years of follow-up. Men who reported falls in the 12 months prior to baseline assessment were at significantly increased risk of being hospitalised due to a fall injury over more than 9 years of follow-up (see Figure 5.1(a)). Of the 284 first fall-injury hospitalisations in the entire follow-up period, 45 (14.6%) first fall-injury hospitalisations occurred in the first 2 years. When the follow-up period was reduced to 2 years, there remained a significant association between history of falls and fall injury hospitalisation (see Figure 5.1 (b)).

Figure 5.1: Kaplan-Meier curve of time to first fall injury hospitalisation stratified for falls history in the 12 months prior to baseline assessment at 10 and 2 years.

(a) 10 years.



(b) 2 years



The results of the univariate cox regression analysis are shown in Table 5.2. Being aged 80 years and older, having a disability in activities of daily living and prior falls history all significantly increased the risk of fall injury hospitalisation. Being single and a low score on the Duke social satisfaction score were associated with a more modest increased risk of fall injury hospitalisation. Additional medical factors such as more than 3 comorbidities, depression, dementia, and poor or very poor self-rated health, also significantly increased the risk of fall injury hospitalisation. Polypharmacy defined by taking more than 4 medications (HR 1.81; 95% C.I. 1.43 – 2.29) and the use of psychotropic agents (HR 1.84; 95% C.I.1.29 – 2.62) increased the risk of hospitalisation due to falls injury. Men who reported low physical activity based on the Physical Activity Scale in the Elderly (PASE) were also at increased risk of hospitalisation due to a fall injury. In terms of physical measures, only poor performance on the floor-sway test of static balance and racetrack test of dynamic balance did not show an increased risk of hospitalisation due to fall injury. All visual measures, tests of walking speed, the remaining tests of balance and grip strength were all significantly associated with increased fall injury hospitalisation. Men who were still employed at the baseline assessment were significantly less likely to have a fall injury hospitalisation (HR 0.31; 95% C.I. 0.15 – 0.62). Being born in a non-English speaking country was also associated with reduced the risk of fall injury hospitalisation (HR 0.49; 95% C.I. 0.38 – 0.64).

Table 5.2: Univariate analysis of risk factors for fall injury hospitalisations in the CHAMP cohort

Variable		Fall injury hospitalisation Hazards Ratio (HR) (95% CI)	P value
Age (years)	≥80 years	2.60 (2.06 – 3.30)	<0.0001
Marital status	Single	1.60 (1.24 – 2.06)	0.0005
Accommodation	Owner occupier	1.0	
	Rental	1.22 (0.80 – 1.88)	0.66
	Other	0.95 (0.39 – 2.30)	
Employment	Yes	0.31 (0.15 – 0.62)	<0.0001
Income	Aged pension	1.0	
	Part Aged Pension	1.28 (0.93 – 1.77)	0.10
	Self-funded	0.89 (0.68 – 1.16)	
Years of education	0-14 years	1.19 (0.93 – 1.51)	0.16
Country of birth	Non-English-speaking countries	0.49 (0.38 – 0.64)	<0.0001
Smoking	Non-smoker	1.0	
	Ex-smoker	1.03 (0.81 – 1.31)	0.51
	Current smoker	0.74 (0.41 – 1.34)	
Alcohol intake	Current drinker	0.83 (0.64)	0.18
ADL Disability	Yes	2.10 (1.47 – 3.01)	0.0002
Duke satisfaction score	Low satisfaction <19	1.53 (1.18 – 1.98)	0.002
History of falls	Yes	2.22 (1.72 – 2.87)	<0.0001
Number of comorbidities	>3	1.64 (1.27 – 2.11)	0.002
Dizziness	Yes	1.17 (0.91 – 1.51)	0.24
Depression	Yes	1.91 (1.43 – 2.56)	<0.0001
Cognitive function	Normal	1.0	
	MCI	1.24 (0.79 – 1.93)	<0.0001
	Dementia	3.34 (2.29 – 4.86)	
Urinary incontinence	Incontinent	1.23 (0.89 – 1.69)	0.22
BMI	≤24.9 kg/m²	1.21 (0.93 – 1.58)	0.17
PASE score	< 85	1.55 (1.21 – 1.99)	0.001
Self-rated health	Poor / very poor	1.31 (1.02 – 1.68)	0.04
Polypharmacy	>4 medications	1.81 (1.43 – 2.29)	<0.0001
Psychotropic medications	Yes	1.84 (1.29 – 2.62)	0.002

ADL – activities of daily living; MCI – mild cognitive impairment; BMI – body mass index; PASE – physical activity score in the elderly;

Table 5.2: Univariate analysis of risk factors for fall injury hospitalisations in the CHAMP cohort (Continued)

Variable		**Fall injury hospitalisation Hazards Ratio (HR) (95% CI)**	**P value**
Visual acuity	Poor vision / unable to test	1.71 (1.30 – 2.26)	0.003
Contrast sensitivity	Poor / unable to test	2.09 (1.65 – 2.65)	<0.0001
Stereopsis	Poor / unable to test	1.73 (1.35 – 2.20)	<0.0001
Walking speed	Slow	2.44 (1.89 – 3.16	<0.0001
Narrow walking speed	Slow	2.26 (1.62 – 3.16)	<0.0001
Chair stand test	Slow / unable to perform	2.44 (1.72 – 3.47)	<0.0001
Floor sway test	Poor / unable to perform	1.50 (0.89 – 2.52)	0.15
Foam sway test	Poor / unable to perform	2.17 (1.58 – 2.97)	<0.0001
Racetrack test	Poor / unable to perform	1.46 (1.00 – 2.14)	0.61
Grip strength	Poor	2.31 (1.78 – 2.99)	<0.0001

ADL – activities of daily living; MCI – mild cognitive impairment; BMI – body mass index; PASE – physical activity score in the elderly;

Multivariate cox proportional hazards regression was performed using 2 models for the 10-year follow-up data and 2-year follow-up data: model 1 excluded the variable history of falls in the past 12 months, and model 2 included the fall history variable. It was hypothesised that fall history may mask the effect of other variables. Table 5.3 shows the results of the multivariate analyses.

Data for the 10-year period was felt to be the most complete data, given that fewer fall injury hospitalisations occurred in the first 2 years of follow-up, and will be discussed first. Examining the regression analysis for the 10-year follow-up period, in model 1 age 80 years and older, dementia, the use of more than 4 medications, slow walking speed and poor grip strength all increased the risk of fall injury hospitalisation. The greatest magnitude of association with hospitalisation due to falls injury was for dementia (HR 2.72; 95% C.I.1.72 – 4.30). Being employed and being born in a non-English speaking country were both protective against having a hospitalisation due to a fall injury. The addition of history of falls did not alter the factors that were associated with hospitalisation due to falls or change the strength of these associations significantly. A history of falls in the previous 12 months was associated with increased risk of fall injury hospitalisation (HR 1.48; 95% C.I. 1.09 – 1.99). Men who were born in a non-English speaking country and men who were still employed at the time of the baseline assessment were at reduced risk of being hospitalised due to a fall injury.

Analyses were also performed including only the physical parameters and age, with and without history of falls, to establish the association between physical parameters and falls that may have been suppressed by the effect of other demographic or medical factors (data not in Tables). Slow narrow walking speed (HR 1.80; 95% C.I. 1.24 – 2.62) and poor grip strength (HR 1.73; 95% C.I. 1.18 – 2.54) were both significantly associated with increased risk of hospitalisation due to a fall injury. There was only a modest change in the magnitude of the association with the addition of fall history in the model – slow narrow walking speed HR 1.68 (95% C.I. 1.15 – 2.45) and poor grip strength HR 1.79 (95% C.I.1.22 – 2.63). However, with a large number of men with missing data for narrow walking speed, the effect of this variable should be viewed with caution.

The analyses described above were repeated for the follow-up period of 2 years and is shown in Table 5.3. Inclusion of falls history in the model did not have a significant effect on the magnitude of risk of fall injury hospitalisation in the variables retained in the model. Dementia was associated with a 2-fold increase in the risk of fall injury hospitalisation compared to normal cognition (Model 2 HR 2.04; 95% C.I. 1.36 – 3.06). Mild cognitive impairment was not significantly associated with increased risk of fall injury hospitalisation (HR 1.05; 95% C.I.0.64 – 1.70). Age 80 years and older, the use of more than 4 medications and poor grip strength were also associated with increased risk of fall injury hospitalisation. As seen in the analysis of the 10-year outcome data, being born in a non-English speaking country was protective against fall injury hospitalisation (HR 0.58; 95% C.I.0.44 – 0.77). In analyses which examined the effect of physical measures on fall injury hospitalisations (data not in Tables), slow narrow walking speed (HR 1.56; 95% C.I. .07 – 2.27) and poor grip strength (HR 1.04; 95% C.I. 1.04 – 2.23) were again associated with increased risk of hospitalisation when adjusted for age and fall history,

Table 5.3: Multivariate logistic regression for factors associated with hospitalisation due to falls injury by 2-year and 10-year follow-up periods

Variable		2-year Year follow-up period				10-year follow-up period			
		Multivariate analysis Adjusted Hazards Ratio (HR) (95% CI) Model 1	P value	Multivariate analysis Adjusted Hazards Ratio (HR) (95% CI) Model 2	P value	Multivariate analysis Adjusted Hazards Ratio (HR) (95% CI) Model 1	P value	Multivariate analysis Adjusted Hazards Ratio (HR) (95% CI) Model 2	P value
Age (years)	≥ 80 years	1.46 (1.12 – 1.90)	0.005	1.43 (1.10 – 1.87)	0.008	1.67 (1.25 – 2.24)	0.0005	1.63 (1.22 – 2.19)	0.001
Employment	Yes	…	…	…	…	0.40 (0.20 – 0.82)	0.01	0.42 (0.21 – 0.85)	0.02
Country of birth	Non-English-Speaking Country	0.57 (0.43 – 0.75)	<0.0001	0.58 (0.44 – 0.77)	0.0001	0.43 (0.32 – 0.58)	<0.0001	0.45 (0.34 – 0.61)	<0.0001
Cognitive function	Normal	1.0	0.001	1.0	0.003	1.0	0.0001	1.0	0.0001
	MCI	1.06 (0.65 – 1.72)		1.05 (0.64 – 1.70)		1.26 (0.76 – 2.10)		1.28 (0.77 – 2.13)	
	Dementia	2.11 (1.41 – 3.17)		2.04 (1.36 – 3.06)		2.72 (1.72 – 4.30)		2.67 (1.69 – 4.22)	
History of falls	Yes	…	…	1.31 (0.98 – 1.74)	0.07	…	…	1.48 (1.09 – 1.99)	0.01
Polypharmacy	>4 medications	1.38 (1.07 – 1.77)	0.01	1.35 (1.05 – 1.74)	0.02	1.70 (1.31 – 2.21)	<0.0001	1.66 (1.28 – 2.16)	0.0001
Walking speed	Slow	…	…	…	…	1.64 (1.21 – 2.23)	0.001	1.59 (1.18 – 2.16)	0.003
Grip strength	Poor	1.52 (1.17 – 1.99)	0.002	1.47 (1.12 – 1.93)	0.005	1.70 (1.27 – 2.27)	0.0003	1.66 (1.24 – 2.22)	0.0006

Model 1: adjusted for all variables excluding history of falls

Model 2: adjusted for age all variables

5.4 Discussion

In this prospective cohort study of community dwelling older men, the risk predictors of fall injury hospitalisation over 10 years and 2 years of follow-up were determined. Dementia was associated with a more than 2-fold increased risk of being hospitalised due to a fall injury at 10 years and 2 years of follow-up, when adjusted for age and history of falls in the previous 12 months. Men who were aged 80 years or older were also at greater risk of being hospitalised due to a fall injury and the association was maintained over the two time periods. Polypharmacy, defined as using more than 4 medications, and poor grip strength were also associated with increased risk of hospitalisation due to a fall injury, but slow walking speed was only significantly associated with increased risk when men were followed out to 10 years. Men from a non-English speaking country of birth were at a significantly reduced risk of being admitted with a fall injury and men who were still working at the time of their baseline assessment were also at reduced risk of being hospitalised with a fall injury when followed out to 10 years. Some of the factors significantly associated with falls injury hospitalisations are the same factors that were shown to be associated with self-reported falls in the same cohort (chapter 4) - age >80, dementia and history of falls. Birth in a non-English-speaking country was protective in both analyses. There was a more definite association between polypharmacy and falls injury hospitalisations than was shown for self-report of falls regardless of injury. Since there is some overlap in what is being measured between factors such as ADL disability, number of comorbidities, walking speed, grip strength and visual acuity it is not surprisingly that there are differences in which of these factors are included in the final multivariate models depending on which outcome is the dependent variable.

We think it is an important finding that the factors associated with falls injury related hospitalisations at 2 years were still associated with this outcome at 10 years. We hypothesised that the strength of association between risk factors for fall injury hospitalisation at 2 years would have weakened at 10 years, or that the risk factor profile would have changed between the two time periods. We are not aware of any other cohort study on risk factors for falls that has reported on a prolonged follow-up period such as our 10-year follow-up.

There is limited cohort study data examining risk factors for fall hospitalisations with or without associated injury. Only one previous prospective study has reported on the risk of fall injury hospitalisation in a cohort of older people living in the community. (147) As part of the Cardiovascular Health Study in the United States, 702 older people of a study cohort of 5,356, had an injurious fall between the period of 1990 and 2005. This was a mixed gender cohort (male n = 2260 (42.2%)) and women were significantly more likely to be hospitalised due to a fall injury than men. Dementia was significantly associated with increased risk of fall injury hospitalisation as demonstrated by poor performance on the Digit Symbol Substitution Test (DSST) at baseline, and the association was maintained in a model fully adjusted for age, comorbidities, medication use and measures of physical function (HR 1.91; 95% C.I. 1.44 – 2.53). A regression analysis was repeated and examined the effect of change in DSST score and 3MS (Modified Mini-Mental State Examination) over the follow-up period. In the fully adjusted model, the lowest quartile DSST score was associated with a 2.9-fold increased risk of a fall injury hospitalisation (HR 2.90; 95% 2.08 – 4.03), but all scores below the top 25% were associated with an increased risk of a serious injurious fall. Older people with cognitive impairment, as determined by a 3MS score of less than 80, had a 2-fold increase in the risk of fall injury hospitalisation only when coronary heart disease was not prevalent at baseline (HR 2.16; 95% C.I. 1.60 – 2.91). This supports the findings in our study of a 2-fold increased risk of fall injury hospitalisation in men with a diagnosis of dementia at baseline (HR 2.67; 95% C.I.1.69 – 4.22). The association between serious fall injury requiring E.D. treatment or hospital admission is also reported in a cross-sectional study which reported that 26% of fallers attending the E.D. had cognitive impairment. (66) It is also worth noting that dementia has been shown to be associated with hip fractures associated with falls. (180, 181)

In chapter 4, we did not find a consistent association between polypharmacy and falls in the CHAMP cohort. The analyses shown in this chapter, however, found that there was a significant association between polypharmacy and fall injury hospitalisation in the same cohort, with an increased risk over 2 years and 10 years of follow-up. This finding is the first large prospective study to show a definite association between polypharmacy and a falls related outcome in men. Tromp et al. have found that polypharmacy was associated with an increased risk of any fall in a mixed gender cohort, but there was no significant association with recurrent falls or fractures. (182) A previous prospective cohort study in New Zealand found no association between polypharmacy and falls in the subgroup of men in the study, but did demonstrate a significant association in females in the same study. (39) The authors of this study hypothesised that this may be due to a smaller sample of men in the cohort. Polypharmacy has been shown to be associated with increased risk of unplanned hospitalisation. A retrospective Scottish study linking data on prescriptions with admitted patient data, found a 25% increased risk of hospitalisation with the use of between 4 and 6 medications (OR 1.25; 95% CI 1.11 – 1.42). (183) A three-fold increased risk was seen with the use of 10 or more medications (OR 3.42; 95% CI 2.72 – 4.28) in patients with a low disease burden (that is one medical condition). In those who had an increased disease burden the risk associated with increased drug use was attenuated, with the use of 10 or more medications associated with 1.5 times increased risk of unplanned hospitalisation. There is more limited data regarding the risk predictors for fall injury hospitalisations. Tiedemann et al. also identified the use of 6 or more medications as a risk predictor for further falls in the validation of a falls risk predictive tool to be used in the Emergency Department (E.D.), but this was based on data from an E.D. cohort of men and women. (71) This risk predictor tool was not designed to establish risk for fall injury hospitalisation, but the majority of falls experienced by the cohort in the follow-up period where injurious. Our study does suggest that screening for polypharmacy in older men and targeting interventions to review multiple drug prescriptions may reduce the risk of fall injury hospitalisation.

Slow walking speed was shown to increase the risk of fall injury hospitalisation in our cohort when followed for more than 10 years. The study by Welmerink et al. did not find a significant association between gait speed and fall injury hospitalisation. (147) Longer time to complete five chair stands was the only physical parameter associated with increased risk of hospitalisation due to a fall injury in this cohort, but was not significantly associated in our study. The Healthy, Aging and Body Composition prospective study examined the association between various physical parameters and health outcomes in a mixed gender cohort. (184) Slow walking speed was associated with increased risk of death (RR 1.64; 95% C.I. 1.14 – 2.37) and hospitalisation (RR 1.48; 95% C.I. 1.02 – 2.13) when adjusted for age, sex and other comorbidities and measures of frailty. A Finnish community based cohort found that gait impairment was associated with major injury due to a fall (OR 2.8; 95% CI 0.87 – 8.78) and any fall injury (OR 3.5; 95% CI 1.40 – 8.77). (63) Slow walking speed is also an important feature of frailty and is a component of frailty scores. (145) Frailty has been recognised as a risk factor in the development of functional dependence, and increases the risk of hospitalisation and death. Fried et al. described a frailty phenotype including exhaustion, weight loss, low activity, slow walking speed and reduced grip strength. In those who were "frail" the risk of hospitalisation over 3 years of follow-up was increased by 29% compared with those who were not frail (HR 1.29; 95% CI 1.09 – 1.54). The frail group also had a 2.2-fold increase in the risk of death over the 3-year follow-up period (HR 2.24; 95% CI 1.51 – 3.33). The study did not report specifically on whether frailty was associated with hospitalisation due to falls.

Grip strength was also associated with a significant increased risk of fall injury hospitalisation and this was found at 2 years and 10 years of follow-up. This is consistent with the finding from the MrOS International prospective cohort study. (185)
In this study 2,047 of 10,998 men participating in the study reported that they had fallen, with 842 falling more than once in 12 months. When compared with non-fallers, recurrent fallers had significantly lower right-hand grip strength (P<0.0001). Men whose grip strength measured at greater than -2 SD below average had a 2.4-fold increased risk of having recurrent falls (OR 2.4; 95% C.I. 1.7 – 3.4). This suggests that grip strength could be used as a simple and cost-efficient method to assess risk of falls and fall injury hospitalisation.

Consistent with what was found in Chapter 4, men born in a non-English background country were at lower risk of hospitalisations due to falls. The AIHW report on trends in falls injury hospitalisations reported that lower rates of fall injury hospitalisations in Italian born immigrants to Australia compared to Australian born people (186) Stanaway et al. found that Italian born men in the CHAMP cohort were significantly less likely to have a self-reported falls compared to men who were born in Australia. (178) Italian-born men were the largest group of men born in a non-English-speaking country in the CHAMP study (19.6% of men in

CHAMP were born in Italy). Our similar findings in analyses of falls injury hospitalisations, suggest that the earlier finding of less falls in Italian men was a true finding rather than due to recall bias leading to less self –report of falls by Italian born men. However, we must also consider that people born in non-English-speaking countries are less likely to use healthcare in Australia and that this too may influence the rate of falls injury hospitalisations.

Men who were continuing to work when assessed at the baseline assessment were at reduced risk for fall injury hospitalisation when looking at the outcome over 10 years. Employment status is not routinely included in prospective cohort studies and may be a proxy measure of cognition and function. The analyses in our study were repeated with employment replaced by disability in activities of daily living (ADL) variable and perhaps surprisingly no significant association was seen between ADL and fall injury hospitalisation.

There are a number of factors to consider in terms of limitations of our study. In this community sample of men, the number of men who were hospitalised due to a fall related injury was low with 45 men (2.6%) admitted in the first 2 years, increasing to 284 men (16.8%) over 10 years of follow-up. In chapter 4 we showed that 246 men had a single fall in the first 2 years of follow-up and 230 men had 2 or more falls (total falls n = 1511). As we are examining the first fall injury hospitalisation it is possible that these men could experience more than one fall injury hospitalisation in the follow-up period and that we are underestimating the total number of hospitalisations due to fall injury in this cohort. As discussed in section 1.2 community cohort studies with mixed gender cohorts have previously reported between 6% and 11% of falls resulting in major injuries, such as fractures. (13, 19, 26, 175) Using these data, the expected number of major injurious falls would be 90 to 160 in 2 years, which is higher than what we reported. It may be that fewer falls in community living older men result in major injuries that require hospitalisation, or that we are underestimating the rate by only reporting on the time to the first fall hospitalisation.

There are always questions about the representativeness of the men within the cohort in these types of studies. The final cohort constituted 47% of the total eligible population of men, but as we discussed in the previous chapter this is comparable to other studies as has been reported previously. (156) Linked data affords greater certainty that all falls injury hospitalisations have been accounted for and is likely to be more accurate than self-report on falls and falls related injuries. The extensive assessment of baseline characteristics and physical parameters was a strength of the study, as was the assessment of cognition based on rigorous assessment and multidisciplinary consensus approach to diagnosis.

5.5 Conclusion

This prospective study adds some valuable information about the risk predictors for fall injury hospitalisations in older men living in the community. Dementia is a strong predictor of future hospitalisations due to fall injuries. Many falls prevention interventions specifically exclude older people who have more than mild cognitive impairment, therefore specific strategies to prevent falls in older men with dementia deserves specific focus. Fall injuries hospitalisations were associated with polypharmacy, grip strength and waking speed. All of these measures remain significant predictors of fall injury hospitalisation with or without falls history included. These are factors which can be easily assessed in both hospital based clinics and in general practice, so as to target older men appropriately for prevention interventions. The role of ethnicity in the risk of fall injuries and all-cause hospitalisations warrants further investigation.

Chapter 6: Comparison of a specialist-led, hospital based, multifactorial falls prevention intervention versus enhanced General Practice falls prevention – a randomised controlled trial.

6.1 Introduction

Secondary prevention of falls in older people is important and this fact is highlighted by the increasing evidence surrounding interventions designed to prevent further falls. The volume of evidence in this regard has increased over the last 3 decades. (187) There have been 3 editions of the Cochrane systematic review and meta-analysis examining interventions designed to reduce falls in community dwelling older people, and there is a further edition in progress. (80-82) In section 1.7.1.1 we have discussed in more detail the results of the most recent Cochrane meta-analysis in terms of multifactorial interventions. Gillespie et al. in the 2012 meta-analysis demonstrated that multifactorial interventions significantly reduced the rate of falls (RaR 0.76; 95% CI 0.67 – 0.86) but not the number of fallers, and therefore did not reduce the risk of falling (RR 0.93; 95% CI 0.86 – 1.02). (80) One of the key features of the positive trials was that the interventions were organised by specialist services. Intervention such as the alterations to medications, exercise therapy and home hazard assessments were provided directly by the intervention team, and any referrals to other services were organised by the intervention team. Interventions that relied on the General Practitioner or Primary physician to coordinate or make referrals for treatment following the research team's risk assessment have generally been shown in trials to be ineffective. (80, 122) This could be because the General Practitioners and Primary physicians were not given adequate access to the falls prevention interventions that were needed.

Translating the evidence from falls research into everyday clinical practice has been difficult. Hospital based "Falls clinics" has been the way that many health systems have provided falls prevention interventions to people at risk. In the Australian setting, a review of falls clinics in 2001 demonstrated a variety of approaches to staffing, assessment and interventions. (126)

The clinics tended to be resource intensive from a healthcare perspective, and time intensive for both health professionals and patients. Older people at risk of falls were generally required to travel for assessment, and in some cases, for treatment. Many aged care units would not have the resources to sustain a falls service that was this resource intensive. There remains the question about whether a less resource intensive falls clinic using existing aged care services would be effective in prevention of falls or whether interventions could be organised though primary care if the time-consuming aspect of falls risk assessment was done by a specialist nurse, and General Practitioners were given specific advice on which interventions were needed and how to organise them. Both approaches are an acknowledgement of the resource limitations in the "real world" setting even in a relatively well-resourced health system that exists in Australia. Many studies have targeted the population of community dwelling older people who have come into contact with their General Practitioner following a fall or have attended the Emergency Department due to a fall or fall-related problem. We have demonstrated in Chapter 2 that older people attending the Emergency Department following a fall are at risk for further falls related Emergency Department care even up to 5 years following an index fall. This highlights the importance of reducing the risk of further falls and injury in older people in the community.

The aim of this study was to determine the effectiveness of two approaches to providing multifactorial falls prevention intervention in reducing the risk of falls in community dwelling older people. The comparison was between a hospital based, specialist-led service providing and organising interventions to prevent falls compared to an enhanced General Practice intervention, with nurse-led assessment and tailored advice on appropriate interventions with the General Practitioner responsible for the referrals.

6.2 Methods

The Concord Falls and Bone Service study (CONFABS) is a randomised controlled trial of a multifactorial falls prevention intervention. Ethical approval for this study was provided by the Sydney Local Health District Human Research and Ethics Committee of Concord Hospital, and all participants provided their consent. The trial was registered with Australian New Zealand Clinical Trials Registry record number 1261000838011.

Participants

Community-dwelling older people aged 65 years and older, living in four Local Government Areas (LGAs) in inner western Sydney, were eligible for inclusion. The LGAs of Ashfield, Burwood, Canada Bay and Strathfield were targeted as these areas are in the same Local Health District – Sydney Local Health District – and make up the catchment area of Concord Repatriation General Hospital. Older people who were not ordinarily resident in the 4 LGAs described above were ineligible.

Older people were eligible if they were aged 65 years or older, had one or more fall in the preceding 12 months, were living in the community and were independently mobile with or without a mobility aid and would be residing in the area for at least the next 12 months. A prior history of falls was based on self-report, carer report or documentation of attendance at the E.D. with a fall or fall-related problem in the preceding 12 months. All study documents were written in English and therefore only participants who could understand the documents and provide informed consent were eligible for enrolment. There were a number of additional exclusion criteria. People with cognitive impairment based on MMSE score of less than 20 out of 30 were ineligible, as there is doubt as to the effectiveness of falls prevention interventions in older people with dementia. Potential participants with a terminal illness and life expectancy of less than 12 months were also ineligible. Older people with Parkinson's disease were also excluded, as more specific interventions have been trialled in this patient population, and were not available in this intervention. It was important to be able to satisfy ourselves that this multifactorial intervention was responsible for any changes in fall outcomes in this cohort, therefore any potential participant who had a comprehensive Geriatric assessment (CGA) in the previous 12 months was excluded. Since the control arm depended upon the actions of a General Practitioner, any potential participant who had not attended a General Practitioner in the preceding 12 months was ineligible.

<u>Recruitment</u>

Recruitment commenced in October 2010 and was completed in June 2013. Potential participants were first identified from the following sources:

1. *The Emergency Department (E.D.) of Concord Hospital a university teaching hospital of the University of Sydney.*

   Two potential sources for recruitment were used targeting subjects who had attended the E.D. It was anticipated that the majority of subjects would be identified from the E.D.

   (a) The electronic medical record (eMR) and Emergency Department Information System (EDIS) were reviewed daily to identify potentially eligible subjects. The study research nurse would identify potential subjects based on their age, triaged presenting complaint and place of residence to identify all people over the age of 65 years old who may be a potential subject. A range of triage categories were used to identify older people who had fallen in addition to the specific category "falls in the elderly". These categories included specific injuries, syncope, pain in limbs, and head injury. Only older people who were discharged from the E.D. were eligible for inclusion.

(b) Additional potential subjects were directly referred from the E.D. staff, Aged Services in the Emergency Team (ASET) and allied health in the E.D. if they had presented to the E.D. as a direct result of a fall and had been discharged.

2. *The Aged and Chronic Care and Rehabilitation (ACC&R) community referral information centre at Concord Hospital.*

   All referrals to Aged Care and Rehabilitation community teams servicing the 4 previously mentioned LGAs are triaged through the SLHD northern central intake centre. A daily report is produced and this was reviewed on a weekly basis to identify potentially eligible subjects. There was some overlap between those potentially eligible subjects identified in the E.D. and those identified through the ACC&R referral centre as the same person may have attended the E.D. and then had referrals made for follow-up with community care teams. The ACC&R team routinely use the FRAT (Falls Risk Assessment Tool) screening tool to identify older people who are at high risk of falls. (188) Only those who had a history of falls in the previous 12 months were included, even if other items in the FRAT screening tool were positive. The research team reviewed these daily reports and the eMR for each patient who had been flagged at risk of falls or who had had a fall documented in the referral information to identify reasons for inclusion or exclusion.

3. *The Aged Care Assessment Team, Homecare and Community Aged Care Providers and Community Health Nurses.*

   It was anticipated that people who were new referrals to the Aged Care Assessment Team (ACAT) may be identified for the first time as at risk of falls following an in-home assessment by the trained assessors either by using the FRAT screening tool as outlined above, or during the initial or subsequent assessments, the client volunteered a history of a recent fall.

Homecare and Community Aged Care Providers deliver in-home and community assistance to people aged 65 years and older. It was anticipated that new and existing clients may have falls and not seek medical assistance.

Community Health nurses provide in-home care to older people including, for example, wound care. It was again anticipated that new and existing clients may have falls and not seek medical assistance.

The research team met with each of these groups of nursing and aged care professionals to provide information about the study and to encourage referral of clients who had fallen within the previous 12 months to the research team, or to encourage the individual or their family to make direct contact with the research team.

4. *Self-referral / community advertising / word of mouth.*

   Details of the CONFABS study were advertised in a local newspaper, on local community radio and in the newsletter of the local General Practitioner network. The lead investigator was interviewed for a local newspaper and for the General Practitioner newsletter. People aged 65 years and older who were living in the community, could mobilise independently without an aid and who had fallen in the previous 12 months were encouraged to contact the research team for further details on the study. A study leaflet outlining details of the study, and posters with information on who was eligible, and who to contact about further details on the study, were made available in the community and around the hospital environment.

All potentially eligible subjects from the above 4 sources were screened by the research team using the eMR for basic details such as age, residential address and their most recent contact with the hospital and in particular if they had been admitted under the care of or attended the out-patient clinic of a Geriatrician practising in Sydney Local Health District. The eMR was also interrogated for information on clinical history looking for exclusion criteria, such as dementia or Parkinson's disease. All potentially eligible subjects who passed this screening procedure were then sent information on the study and received a follow-up phone call. During this phone call, eligibility was again assessed specifically by asking the subject's age, address and plans to reside in the area for the following 12 months, and details of their General Practitioner. Details on history of falls in the previous 12 months were confirmed at this time. Subjects who were excluded at this point did not have a history of falling in the last 12 months, did not plan to reside in the local area for the duration of the study and did not have a G.P. or did not see their G.P. regularly. All subjects who were deemed eligible at this point proceeded to a baseline assessment. Potential participants could be deemed ineligible by fulfilling one or more of the exclusion criteria.

<u>Baseline assessment including falls risk assessment</u>

Each participant was seen by the research nurses who undertook a recheck of the inclusion/exclusion criteria, obtained consent from the participant to take part in the trial and undertook a baseline assessment. This assessment was performed in the participant's home or at a hospital clinic, according to the preference of the participant. The baseline assessment gathered information on the baseline characteristics of the participants. Basic socio-demographic details were recorded including age, gender, country of birth, smoking and alcohol use, living arrangements and baseline use of community services. Details of the most recent fall, including the cause of the fall and injuries sustained, were recorded. Baseline fear of falling was assessed using the question: "Are you afraid of falling?" Additional assessment of fear of falling was made using the Iconographical Falls Efficacy Scale (icon-FES), a pictorial scale identifying activities that challenge balance and a score which determines fear of falling. (189) Baseline history of osteoporosis and risks for low calcium intake and Vitamin D exposure were recorded. Comorbidities were listed using the Functional Comorbidity Index by Groll. (190) Medication use was self-reported and included prescription and over the counter medications and supplements. In-home baseline assessments permitted the research nurse to sight all medications used. Measures of function, cognition and depression were undertaken using the Barthel Index for Activities of Daily Living (ADL) (191), Lawton Index for Instrumental Activities of Daily Living (IADL) (192), Mini Mental State Examination measure of cognition (159) and the 5 item Geriatric Depression Scale (193). Postural hypotension was assessed by performing seated and 1, 3 and 5-minute standing blood pressure readings and recording any symptoms. A Timed Up and Go Test was also performed and the best time of 2 trials was recorded. On completion of the assessment, the details of the baseline assessment were reviewed by the research team, and a risk profile for falls was determined including risk for osteoporosis. This was completed for all subjects to ensure allocation concealment for the research nurse who was performing the outcome assessments. The research team that formulated the falls risk profile consisted of a Geriatrician with expertise in falls and osteoporosis, and the research nurse with significant clinical experience.

Randomisation

After baseline falls risk assessment, subjects were randomised 1:1 to either the specialist-led intervention arm or the G.P. intervention arm, using a block randomisation schedule stratified by age and history of falls. The subjects were stratified as aged 65 to 79 years or 80 years and older, and having a history of one fall or 2 or more falls in the preceding 12 months. Random block sizes of 4 and 6 were used and the randomisation schedule was held by the chief investigator, who was not involved in outcome assessments and was blinded to any baseline information other than the stratification variables. The outcome assessor was blinded to the intervention received as much as was possible. There were, however, instances where the study subjects did unmask their allocation during the course of follow-up by the outcome assessor. The research doctor performing the specialist hospital-based intervention could not be blinded.

Interventions

The study had two intervention arms as follows:

1. *Specialist-led hospital-based multifactorial intervention – "CONFABS clinic"*

   All participants randomised to the Specialist-led hospital-based multifactorial intervention arm were invited to attend a hospital-based clinic for comprehensive medical assessment by a Geriatrician. If the participant could not attend the clinic, a home-based comprehensive assessment was conducted. Risk factors for falls were determined during this face to face assessment, incorporating the information from the falls risk assessment from the baseline research nurse assessment. Specific attention was paid to osteoporosis risk assessment. Medications were checked, and additional steps were taken to confirm doses and prescriptions with the participant's General Practitioner or pharmacist if necessary. In particular, medications known to increase risk of falling, such as antidepressants, antipsychotics and antihypertensives, were identified. If a participant screened positive for depression based on the baseline GDS score of 2 or more, the 15 item GDS (158) was administered and further questioning on mood was undertaken.

Physical examination focussed on measures of postural hypotension, neurological function and specific tests of gait, strength and balance. Weight and height were recorded to accurately calculate the body mass index (BMI). Supine blood pressure was measured after the participant has been lying on the examination bed supine for 15 minutes, followed by standing blood pressure at 1, 3 and 5 minutes. Symptoms of dizziness were recorded at the time of the postural blood pressure readings. Vision was assessed by testing visual acuity using a Snellen chart and an eye examination to document the presence of cataracts and clinical assessment of visual fields. Neurological examination focused on muscle strength, peripheral sensation, extrapyramidal system and cerebellar signs. Gait and balance were assessed using the Timed Up and Go Test (TUGT) (194), 4 stage stance for balance (195), sit to stand test times five (STS-5 or chair stand test as described in chapter 4), and timed 6m walk (184).

The following osteoporosis related investigations were performed: blood tests to screen for secondary causes of osteoporosis and Dual Energy X-ray Absorptiometry (DEXA) (if no previous diagnosis of osteoporosis or if not performed in the last 2 years). Participants had x-rays of the thoraco-lumbar spine, as an additional or alternative diagnostic investigation for the diagnosis of osteoporosis, if DEXA was not feasible to perform, or if the DEXA result suggested an erroneously elevated bone mineral density (due to degenerative spine disease). In Australia, patients are eligible for government funded osteoporosis medications, based on demonstrating osteoporotic vertebral deformities on thoraco-lumbar spine x-rays, without requiring a bone density result.

Additional cardiac investigations were performed if there was clinical suspicion for syncope. These included 24 -hour ambulatory Holter monitor or trans-thoracic echocardiogram.

At the end of the consultation, the Geriatrician developed a falls risk profile and management plan. Appendix A gives outlines how risk factors were defined following the comprehensive assessment. These falls risk factors were then used to determine which interventions and additional investigations each participant received and are also outlined in Appendix A. These interventions included the following: falls specific exercise interventions; medication adjustment – discontinuation or dose reduction of antipsychotics, antidepressants, sedatives or blood pressure lowering medications; occupational therapist home hazard assessment; osteoporosis management; referrals to podiatrist, ophthalmologist, optometrist and dietician; and educational material on falls prevention and osteoporosis. The management plan was discussed with the participant and they received a written plan by post in the week following the assessment. The participant's General Practitioner also received a written tailored falls prevention management plan. The General Practitioner was specifically responsible for coordinating medication changes based on these recommendations, and referrals to podiatrists only. The research team were responsible for initiating all other referrals to specialists, allied health professionals, and reviewing the results of investigations and adjusting the management plan accordingly to maximize compliance. For example, the physiotherapist could progress the participant from home based to group based falls prevention exercises based on their clinical judgement, and/or changing clinical needs. If a change to the exercise intervention was warranted, this must be discussed and approved by the research team. The 3 options of falls prevention exercises were: home based Otago exercise program, Day Hospital based group Otago exercise program and Day Hospital based group Tai Chi exercise program. The Otago exercise program is a previously validated exercise program of flexibility, strengthening and balance retraining exercises. (196, 197)

Participants in the intervention group had 4 assessments by the Geriatrician in the CONFABS clinic - at 1, 6, 16 and 52 weeks following randomisation. The initial comprehensive geriatric falls risk assessment was performed at the 1-week assessment. The 6 and 16-week visits were to review the results of investigations, tailor treatments further and maximize compliance with recommendations. The 52-week assessment was at the completion of the participant's involvement in the study and facilitated data collection on compliance with recommendations. The participant's General Practitioner was provided with written correspondence at each of these visits, with additional telephone contact made as necessary.

2. Enhanced General Practice intervention

The information obtained from the baseline assessment by the research nurse was reviewed by the research team and a consensus falls risk profile risk was created for each participant. A standardised letter was then sent to the participant and the participant's General Practitioner which included the falls risk profile and information on how to intervene for each of the risk factors. The participant also received standard falls prevention educational material. No further written contact was made by the research team with the General Practitioner. The falls prevention interventions advised to the General Practitioner, were aligned with those outlined in Appendix A and are referred to in Appendix B. Information on community based allied health services such as home-based physiotherapy and instructions on how to make referrals, including the community services referral form, were provided to the General Practitioner. Falls prevention interventions provided by community allied health services or Day Hospital services provided the same falls prevention interventions, as those received by participants referred by the CONFABS clinic allocated participants. Referrals to private community based allied health practitioners were also available to the participant's General Practitioner, but may not have provided a similar falls prevention intervention. General Practitioners may also request a further comprehensive geriatrics assessment, in addition to the advice received through the falls risk assessment. These assessments were conducted by Geriatricians at the same clinical site as this trial, but who were not involved in the design or conduct of this study.

Outcome ascertainment

The two primary outcomes of interest in this study were number of falls, and hence the rate of falls over 12 months, and number of fallers. Secondary outcomes included numbers of injurious falls and numbers of fractures.

A standardised definition of a fall was used according to the guidelines for falls research by Lamb et al. (1) Each participant was provided a 12 month falls calendar which was used to record any falls experienced during the study period. The calendar consisted of a pre-addressed, stamped, tear-off postcard for each month. Participants were asked to record on each day an "N" if they did not fall and an "F" if they had a fall. When the calendar was returned, the research nurses contacted the participant to ascertain further information about any falls documented on the falls calendar. If a calendar was not returned, the research nurse would call the participant to confirm if any falls had occurred in that month. Any injuries sustained were recorded and classified on the basis of severity.

Each participant was also contacted at 4, 8 and 12 months to complete an additional questionnaire. This questionnaire included details of current health status, level of independence, falls history within the last 4 months and use of any health-related services. As part of the consent process for the study, permission was sought to be able to contact specialists, General Practitioners, imaging and pathology services, and the electronic medical record (eMR) to be able to ascertain details about any injurious fall sustained.

An exit assessment similar to that completed at baseline was performed by the research nurse.

Adverse events

Adverse events were reported to the appropriate research and ethics committee. In addition, events occurring during the provision of care by any of the community staff or research staff were reported in line with New South Wales Health clinical incident reporting, and were reported as adverse events if they occurred in the course of following falls prevention interventions, such as a home exercise program. No serious adverse events were reported related to the intervention. All falls related hospitalisations were reported to the safety monitoring board.

Sample size estimates

It was estimated that the annual fall rate for this cohort would be 30%. In order to detect an absolute reduction in the annual rate of falls of 15% it was calculated that 182 subjects were required in each intervention arm to have 80% power to detect the change at the 5% significance level. To allow for a 10% attrition rate for death and withdrawal from the study, it was planned to recruit a sample size of 200 subjects in each intervention arm.

Statistical analysis

Basic descriptive statistics were used to examine the baseline characteristics of the intervention arms, and to assess for any significant differences between the groups, using Chi-squared and Fischer's exact tests for categorical variables and student's t-test for continuous variables. Recommendations from Robertson and Campbell on data analysis in fall intervention trials were followed. (198) The outcome of falls in the 12-month follow-up was assessed using negative binomial regression to compare the rate of falls in each intervention arm. Multivariate negative binomial regression adjusted for age and fall history at baseline was then calculated to compare incident rate ratio of falls in each intervention arm. Risk of falling in the intervention arms was assessed using logistic regression, with multivariate analysis adjusted again for age and baseline fall history.

Data analysis was performed using SAS version 9.3 (SAS Institute, Inc., Cary, NC, USA).

6.3 Results

A total of 5,270 people aged 65 years or older presented to the Emergency Department of Concord Hospital, or were referred to the Aged Chronic Care and Rehabilitation (ACC&R) services between October 2010 and June 2013. Recruitment for the study was ceased in June 2013, before the calculated sample size was reached, due to time and resource limitations. Attempts to extend recruitment at a second site were unsuccessful. Figure 6.1 shows details of the recruitment process. Of the 5,270 people identified as potential participants, only 420 older people were identified as provisionally meeting eligibility for the study, and were sent information inviting them to take participate. Using information contained in referrals to the ACC&R services and the electronic medical record of Concord Repatriation General Hospital, 4,850 were initially excluded from the study. The most common reasons for exclusion are shown in Table 6.1, exact number are not reported as participants were excluded for more than one reason in the main. Of note 42 different languages or dialects were identified from requests for interpreter services.

Table 6.1: Top 10 reasons for exclusion from the CONFABS study

Assessment for urgent permanent placement in residential aged care
Assessment for urgent respite care in residential aged care
Current admission under the care of a Geriatrician
Documented dementia (moderate or severe) or MMSE score <20
Seen by a Geriatrician in the previous 12 months
History of mental health disorders which affected the person's ability to consent to participate
Non-English speaking – request for interpreter services
Active referral to psychogeriatric services
Referral for review by a Geriatrician
Request for social and financial assistance / social work assessment

Figure 6.1: CONFABS study recruitment process

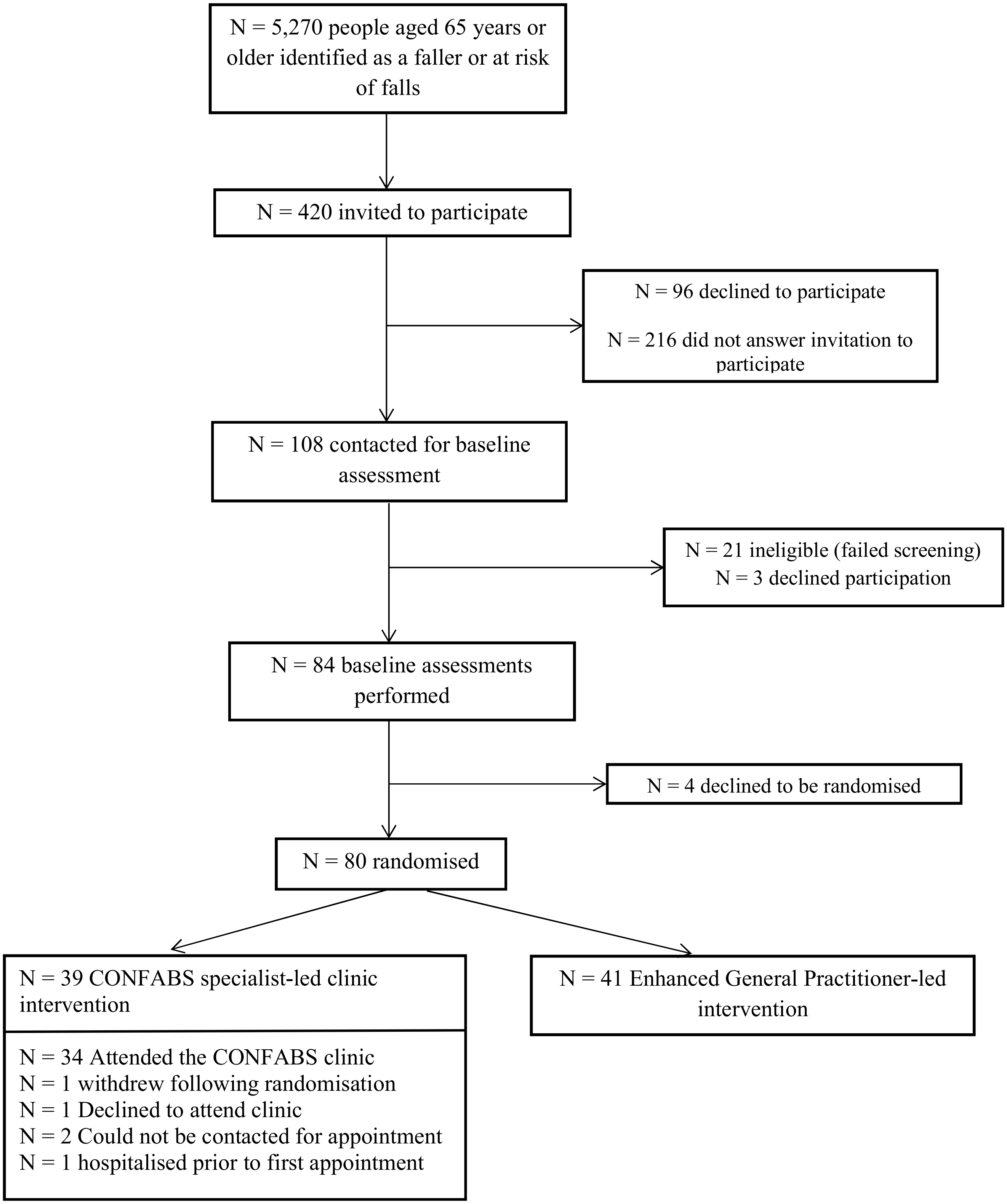


Figure 6.1 shows the participation for the 420 people who were sent detailed information on participation in the study. Two hundred and sixty potentially eligible participants did not respond to written study correspondence or answer telephone recruitment phone calls. One hundred and eight potential participants underwent telephone screening by the research nurse. Twenty-one potential participants were excluded during telephone screening, due to no history of falls in the preceding 12 months, or not attending a General Practitioner regularly. Eighty-four participants agreed to undergo a baseline assessment, of which 4 declined to be randomised. Of the 80 participants who provided consent to be randomised, 39 were allocated to the specialist-led CONFABS clinic and 41 were allocated to the enhanced General Practitioner arm. Of the 39 participants allocated to the CONFABS clinic, 1 withdrew from the study 1 day following randomisation, prior to any intervention and so was not included in the data analysis. A further 3 participants did not attend the clinic, either declining to attend or were uncontactable to schedule an appointment. One participant was hospitalised prior to the visit scheduled clinic appointment, and was subsequently re-admitted a further two times and then referred for Geriatrician assessment on discharge from hospital. One participant was seen only once in the CONFABS clinic, although outcome data was available on this participant to the completion of the study.

Table 6.2 shows the baseline characteristics of participants in the study: 41 participants in the enhanced General Practitioner care intervention arm and 38 participants in the CONFABS clinic intervention arm. There was no statistically significant difference in baseline characteristics between the two cohorts, although there was a non-significant trend to an increased number of participants with cognitive impairment in the enhanced General Practitioner care intervention arm, with a trend to a lower MMSE in this group (see Table 6.2). Most participants were identified for inclusion in the study via interrogation of the eMR, rather than referrals from the Emergency Department staff or referrals to the ACC&R services. The specialist-led CONFABS clinic intervention was more likely to have recruited participants who contacted the study directly for participation.

In terms of the characteristics of the participants, both intervention arms had more females than males recruited, with more females recruited to the enhanced General Practitioner care intervention arm (81% General Practitioner intervention versus 68% CONFABS clinic intervention), although this was not statistically significant. In terms of age, again there was a non-significant difference between in the intervention arms in terms of distribution between the pre-defined age groups. However, there was a greater proportion of participants in the 65 – 79-year-old age group in the CONFABS clinic intervention arm, and a greater proportion of participants over the age of 80 years in the enhanced General Practitioner care intervention arm (see Table 6.2). The mean age of participants was younger in the CONFABS clinic intervention arm (78 years CONFABS clinic arm versus 80 years G.P. enhanced care arm). The majority of participants were born in Australia or an English-speaking country.

No statistically significant difference was identified between the intervention arms and measures of mobility and physical function. In both intervention arms, the majority of the participants were mobile independently without the use of a walking aid, both indoors and outdoors. There was a greater proportion of participants using a walking frame to mobilise outdoors in the enhanced General Practitioner care intervention arm, but this was not statistically significant. The majority of participants in both intervention arms were independent in their basic activities of daily living based on Barthel Index score. However, when function was assessed in terms of instrumental activities of daily living, more participants in both intervention arms were impaired based on score on the Lawton scale (impairment was measured as scoring less than 8 on the scale). There was again no statistically significant difference between the intervention arms and who participants lived with or the use of community services. More participants in the CONFABS clinic intervention arm lived alone than with others (58% alone versus 42% with others), whereas the reverse was seen in the enhanced General Practitioner care intervention arm (49% alone versus 51% with others). More participants were supported with informal care support arrangements than formal community services in both intervention arms and these services ranged from assistance with transport to assistance with bathing. Fifty-two percent of all participants received allied health or nursing care in the community, with podiatry the most common health professional service used.

Table 6.2 provides details on the previous falls history, fall characteristics and fall risk factors of the study participants. A history of recurrent falls in the 12 months prior to recruitment was more prevalent in both intervention arms than having had a single fall. A simple slip or trip was the most common cause for the last fall experienced by participants in both intervention arms, followed by falls due to loss of balance. Although there was no significant difference in the causes of the previous fall, 15% of participants receiving the enhanced General Practitioner care intervention were unclear as to the cause of their previous fall. The last fall prior to recruitment resulted in more injurious falls then no injury, with a non-significant increase in the proportion of participants experiencing a major injurious fall in the enhanced General Practitioner care intervention arm. Most participants were able to get up without assistance following their last fall, regardless of intervention arm. In the CONFABS clinic intervention arm, the participants equally rated their balance between good/very good and fair/poor. In the GP intervention arm however, a greater proportion of participants rated their balance as poor. The majority of the cohort reported a fear of falling when asked "Are you afraid of falling?" There was no significant difference between the intervention cohorts in terms of iconographical Falls Efficacy Scale (iconFES), with the majority scoring above 12. Higher scores indicate greater fear of falling, with the short form iconFES containing 10 items and scoring 1 for "not afraid" and 4 for "very afraid", producing a range of scores from 10 to a maximum of 40. (189)

The total number of comorbidities was dichotomised to ≤ 3 comorbidities and >3 comorbidities. The majority of participants reported more than 3 comorbidities with no significant difference between the intervention groups. The majority of participants reported that their memory was good or average compared to below average, with a trend to lower MMSE score and greater proportion of participants scoring ≤ 24 out of 30 in the G.P. intervention arm as previously discussed. The majority of participants screened negative for depression based on the 5-point Geriatric Depression Scale (GDS). Baseline physical parameters recorded included postural blood pressure and Timed Up and Go Test (TUGT). The majority of participants did not have a significant decrease in their systolic or diastolic blood pressure on standing when tested. And the majority of participants performed faster than 14 seconds on the TUGT – times to perform the test slower than 14 seconds have been associated with increased risk of falls by Shumway-Cook et al. (199)

Additional risk factors for falls included in the baseline assessment were the medications used by participants. There was no significant difference between the intervention groups in terms of the absolute number of medications used. In both intervention groups the majority of participants reported the use of more than 4 medications. The majority of participants were not diagnosed with osteoporosis, and there were an even smaller proportion of participants using medications for the treatment of osteoporosis than had the diagnosis. Approximately half of participants used calcium and /or vitamin D supplements, with only a small proportion reporting an adequate dietary intake of calcium.

Table 6.2: Comparison of baseline characteristics of study participants based on intervention received

Variable		CONFABS clinic intervention *n = 38* n (%)	Enhanced G.P. intervention *n = 41* n (%)	P value
Gender	Male	12 (31.6)	8 (19.5)	0.22
	Female	26 (68.4)	33 (80.5)	
Age group (years)	65 – 79 years	20 (52.6)	20 (48.8)	0.73
	≥ 80 years	18 (47.4)	21 (51.2)	
Age (years)	Mean (SD)	78.4 (6.8)	80.6 (7.0)	0.15
	Range 66-93 years			
Country of birth	Australia / ESB	31 (81.6)	37 (90.2)	0.34
	NESB	7 (18.4)	4 (9.8)	
Living arrangements	Home alone	22 (57.9)	20 (48.8)	0.42
	Home with others	16 (42.1)	21 (51.2)	
Baseline mobility indoors	No walking aid	29 (76.3)	27 (65.9)	0.20
	Walking stick	8 (21.1)	8 (19.5)	
	Walking frame	1 (2.6)	6 (14.6)	
Baseline mobility outdoors	No walking aid	25 (65.8)	26 (63.4)	0.86
	Walking stick	10 (26.3)	9 (22.0)	
	Walking frame	3 (7.9)	5 (12.2)	
	Not mobile outdoors	0 (0)	1 (2.4)	
Baseline mobility	No walking aid	25 (65.8)	26 (63.4)	0.83
	Walking aid	13 (34.2)	15 (36.6)	
ADL disability	Yes	13 (34.2)	19 (46.3)	0.28
IADL disability	Yes	28 (73.7)	25 (61.0)	0.23
Informal community services	Yes	20 (52.6)	22 (53.7)	0.93
Formal community services	Yes	14 (36.8)	20 (48.8)	0.28
Community allied health or nursing	Yes	18 (47.4)	23 (56.1)	0.44

G.P. – General Practitioner; SD – standard deviation; ESB – English speaking background; NESB – Non-English-speaking background; ADL – activities of daily living; IADL – instrumental activities of daily living;

Table 6.2: Comparison of baseline characteristics of study participants based on intervention received (Continued)

Variable		CONFABS clinic intervention *n = 38* n (%)	Enhanced G.P. intervention *n = 41* n (%)	P value
Source of referral	eMR	21 (55.3)	27 (65.9)	0.07
	E.D. staff	1 (2.6)	4 (9.8)	
	ACC&R referrals	7 (18.4)	8 (19.5)	
	Direct referral	9 (23.7)	2 (4.9)	
History of falls in past 12 months	Single fall	17 (44.7)	15 (36.6)	0.46
	2 or more falls	21 (55.3)	26 (63.4)	
Reason for last fall	Slip/trip	24 (63.2)	26 (63.4)	0.74
	Loss of balance	7 (18.4)	6 (14.6)	
	Dizziness	1 (2.6)	0 (0)	
	Failure of support	1 (2.6)	2 (4.9)	
	Syncope	2 (5.3)	1 (2.4)	
	Unclear	3 (7.9)	6 (14.6)	
Ability to rise from the ground following fall	No	12 (31.6)	13 (31.7)	0.99
	Yes	26 (68.4)	28 (68.3)	
Injuries sustained	No	10 (26.3)	3 (7.3)	0.08
	Minor injuries	13 (34.2)	18 (43.9)	
	Major injuries	15 (39.5)	20 (48.8)	
Self-rated balance	Good / very good	19 (50.0)	15 (36.6)	0.23
	Fair / poor	19 (50.0)	26 (63.4)	
Fear of falling	No	11 (29.0)	7 (17.1)	0.28
	Yes	27 (71.1)	34 (82.9)	
iFES score	Mean (SD)	16.5 (4.6)	16.3 (6.0)	0.90
	Median (IQR)	17 (12 – 21)	15 (12-18)	
	No fear (low score ≤ 12)	12 (31.6)	12 (29.3)	0.82
	Fear of falling (score >12)	16 (68.4)	29 (70.7)	
Comorbidities	≤ 3	9 (23.7)	12 (29.3)	0.62
	>3	29 (76.3)	29 (70.7)	
Self-rated memory	Good	32 (84.2)	35 (85.4)	1.0
	Poor	6 (15.8)	6 (14.6)	
MMSE score	Mean (SD)	28.0 (2.0)	26.8 (3.0)	0.06
	Median (IQR)	28.5 (26 – 30)	28 (25 – 29)	
Cognition	Normal	34 (89.5)	31 (75.6)	0.07
	Impaired (MMSE ≤ 24)	4 (10.5)	10 (24.4)	
Depression	GDS-5 0 – 1	25 (69.4)	21 (52.5)	0.13
	GDS-5 ≥ 2	11 (30.6)	19 (47.5)	

G.P. – General Practitioner; SD – standard deviation; IQR – interquartile range; eMR – electronic medical record; E.D. – Emergency Department; ACC&R – Aged and Chronic Care and Rehabilitation; iFES – iconographical Falls Efficacy Scale; MMSE – Mini Mental State Examination; GDS – Geriatric Depression Scale

Table 6.2: Comparison of baseline characteristics of study participants based on intervention received (Continued)

Variable		CONFABS clinic intervention *n = 38* n (%)	Enhanced G.P. intervention *n = 41* n (%)	P value
Postural hypotension	No	30 (83.3)	35 (87.5)	0.75
	Yes	6 (16.7)	5 (12.5)	
TUGT	Good <14 secs	29 (76.3)	23 (59.0)	0.15
	Poor ≥ 14 secs	9 (23.7)	16 (41.0)	
TUGT	Mean (SD)	12.8 96.6)	14.5 (8.5)	0.31
	Median (IQR)	11 (9 – 13)	13 (9 – 15)	
Total number of medications	Mean (SD)	7.2 (3.2)	8.0 (3.5)	0.31
	Median (IQR)	7 (4 – 9)	8 (5 – 10)	
Polypharmacy	≤ 4 medications	10 (26.3)	5 (12.2)	0.15
	>4 medications	28 (73.7)	36 (87.8)	
CNS active medications	Yes	11 (29.0)	12 (29.3)	0.96
	Antidepressants	5 (13.2)	7 (17.1)	0.76
	Antipsychotics	1 (2.6)	0 (0)	0.48
	Benzodiazepines	3 (7.9)	6 (14.6)	0.48
	Opiates	1 (2.6)	4 (9.8)	0.36
Cardiac medication	Yes	26 (68.4)	33 (80.5)	0.30
	ACEI	11 (29.0)	6 (14.6)	0.17
	ARB	8 (21.1)	17 (41.5)	0.06
	Beta Blocker	11 (29.0)	11 (26.8)	0.83
	CCB	11 (29.0)	15 (36.6)	0.47
	Diuretic	9 (23.9)	7 (17.1)	0.58
	Nitrate	5 (13.2)	1 (2.4)	0.10
	Antiplatelet	13 (34.2)	16 (39.0)	0.66
	Anticoagulant	6 (15.8)	4 (9.8)	0.51
Diagnosed Osteoporosis	Yes	13 (34.2)	17 (41.5)	0.51
Medications for Osteoporosis	Yes	5 (13.2)	3 (7.3)	0.47
Calcium and /or Vitamin D	Yes	19 (50.0)	23 (56.1)	
Dairy intake	3 or more serves per day	6 (15.8)	5 (12.2)	0.27
	< 3 serves per day	32 (84.2)	36 (87.8)	
Sun exposure	Daily	29 (76.3)	26 (65.0)	0.27
	Weekly or less	9 (23.7)	14 (35.0)	

G.P. – General Practitioner; SD – standard deviation; IQR - interquartile range; TUGT – Timed Up and Go Test; ACEI – Angiotensin Converting Enzyme Inhibitor; ARB – Angiotensin Receptor Blocker; CCB – Calcium channel blocker;

Table 6.3: Falls risk factor profile following nurse-led assessment based on consensus opinion between the research Geriatrician and nurse.

Variable	CONFABS clinic intervention ***n = 38*** n (%)	Enhanced G.P. care intervention ***n = 41*** n (%)	P value
Balance or gait impairment	25 (65.8)	26 (63.4)	0.83
Polypharmacy	25 (65.8)	31 (75.6)	0.34
Falls risk increasing drugs	22 (57.9)	29 (70.7)	0.23
Postural hypotension	11 (29.0)	11 (26.8)	0.83
Symptoms of syncope	3 (7.9)	3 (7.3)	1.0
Self-reported poor vision	12 (31.6)	11 (26.8)	0.64
Home environmental hazards	22 (57.9)	29 (70.7)	0.23
Inappropriate footwear	4 (10.5)	7 (17.1)	0.52
Depression	12 (31.6)	10 (24.4)	0.48
Fear of falling	25 (65.8)	26 (63.4)	0.83
Cognitive impairment (MMSE ≤ 24)	1 (2.6)	6 (14.6)	0.11

G.P. – General Practitioner MMSE – Mini Mental State Examination;

Table 6.3 shows the falls risk factor profiles for participants in the CONFABS clinic intervention arm and the enhanced General Practitioner care intervention arm, following baseline assessment and consensus reached between the research Geriatrician and nurse. No significant difference in the risk factor profile was identified between the two interventions. The most common risk factors identified in each group were gait and balance impairment, polypharmacy and the use of falls risk increasing drugs (FRID), home environmental hazards and fear of falling.

Figure 6.1 has previously described the compliance with the protocol for the specialist-led CONFABS clinic intervention arm. A total of 34 participants attended the CONFABS clinic and had a total of 110 visits ranging from 1 visit to 4 visits – 22 participants were seen for all

4 visits as per protocol. Table 6.4 shows details of the falls prevention strategies used and the compliance with these strategies for each of the intervention arms. Appendix B provides additional detail on these interventions. Table 6.4 details for each fall prevention strategy the number of participants recommended to have each strategy and the number of participants who received each strategy. Adherence to recommendations was recorded where it could be ascertained. This information was derived from the monthly falls calendars, 4 monthly follow-up phone calls, 12-month close of study assessment, by direct report at the CONFABS clinic and interrogation of the eMR (electronic medical record). The eMR is used by all hospital-based and Aged Chronic Care and Rehabilitation (ACC&R) community-based services and contains details of appointment bookings for community and hospital-based services, some clinical case-notes and referrals to ACC&R services for the entire Sydney Local Health District, not restricted to those at the study site alone. Falls prevention interventions which were promoted for use by both intervention arms, used the eMR to record participant appointments, with the exception of podiatry and optometry. Referrals made to private allied health professionals or specialist private clinics by the participant's General Practitioner could not be verified if they were not reported by the participant or their carer.

In terms of specific falls prevention interventions, there was a significantly higher proportion of participants in the specialist-led CONFABS clinic intervention arm who received specific osteoporosis treatment recommendations (26 participants versus 4 participants). No significant difference was reported in the proportion of participants who complied with these recommendations, however there was a trend to a greater proportion complying fully with recommendations in the CONFABS clinic intervention arm. There was no other significant difference in the number of participants receiving any of the other falls prevention strategies, although there were trends suggesting greater number of recommendations for physiotherapist-led and occupational therapist-led strategies, and advice on footwear in the CONFABS clinic cohort. A significant difference in the use of specific exercise based falls prevention strategies was reported between the two intervention arms. A greater proportion of participants in the CONFABS clinic intervention arm participated in Tai Chi, and the participants of the enhanced General Practitioner care intervention participated in more home-based Otago program exercises. There was no significant difference in the median number of sessions for all exercise interventions between the 2 cohorts. The CONFABS clinic cohort had a greater proportion of participants receiving appropriate numbers of sessions for each of the interventions – we determined Otago based exercises should have at least 6 sessions and Tai Chi 8 sessions based on protocols used in other studies as outlined in Appendix A. (196, 197) There was poor uptake of recommendations to have a home hazard assessment by a trained Occupational Therapist in both study arms. If a home hazard assessment was performed there was a non-significant trend to greater compliance with recommendations in the CONFABS clinic intervention arm. There was also a trend to suggest greater adherence to recommendations to reduce or stop falls risk increasing drugs (FRID) in the CONFABS clinic intervention arm. Partial or complete adherence to FRID drug withdrawal was shown in 61% of participants who were recommended to withdraw these medications versus 31% in the enhanced General Practitioner care intervention arm. Participants were partially adherent to recommendations if they had managed to dose reduce the identified medication, but had been unable to completely withdraw them.

Table 6.4: Falls prevention strategies and adherence to recommendations for the CONFABS clinic and enhanced G.P. interventions

Falls prevention strategy		**CONFABS clinic intervention N = 38**	**Enhanced G.P. coordinated care intervention N = 41**	**P Value**
Physiotherapy	All recommendations	31/38(81.6%)	29/41 (70.7%)	0.08
Specific strategies	Home based Otago program	5/31 (16.1%)	14/29 (48.3%)	0.0008
	Day Hospital based group Otago program	16/31 (51.6%)	14.29 (48.3%)	
	Day Hospital Tai Chi	12/31 (38.7%)	1/29 (3.4%)	
	Median number of visits (IQR)	5 (IQR 4 – 11) Range 1 - 29	4 (IQR 2 – 7) Range 1 - 16	0.31
	Adherence to recommended number of visits	11 / 31 (35.5%)	4 / 29 (13.8%)	
Occupational Therapy	All recommendations	22/38 (57.9%)	31/41 (75.6%)	0.15
	Mean number of visits (SD)	3 (SD 0.87) Range 2 – 4	2 (SD 1.22) Range 1 – 4	0.10
Adherence to recommendations	Complete adherence	5/22 (22.7%)	2/31 (6.5%)	0.12
	Partial adherence	3/22 (13.6%)	1/31 (3.2%)	
	Declined recommendations	1/22 (4.5%)	2/31 (6.5%)	
	Declined assessment / Not referred by G.P.	13/22 (59.1%)	26/31 (83.9%)	

IQR – Interquartile range; SD – standard deviation; G.P. – General Practitioner

Table 6.4: Falls prevention strategies and adherence to recommendations for the CONFABS clinic and enhanced G.P. interventions (Continued)

Falls prevention strategy		**CONFABS clinic N = 38**	**Enhanced G.P. coordinated care N = 41**	**P Value**
Polypharmacy	Polypharmacy review	22/38 (57.9%)	29/41 (70.7%)	0.50
Falls risk increasing drugs (FRID)	FRID reduction	26/38 (68.4%)	32/41 (78.0%)	0.45
Adherence to recommendations	Full adherence	12/26 (46.2%)	6/32 (18.8%)	0.18
FRID reduction	Partial adherence	4/26 (15.4%)	4/32 (12.5%)	
	Declined recommendations / unable to make changes	10/26 (38.5%)	22/32 (68.8%)	
Osteoporosis management	Recommended specific osteoporosis treatment	26/38 (68.4%)	4/41 (9.8%)	<0.0001
	Full adherence	19/26 (73.1%)	2/4 (50%)	0.39
	Partial adherence	1/26 (3.8%)	0/4 (0%)	
	Declined recommendations	6/26 (23.1%)	2/4 (50%)	
Vision	Single vision lenses	3/38 (7.9%)	9/41 (22.0%)	1.00
	Full adherence to recommendation	2/9 (22.2%)	0/9 (0%)	
Footwear	Appropriate footwear advised	9/38 (28.9%)	4/41 (9.8%)	0.13
Podiatrist	Attending a podiatrist	15/38 (39.5%)	14/41 (34.1%)	0.65
Dietician	Nutritional support – attending a dietician	2/38 (5.3%)	3/41 (7.3%)	1.00
Specialist referrals	Referral for specialist advice (Neurology/Endocrinology/Continence)	5/38 (13.2%)	1/41 (2.4%)	0.10
ACAT referrals	Referrals for community services	5/38 (13.2%)	4/41 (9.8%)	0.73

FRID – Falls risk increasing drugs; ACAT – Aged Care Assessment Team;

Table 6.5: Falls, injurious falls and fractures in the intervention groups (intention to treat analyses)

		CONFABS intervention n = 39	G.P. intervention n = 41	P value
Follow-up (months)	Mean (SD)	10.6 (3.2)	10.8 (3.4)	0.75
Lost to follow-up*		n = 2	n = 3	…
Outcomes				
Fallers	Total n = 34 (%)	21 (61.8)	13 (38.2)	0.04
	Unadjusted RR	1.71 (1.01 – 2.87)	1.0	0.04
	Adjusted RR**	1.80 (1.10 – 2.96)	1.0	0.02
Falls	Total n (%)	77 (71.3)	31 (28.7)	0.03
	Mean (SD)	2.1 (3.7)	0.9 (1.4)	0.06
	Range	0 - 17	0 - 6	
	Unadjusted IRR	2.48 (1.11 – 5.57)	1.0	0.03
	Adjusted IRR**	2.39 (1.09 – 5.27)	1.0	0.03
Injurious falls	Total (%)	12 (57.1)	9 (42.9)	0.60
	Mean (SD)	0.5	0.4	0.81
	Range	0 - 6	0 - 3	
	Unadjusted IRR	1.16 (0.45 – 2.99)	1.0	0.76
	Adjusted IRR**	1.15 (0.45 – 2.93)	1.0	0.77
Fractures	Total (%)	1 (20.0)	4 (80.0)	0.22
	Unadjusted IRR	0.27 (0.03 – 2.44)	1.0	0.25
	Adjusted IRR**	0.31 (0.03 – 2.86)	1.0	0.26

SD – standard deviation; IRR – incident rate ratio;
*Lost to follow-up – participants analysed as missing data;
** Adjusted for age and baseline falls history (one fall or two or more falls).

Table 6.5 shows the primary and secondary outcomes based on intention to treat analyses. There was no significant difference in the mean follow-up time between both groups (10.6 months vs 10.8 months; P = 0.75). A total of 2 participants were lost to follow-up from the specialist-led CONFABS clinic intervention arm versus 3 participants from the enhanced General Practitioner care intervention arm. A total of 34 fallers experienced 108 falls. There were significantly more fallers in the CONFABS clinic intervention arm than there were in the enhanced General Practitioner care intervention arm (21 fallers vs 13 fallers; P = 0.04). The risk of falling was significantly higher in the CONFABS clinic intervention group over the 12 months of follow-up, after adjustment for age and history of falls at baseline (RR 1.80; 95% C.I. 1.10 – 2.96). There were also significantly more falls in the CONFABS clinic intervention arm than in the enhanced General Practitioner care intervention arm (77 falls vs 31 falls; P = 0.03). There was no significant difference in the mean number of falls between the two groups. The rate of falls was more than double in the CONFABS clinic intervention arm when adjusted for age and falls history at baseline (IRR 2.39; 95% C.I. 1.09 – 5.27).

Thirty-six fall events were generated by 3 participants, all in the CONFABS clinic intervention arm. One participant had 17 falls in the 12-month follow-up period, and had an existing neurological condition which contributed to leg length discrepancy and muscle weakness, both of which were significant factors in their falls. One participant had a new diagnosis of a progressive neuromuscular degenerative disease made during the follow-up period, which was the main cause for their 10 falls. The third of these participants had a history of a seizure disorder, which was assessed to have contributed to the majority of their 9 falls.

In terms of injurious falls, there were 12 falls in the CONFABS clinic intervention arm and 9 falls in the enhanced General Practitioner care intervention arm. There was no significant difference in the rate of injurious falls experienced by participants in the two intervention arms in the univariate and in the multivariate analyses. There were 5 fractures in total with 4 occurring in the enhanced General Practitioner care intervention arm, but this was not a statistically significant. (see Table 6.5).

Table 6.6 shows the results for rate of falls and risk of falls analyses using for 4 different methods for accounting for the 3 participants who had 36 falls and the 5 participants who were lost to follow-up. Model 1 is the intention to treat analysis that has been reported in Table 6.5 and discussed above, and has been included to aid comparison. When the 3 participants with the greatest number of falls were retained in the analysis, a significant increased risk of falling and rate of falls was seen for participants allocated the CONFABS clinic intervention. In Model 2 the analyses are repeated with data from the 3 outlier fallers excluded. There was an increase in the risk of falling (RR 1.56; 95% C.I. 0.94 – 2.57) and increase in the rate of falls (IRR 1.53; 95% C.I. 0.70 – 3.32) in the CONFABS clinic intervention arm, but this increase was no longer significant. For Models 3 and 4 an assumption is made that the participants who were lost to follow-up had one fall during the 12 months from when they were recruited. Model 3 included the participants who were lost to follow-up and excluded the 3 outliers. Neither the risk of falling nor the rate of falling was significantly different between intervention groups in the multivariate analyses. Model 4 included those lost to follow-up and the 3 outliers. There was a 2.3-fold increase in the rate of falls (IRR 2.31; 95% C.I. 1.16 – 4.62 in the CONFABS clinic intervention arm, but not in the risk of falling (RR 1.48; 95% C.I. 0.98 – 2.22).

Table 6.6: Rate of falls and risk of falls by intervention groups showing 4 different ways of accounting for outliers and lost to follow-up adjusted for age and baseline history of falls

	Model 1		Model 2		Model 3		Model 4	
Fallers	Multivariate RR (95% C.I.)	P value	Multivariate RR (95% C.I.)	P value	Multivariate RR (95% C.I.)	P value	Multivariate RR (95% C.I.)	P value
Enhanced G.P care intervention	1.0		1.0		1.0		1.0	
CONFABS intervention	1.80 (1.10 – 2.96)	0.02	1.56 (0.94 – 2.57)	0.08	1.41 (0.91 – 2.17)	0.13	1.48 (0.98 – 2.22)	0.06
Falls	Multivariate IRR (95% C.I.)	P value	Multivariate IRR (95% C.I.)	P value	Multivariate IRR (95% C.I.)	P value	Multivariate IRR (95% C.I.)	P value
Enhanced G.P. care intervention	1.0		1.0		1.0		1.0	
CONFABS intervention	2.39 (1.09 – 5.27)	0.03	1.53 (0.70 – 3.32)	0.29	1.47 (0.75 – 2.87)	0.26	2.31 (1.16 – 4.62)	0.02

IRR – incident rate ratio; RR – risk ratio; 95% C.I. – 95% confidence intervals; G.P. – General Practitioner
Model 1: Intention to treat analysis including the 3 outliers and treating lost to follow-up as missing data
Model 2: exclusion of 3 outliers and treating lost to follow-up as missing data
Model 3: exclusion of 3 outliers with each lost to follow-up counted as a faller having one fall
Model 3: inclusion of 3 outliers with each lost to follow-up counted as a faller having one fall

6.4 Discussion

In this randomised controlled trial of older people living in the community who have had a fall, falls prevention strategies coordinated by a Geriatrician-led, hospital based falls clinic did not decrease the number of fallers or the rate of falls over 12 months compared with an enhanced General Practitioner care intervention. There were significantly higher number of falls and fallers in the follow-up period in the CONFABS clinic intervention arm compared to those in the enhanced General Practitioner care intervention arm. There was no significant difference in the rate of injurious falls in the 12 months follow-up. Although there were fewer fractures in the hospital based falls clinic intervention, this was not statistically significant. This is despite non-significant trends to increased referrals to fall prevention strategies in the CONFABS clinic intervention arm and increased adherence to recommendations, particularly for home hazard assessments, fall risk increasing drug withdrawal and osteoporosis treatment.

Caution should be exercised in interpreting the results of this study given the difficulty in recruiting an adequate number of participants. Despite screening over 5000 older people, we did not succeed in reaching the intended sample size of 200 participants per intervention arm. This fact should be considered in any interpretation of the study findings. There was also no true "usual care" control arm in this study for which to compare either intervention. Comparing two active intervention arms which may have a similar effect on the outcome of interest may have affected the ability to discriminate between the interventions.

With the power limitations in mind, there are a few possible interpretations of the study findings. It could be that a "real world" falls clinic without specific extra resources are not more effective than enhanced General Practitioner coordinated care. It could be the CONFABS falls clinic was not effective because adherence to recommendations and interventions was not high enough. An alternative explanation, however, is that enhanced General Practitioner coordinated care by way of a specialist trained nurse and Geriatrician provided risk assessment and intervention recommendations, is an effective way to deliver falls prevention interventions in the community. The intention to treat analysis shows significantly less falls in the enhanced General Practitioner coordinated intervention arm. This could in part be because of the fact that the three participants with the highest number of falls were in the CONFABS clinic arm. However, the trends in the analyses when the three outlying participants' falls were accounted for does still favour the General Practitioner coordinated intervention arm. When designing our study, we hypothesized that General Practitioners might find it easier to organise falls prevention interventions if someone else undertook the time-consuming task of falls risk assessment, provided information on how to refer to community based allied health services and provided information to patients.

In interpreting the results of our study, it is important to compare these findings with trials that have recruited participants from similar sources, and that have had similarities in terms of the design of the trial. Given that the majority (67%) of the participants were recruited following an attendance at the E.D. with a fall or fall-related problem it is important to consider the outcomes of this study with falls prevention trials which derived their participants from the E.D. The most recent Cochrane review included the details of 8 multifactorial falls prevention trials which recruited participants from the Emergency Department (E.D.) or Accident and Emergency (A&E). (80) The studies are predominantly from the United Kingdom and we have previously discussed the difficulty in translating successful trials in one setting to another in chapter 1. The most similar study in terms of design and recruitment strategy is the 2010 Dutch study by de Vries et al. (89) Two hundred and seventeen older people were recruited following an attendance at the E.D. or visit to their G.P. following a fall. Participants in the intervention arm of this study received a hospital based specialist falls risk assessment with strategies for falls risk reduction targeting exercise, home hazard assessment, psychotropic drug withdrawal and referral to specialists, in conjunction with the participants General Practitioner. No significant reduction in the risk of falling was demonstrated based on the reduction in the number of fallers over a 1-year period, compared to usual care provided by General Practitioners.

It appears that the approach to providing the falls prevention interventions may be one of the most important factors in determining the success of a trial. A common feature of the PROFET trial by Close et al. (64), and the trial by Davison et al. (88), was to provide “blanket” referrals for allied health assessments, specifically occupational therapy in the PROFET trial and physiotherapy and occupational therapy in the Davison et al. study. Both of these studies incorporated a comprehensive medical assessment followed by allied health assessment and treatment. Our study also provided a comprehensive medical assessment, however, the referrals to allied health professionals were only pursued if the participant agreed to the intervention. This approach aligned with what is standard clinical practice, but did affect the compliance with the recommendation to have allied health interventions, and affected referrals to exercise based interventions and home hazard assessments in particular. Similarly, when the successful methodology of the PROFET trial was replicated in the Netherlands, the intervention was no longer successful. (94) The Dutch healthcare system requires that a General Practitioner makes referrals to allied health professionals, and therefore the research team were not directly responsible for the implementing the falls prevention interventions, or maintaining compliance with them.

In terms of studies with an Australian based cohort, Russell et al. recruited 712 older people from the E.D. at seven sites, and combined screening and risk assessment with provision of falls prevention interventions. (65) They found a significant reduction in the rate of falls, but not the risk of falling over 1 year in the active intervention group. The approach to the "control" arm may have reduced the size of the effect of the active intervention arm as advice and education was provided to participants randomised to the "control" arm – this was not usual care. In our study the size of the effect of the "falls clinic" arm may also have been affected by the active General Practitioner intervention arm it was compared against. However, it remains possible that rather than weakening the effect of the specialist-led hospital based clinic intervention, the enhanced General Practitioner coordinated care was the more successful intervention. It is interesting that a study conducted in Australia found that an intervention similar to our enhanced General Practitioner coordinated care intervention was unable to demonstrate a reduction in the risk of falls. (117) The General Practitioner was provided with a risk assessment and suggested interventions. The success of the enhanced General Practitioner coordinated care intervention in this study may lie in the fact that the recommendations were made by the research Geriatrician and that recommendations for falls prevention interventions were accompanied by instructions on how to access these interventions.

In terms of the specific falls prevention interventions recommended in this study, it is interesting to note that the exercise interventions most commonly used in the enhanced General Practitioner care intervention were the Otago exercise program provided both at home and in a group session in the Day Hospital. There is robust evidence of the effectiveness of the Otago based exercise program in preventing falls in community dwelling older people, especially women over the age of 80 years. (196, 200-202) Participants recommended to receive Tai Chi as the falls prevention exercise intervention experienced a delay to commencement of their exercise therapy, which may have influenced the effectiveness of this intervention. The Otago based programs were available for participants to commence therapy within days of referral for the service. Also worth noting is that there was a difference in the types of exercise strategies used in each intervention arm, with the General Practice intervention arm receiving Otago based exercises at home in a greater proportion, and the CONFABS clinic intervention arm receiving more Tai Chi.

As discussed above one of the major limitations of the study was the inability to reach the sample size we required based on our power calculations. In an attempt to ensure that a standardised approach to falls prevention strategies was implemented for both the CONFABS clinic intervention arm and the enhanced General Practitioner coordinated care intervention arm, a single site was chosen for the study. Over 5,000 older people were reviewed over the 3-year recruitment period. Only 8% fulfilled the eligibility criteria so that they could be contacted to be invited to participate in the study. Of the 5,270 people identified only 1.5% were randomised and included in the study. This highlights the difficulty in recruiting older people to participate in clinical trials. Russell et al. had a similar approach to the identification of older people in the E.D. and were able to recruit 712 participants (18%) from 7 sites from a potential 3,883 older people. (65) It may be a reflection of the frailty of the population that we were unable to recruit our target sample. The inclusion / exclusion criteria are similar to those published in the other multifactorial trials described in the Cochrane review. (80) The inclusion of participants with an MMSE score of between 20 and 24 out of 30 is a deviation from the methodology typically reported in these types of clinical trials. There is a general consensus that older people with cognitive impairment may not gain the same benefit from falls prevention interventions. However, with a significant local population who were not born in an English-speaking country, an MMSE of >24 out of 30 may not have been a true reflection of their cognitive ability and risked excluding participants who may have gained benefit. Due to resource limitations we were unable to provide participant trial information in languages other than English to be able to extend recruitment to non-English speaking older people. This is a significant limitation in a multi-lingual country such as Australia.

The strength of this study is that the intervention was designed to reflect the development of some falls prevention services and test, in part, the effectiveness of a “falls clinic”. Hill et al. reported on the models of falls services in Australia in 2000, and there was great variation. (126) The design of our intervention was to permit it to be brought to the participant’s home, to be less resource intensive in terms of staff in the clinic, and to be less time consuming for the participant. The participant was permitted to consent to all further interventions as would be standard clinical practice. The inclusion / exclusion criteria were also designed to be not so restrictive as to allow as many of the potential “real world” patients to be included as possible, yet we still had difficulty recruiting participants into the trial.

6.5 Conclusions

We have been unable to demonstrate that a multifactorial falls prevention intervention designed to reflect what would constitute a falls clinic in the "real world", is effective at reducing falls or the risk of falling in older people living in the community. However, we did demonstrate that care coordinated by a General Practitioner may be successful in reducing the risk of falling. The intervention enhanced standard care by the General Practitioner by providing a falls risk assessment by a specialist trained nurse, recommendations of falls prevention interventions made by a Geriatrician, and advice on how access these interventions in the community. The small sample size of the study is its major limitation. This highlights the difficulty in engaging older people in clinical research, especially within populations with large proportions of people who do not speak English as their first language. In the design of falls prevention interventions, it may be important not to have the falls assessment considered separate to the intervention to ensure maximum compliance with allied health provided falls prevention interventions.

Chapter 7: Thesis summary, discussion and conclusions

7.1 Long term outcomes for older people who attended the Emergency Department with a fall.

The evidence regarding the outcomes for older people who have presented to the Emergency Department (E.D.) with a fall or fall-related problems, in terms of re-attendance at the E.D. with falls or fall injuries, or death is based on limited evidence. Previous cohort studies have focussed on short-term outcomes, usually examining re-attendance rates or mortality at 1 year. This thesis aimed to examine the association between risk factors for falls and re-attendance to the E.D. with a fall or fall injury and mortality over a 5-year follow-up period.

In chapter 2 we described a prospective cohort study of a group of older people aged 65 years and older, who had an index attendance at an E.D. with a fall or fall-related problem. This group of older people continued to fall and present to the E.D. for treatment, with the majority falling in the first 3 years after their index falls presentation. The 1-year re-attendance rate at the E.D. due to falls of 20% was higher than that reported in a cohort, who were aged 40 years and older. (140) A further U.S. based retrospective study reported an all cause re-attendance rate of 25% at 1 year in a similarly aged cohort to our study. (77) Our study demonstrates that older people who present to the E.D. with a fall or fall-related problem will continue to fall unless they receive targeted falls prevention interventions. It also suggests that this ongoing risk over 3 to 5 years for an E.D. representation with a fall or fall-related problem, may warrant a change to the focus of falls prevention in primary care to be included as part of chronic disease management.

When mortality was assessed in this same cohort, at 1-, 3- and 5-year follow-up periods, predictably, it increased with time, with up to 20% of participants dying in the first year following an E.D. attendance with a fall, and over 50% dying by the end of the 5-year follow-up period. Therefore, it could be argued that falls-related E.D. presentations should receive more focussed attention in terms of prevention strategies, and not considered by clinicians and older people as a normal part of ageing. However, with a significant proportion of the cohort dying within 5 years, it also raises the question of whether falls prevention interventions should be more targeted. Can clinicians determine which older people attending the E.D. with a fall, are more likely to gain benefit from falls prevention interventions? Is there a way of selecting those older people who are at a greater risk of death following a fall, so as to be able to provide supportive interventions to support them in their frailty?

In developing a targeted approach to falls prevention after attending the E.D. with a fall or fall-related problem, clinicians look to risk factors in order to select those with greatest need. These studies raise an interesting conundrum. Being aged 80 years and older and requiring assistance with ADLs, both predicated further E.D. attendances due to falls, and mortality. Cognitive impairment was associated with increased mortality, but not with further falls. Cognitive impairment has been used as an exclusion criterion for many falls prevention intervention clinical trials included in the Cochrane reviews, and may serve as a discriminating risk factor in allocating access to falls prevention interventions. (80) However, we would argue that the limitations associated with the determination of cognition in these studies, depending on non-falls trained clinicians' reporting of cognitive impairment and falls, based on self-report or clinical records, is not robust and potentially excludes older people who would benefit from interventions. At a minimum, any assessment of cognition would require the use of formal cognitive testing using validated mental test scores with clinical applicability.

The risk factors identified above, could form the basis for a simplified falls risk profile to help identify those older people who attend the E.D. with a fall or fall-related problem, who should have falls prevention interventions implemented on discharge from the E.D. It could also be argued that with risk maintained over 5 years, that this group of older people should have ongoing repeated risk assessment in primary care. In terms of the research and policy agenda around falls prevention in older people, we would argue that the next step should be to implement clinical trials of community based falls prevention interventions, targeting older people attending the E.D. with a fall or fall-related problem, using the risk factors identified to determine who receives the intervention. The design of such trials would necessitate a more robust assessment of function in terms of ADLs, and cognition, using validated and clinically appropriate scales which could be easily incorporated into standard clinical care in the E.D., to differentiate those older people who may represent the high mortality risk group. It is likely that increasing disease burden was a variable which is closely related to physical frailty and dependence in ADLs in our study cohort, accounting for the lack of association with assistance with ADLs at 5 years. There are clear links between both increasing dependence and disease burden and frailty. (145, 203) Clearly there t are a group of older people who are attending the E.D. with impaired mobility, poor cognition, and serious medical illnesses such as malignancy and heart failure, who are at greater risk of mortality and should receive interventions targeting their frailty, disability and cognition with a focus on their quality of life and even wishes for end of life care, rather than focusing only on falls prevention.

These findings also suggest that older people aged 80 years and older, living in the community and who need assistance with ADLs, warrant particular focus in terms of falls prevention interventions. It is however a challenge to deliver proven falls prevention to people aged 80 years and older, with disability in their activities of daily living. Campbell et al, showed that it was possible to effectively deliver home based exercise programs to people of this age group. (200) It has also been shown that occupational therapy assessments can be conducted in people of this age group. (204) One of the challenges is how to deliver a detailed medical review and have someone organise referral to the right people to deliver these interventions. This is explored further in the clinical trial described in chapter 6.

7.2 Predictors for falls and hospitalisation due to falls injuries in community living older men.

In section 1.4.2 the differences in risk predictors for falls between community dwelling older men and older women based on what was known from cohort studies were described. There is limited data specifically examining risks for falls in older men and our aim was to fill the gaps in this knowledge with respect to risk factors associated with all falls and hospitalisation due to fall injuries.

7.2.1 Risk factors for falls in community dwelling older men.

This study on a cohort of men living in a major metropolitan centre in Australia builds on the evidence that already exists on the risk predictors for falls in community dwelling older men. In the multivariate analysis of risk predictors for falls at 2 years of follow-up, history of at least one fall in the previous 12 months was the most significant predictor of future falls. It could be argued that older people who have had a fall, regardless of injury, should have a falls risk assessment and targeted falls prevention interventions irrespective of any other risk factors. A prior history of falls was associated with a 3-fold increased risk of falls in 2 years of follow-up, a finding that compliments what has been reported in other male only cohorts

(53), and in mixed cohorts and female only cohorts reported in a previous meta-analysis (12). This suggests that asking about history of falls in the previous 12 months may be the most important questions to ask when assessing risk of falls in older men in the community. Therefore, the message to General Practitioners in terms of falls prevention in men, could be simplified to one question asking men “Have you fallen in the past 12 months?”

When looking at other falls risk factors, it is also worth noting that there is considerable overlap between the risk factors predicting further falls in this group of older men living in the community, and those seen in the cohort of older people attending the E.D. with a fall or fall-related problem, discussed in chapters 2 and 3. As with the E.D. cohort, being 80 years and older and reporting disability in ADLs were both associated with fall over the 2-year follow-up period. A history of falls had a strong influence on the multivariate analyses performed as discussed in chapter 5, with some previously recognised risk factors being retained or being removed from the multivariate models depending on the inclusion of history of falls. Additional risk factors such as being single, having dementia, having more than 3 comorbidities and reduced visual acuity were also predictors of further falls at 2 years, in a model which did not include history of falls. In the multivariate model which included history of falls, ADL disability was no longer significantly associated with falls, and appeared to be eliminated from the model by the significant association with polypharmacy (use of more than 4 medications) and poor social satisfaction based on Duke social satisfaction score. Impairment in physical function based on physiological parameters and association with the drug burden index, has been demonstrated in the CHAMP study cohort previously. (205) Gnjidic et al. reported on the use of the drug burden index, a measure of total exposure to anticholinergic and sedative medications, and tests of gait speed, static and dynamic balance in older men. This was associated with slower walking speed, and poorer balance scores, in addition to reduced functional independence. This therefore highlights the association between function and medications, particularly anticholinergic and sedative drugs. There is also probable collinearity between low scores on Dukes social satisfaction scale, and living at home alone, both of which were associated with further falls in our study.

A simplified risk assessment protocol to predict further falls in older men living in the community, is proposed incorporating all these risk factors. We would argue that in men over the age of 70 years who have not had a history of falls in the preceding 12 months, targeted falls prevention interventions should be provided to those who report disability in ADLs, those with dementia or poor visual acuity, those with more than 3 comorbidities and those taking more than four medications. Men living alone, and those who report feelings of social isolation should also be targeted for falls prevention interventions.

Analyses were repeated examining the association between falls and a variety of physical parameters when adjusted for age, as it was felt that risk factors more strongly associated with falls such as age > 80 and dementia may have suppressed the effect of these measures on risk of falls. In these analyses, only poor performance in the chair stand test was associated with increased risk of falling in models with and without the history of falls variable. The MrOS study on the other hand association between impaired grip strength and falls, but did not demonstrate an association with the chair stand test. (54) Reduced leg power, and inability to perform the narrow walk test was also reported as associated with increase in falls risk in the MrOS study, but the exact magnitude of the association was not reported. The findings in this chapter would suggest that perhaps only one measure of strength or balance, such as the chair stand test, is required when assessing falls risk.

An important focus for further research lies in the reasons for men who were born in a non-English-speaking country experiencing fewer falls, than other Australian men. When linked to measures of social participation, and alcohol intake, is there something about the Mediterranean culture which reduces the risk of falling in men? Can some of the differences be explained by recall bias (178) or reduced healthcare utilisation? Are there any lifestyle factors that these men participate in, which can mitigate risk in other men? These are all questions which could inform the falls research agenda.

7.2.2 Predictors for hospitalisation due to fall injuries in community living older men

There are limitations in relying on self-report of falls so to understand more about risk factors for falls, the risk factors for hospitalisations due to falls injury was examined in the CHAMP cohort. Hospitalisations due to falls injury was determined from robust health department data and follow-up was for 10 years. We were interested in whether the risk factors for falls injury hospitalisations would be different for the same outcome at 2 years. The association between fall injury hospitalisations and fall risk factors was examined both including and excluding history of falls in the analysis as it was anticipated that history of falls would have the greatest effect on risk of hospitalisation. There is limited cohort study data examining risk factors for fall hospitalisations with or without associated injury. Only one previous prospective study has reported on the risk of fall injury hospitalisation in a cohort of older people living in the community. (147) Therefore our study adds valuable information on this important outcome.

Prior history of falls in the previous 12 months was significantly associated with time to first fall injury hospitalisation at 10 years (HR 1.48; 95% C.I. 1.09 – 1.99), but was not significant when the analysis was restricted to 2 years (HR 1.31; 95% C.I. 0.98 – 1.74). This may have been due to reduced power at 2 years where there were less outcome events.

The strongest risk factor predicting fall injury hospitalisation at 2 years and 10 years was dementia, associated with a more than doubled risk. No previous cohort study has looked at the effect of dementia on fall related injures over such a long follow-up period. What does this mean for further falls prevention studies since many of the multifactorial falls prevention interventions in the Cochrane excluded participants with cognitive impairment? We argue that falls prevention intervention studies which specifically target older people with cognitive impairment are now an imperative.

Polypharmacy, defined as using more than 4 medications, had a greater association with fall injury hospitalisation at 2 years and 10 years with a 35% to 66% increased risk in the CHAMP cohort. This finding is the first large prospective study to show a definite association between polypharmacy and a falls related injuries outcome in men. Previous studies have demonstrated an association between polypharmacy and falls in female only and mixed gender cohorts. (15, 182) Physical parameters associated with fall injury hospitalisation were poor grip strength and slow walking speed when adjusted for age and fall history. These parameters have been shown to be associated with falls in other prospective cohort studies, including in those with male only cohorts. (184, 185) There are clear links between poor physical function, the use of anticholinergic and sedative medications and poor function. (205) Perhaps then, there is a role for pharmacists to link with General Practitioners when dispensing multiple medications to frail older men, and discuss falls prevention interventions. Is the local pharmacy an unmined area for potential falls prevention education? Previous studies make it clear that rationalising medications, even in the face of increased risk of falls, is difficult to achieve. (119, 120)

Men who were born in a non-English speaking country were at lower risk of hospitalisations due to falls consistent with what was found when looking at any falls outcome. As mentioned above there is a possibility that when it comes to self-report of falls there are differential reporting biases based on where the men are born. Fall injury hospitalisation data however is not going to be biased by country of birth which suggests that men who are born in a non-English speaking country are truly at lower risk of hospitalisation due to falls. The multivariate analyses suggest that this cannot be explained by strength, gait or balance measures. Nor can the finding be explained by health-related factors. The CHAMP investigators are very interested in exploring the reasons for differences in outcomes based on country of birth are in the process of exploring this further in the CHAMP cohort including looking at the influence of diet and nutrition and learning more about the influence of physical activity and lifestyle on outcomes such as falls and hospitalisations. Men who were still working when assessed at the baseline assessment were also at reduced risk for fall injury hospitalisation 10 years later. It would be of value to explore what the effect of continued work into older age and the influence of work related activity, leisure related activity and housework on falls and falls related injuries.

7.3 A randomised controlled trial comparing a specialist-led, hospital-based multifactorial falls prevention intervention and enhanced G.P. coordinated falls prevention intervention.

The final study discussed in this thesis examined the outcome of a randomised controlled trial which compared the two types of interventions designed to reduce the risk of further falls in a cohort of older people living in the community - a specialist-led, hospital-based "falls clinic" versus an enhanced G.P. coordinated intervention. The aim of the study was to determine if a hospital-based falls service, which mimicked what exists as "falls clinics" in a "real world" clinical setting would reduce the risk of further falls and reduce the number of fallers. Alternatively, would G.P. coordinated care be just as effective as a "falls clinic" in preventing falls if the G.P. had someone else perform the time-consuming aspect of a comprehensive falls risk assessment and the G.P. was provided with information about how to organise intervention for their patients?

Participants were followed over 1 year. Based on an intention to treat analysis the rate of falls was significantly increased in the CONFABS clinic intervention group compared to the enhanced G.P. intervention group, with the rate of falls increased by 2.4-fold (IRR 2.39; 95% C.I. 1.09 – 5.27). The risk of falling was also increased by 1.8-fold (RR 1.10 – 2.96). There was no significant difference in the rate of injurious falls or in the number of fractures in each of the intervention arms.

The results of this study need to be interpreted with caution as we were unable to recruit the number of participants we wanted based on sample size calculations. We identified more than 5,000 older people who attended the E.D. with a fall, or who were screened at high falls risk using the FRAT risk assessment tool, but were only able to recruit a small fraction to the clinical trial. The recruitment strategy for this trial was designed to be as inclusive as possible, and to reflect the older people who present to the E.D. with a fall, but still meant that a large proportion of potential participants were excluded from the study. We did not include people who did not have sufficient English ability to understand the study, whereas in day –to-day clinical practice, provision of information and access to education and services for those who do not speak English is important for the successful implementation of fall prevention interventions. It may be a reflection of the frailty of the population that we were unable to recruit our target sample. The inclusion / exclusion criteria are similar to those published in the other multifactorial trials described in the Cochrane review. (80) The inclusion of participants with an MMSE score of between 20 and 24 out of 30 is a deviation from the methodology typically reported in these types of clinical trials. There is a general consensus that older people with cognitive impairment may not gain the same benefit from falls prevention interventions. However, with a significant local population who were not born in an English-speaking country, an MMSE of >24 out of 30 may not have been a true reflection of their cognitive ability and risked excluding participants who may have gained benefit. Due to resource limitations we were unable to provide participant trial information in languages other than English to be able to extend recruitment to non-English speaking older people. This is a significant limitation in a multi-lingual country such as Australia.

The ability to demonstrate a reduction in the falls in the "falls clinic" intervention arm may have been affected by both compliance with falls prevention strategies and the success of the enhanced G.P. coordinated care intervention. The design of the intervention was that participants were able to decide for themselves if they wanted the allied health interventions, such as strength and balance exercises and Occupational Therapy home hazard assessments as would happen in everyday clinical practice. This varied from positive clinical trials that had mandatory allied health interventions. (64, 88) Previous studies have demonstrated a lack of effectiveness when depending on the participant's G.P. to coordinate falls prevention strategies. (89, 94) One explanation of our study finding is that the success of the G.P coordinated intervention arm may have been because the G.P. found it easier to organise and implement falls prevention strategies once the time-consuming tasks of falls risk assessment, providing information on how to refer to community based allied health services and providing information to patients were performed by the research team. It is interesting that a study conducted in Australia found that an intervention similar to our G.P. coordinated care arm did not reduce the risk of falling when compared to a home visit which did not provide interventions or education. (117)

The strength of this study is that the intervention was designed to reflect the development of some falls prevention services and test, in part, the effectiveness of a "falls clinic". The design of our intervention was to permit it to be brought to the participant's home, to be less resource intensive in terms of staff in the clinic, and to be less time consuming for the participant. However, the most important factor in the implementation of falls prevention strategies may be not to have the falls assessment considered separate to the intervention to ensure maximum compliance with allied health provided falls prevention interventions.

7.4 Concluding thoughts and implications

In this thesis it has been shown that there are a number of difficult issues to consider and weigh up when developing falls prevention services. A clear theme is that having a fall places the older person at risk of further falls and hospitalisation. Is it therefore adequate to direct all older people who have had a fall, either in the community or attending an E.D. to falls prevention interventions? The dilemma of shared risk factors for mortality and further falls in older people attending the E.D. with a fall, suggests that perhaps it is better not place too much emphasis on factors associated with mortality in this group and focus on how to provide proven interventions to as many people as possible within resource limitations.

In the community living older male cohort we studied, their falls risk factors were similar to that seen in cohorts of older women. Therefore, gender specific risk assessments do not appear to be necessary. One issue clearly outlined by these studies relates to increased falls risk associated with cognitive and dementia. Further research into strategies to address this risk is a high priority for falls researchers.

And finally, the clinical trial, despite the limitation of being under-powered, did suggest that falls prevention strategies could be implemented in General Practice when primary care is supported in clinical decision making and in the provision of evidence-based intervention strategies, such as exercise. Perhaps the success, is driven by the relationship between the primary care physician and their patients, and therefore the willingness of the older person to accept falls prevention advice from a health professional they trust. The role of the specialist then is to provide advice and support in clinical risk assessment and decision-making.

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Appendix

Appendix A

Concord Falls and Bone Service (CONFABS) Study

Decision aid for falls prevention interventions – CONFABS study

Risk factor	Interventions and/or investigations
Gait impairment and/or balance impairment - Abnormal gait pattern. - Inability to perform STS-5. - Inability to perform 4 stage stance test. - Timed Up and Go Test ≥14 secs.	Exercise interventions: 3 available options, with the choice based on Timed Up and Go Test (TUGT) result, physiotherapist clinical discretion and patient preference to maximize compliance with a falls prevention exercise intervention. 1. <u>Otago based home exercise program.</u> Participants with a TUGT ≥14 seconds, unwilling or unable to attend group based exercises. Dedicated community based physiotherapist provided service. Physiotherapist assessments, up to 6 sessions at weeks 1, 2, 4, 6, 10, 14. Participants are provided with an individualized home exercise program based on the Otago exercise program. The elements of the flexibility, strength and balance exercises are tailored to the needs of the participant. Resistance exercises are achieved using resistance bands (not ankle weights). Walking exercise included if appropriate. Physiotherapists must complete online training in providing the Otago exercise program. Week 1 visit for assessment, development of tailored exercise plan and goal setting – at least 1-hour duration. Weeks 2, 4, 6 and 10 for education, progression of exercises and monitoring of compliance – 30 minutes duration. Week 14 for assessment of goals achieved and re-education. Progression of exercises as per the guidelines for the implementation of the Otago exercise program. Adverse events, such as falls associated with performing the exercises to be recorded by the physiotherapist as part of the clinical record, and reported as per the Sydney Local Health District guidelines for reporting clinical incidents. All falls related to performing the exercises prescribed will be recorded as an adverse event to the supervising Human Research and Ethics Committee.

STS-5 – sit to stand test; TUGT – timed up and go test; GDS – Geriatric Depression Scale; SSRI – selective serotonin reuptake inhibitor; MMSE – Mini-mental scale examination; BMD – bone mineral density; DEXA – dual energy densitometry; FBC – full blood count; EUC – electrolytes, urea, creatinine; LFTs – liver function tests; CMP – calcium magnesium phosphate; CRP – C-reactive protein; TFTs – thyroid function tests; PTH – parathyroid hormone;

Decision aid for falls prevention interventions – CONFABS study

Risk factor	Interventions and/or investigations
Gait impairment and/or balance impairment	2. Otago based group exercise program (Day Hospital). Participants with a TUGT ≥14 seconds, willing and able to attend group based exercises. Dedicated Day Hospital based physiotherapist provided service. Physiotherapist assessments, up to 6 sessions at weeks 1, 2, 4, 6, 10, 14. Participants are provided with an individualized Day Hospital based exercise program based on the Otago exercise program. The elements of the flexibility, strength and balance exercises are tailored to the needs of the participant and are completed in group sessions at 6 stations in the Day Hospital. Resistance exercises are achieved using resistance bands (not ankle weights). Walking exercise is included if appropriate. Participants are provided with educational material to continue Otago exercises at home. Physiotherapists must complete online training in providing the Otago exercise program. Week 1 visit for assessment, development of tailored exercise plan and goal setting – at least 1-hour duration. Weeks 2, 4, 6 and 10 for education, progression of exercises and monitoring of compliance – 1-hour group. Week 14 for assessment of goals achieved and re-education. Progression of exercises as per the guidelines for the implementation of the Otago exercise program. Additional telephone contact between the physiotherapist and the participant will be at the clinical discretion of the physiotherapist. Adverse events, such as falls associated with performing the exercises to be recorded by the physiotherapist as part of the clinical record, and reported as per the Sydney Local Health District guidelines for reporting clinical incidents. All falls related to performing the exercises prescribed will be recorded as an adverse event to the supervising Human Research and Ethics Committee.

STS-5 – sit to stand test; TUGT – timed up and go test; GDS – Geriatric Depression Scale; SSRI – selective serotonin reuptake inhibitor; MMSE – Mini-mental scale examination; BMD – bone mineral density; DEXA – dual energy densitometry; FBC – full blood count; EUC – electrolytes, urea, creatinine; LFTs – liver function tests; CMP – calcium magnesium phosphate; CRP – C-reactive protein; TFTs – thyroid function tests; PTH – parathyroid hormone;

Decision aid for falls prevention interventions – CONFABS study

Risk factor	Interventions and/or investigations
Gait impairment and/or balance impairment	3. Tai Chi based group exercise program (Day Hospital) Participants with a TUGT <14 seconds, willing and able to attend group based exercises. Dedicated Day Hospital based physiotherapist provided service. 8-week course duration – 1-hour session, once per week. Participants encouraged to complete 2 courses of Tai Chi classes (16 weeks in total). Maximum of 8 participants per class. Walking exercise is also encouraged between classes. Physiotherapists must complete face-to-face training in providing a Tai Chi exercise program. A 1-hour visit for assessment, trial of Tai Chi exercises and goal setting to be completed prior to commencing Tai Chi classes. Additional telephone contact between the physiotherapist and the participant will be at the clinical discretion of the physiotherapist. Adverse events, such as falls associated with performing the exercises to be recorded by the physiotherapist as part of the clinical medical record, and reported as per the Sydney Local Health District guidelines for reporting clinical incidents. All falls related to performing the exercises prescribed will be recorded as an adverse event to the supervising Human Research and Ethics Committee.

STS-5 – sit to stand test; TUGT – timed up and go test; GDS – Geriatric Depression Scale; SSRI – selective serotonin reuptake inhibitor; MMSE – Mini-mental scale examination; BMD – bone mineral density; DEXA – dual energy densitometry; FBC – full blood count; EUC – electrolytes, urea, creatinine; LFTs – liver function tests; CMP – calcium magnesium phosphate; CRP – C-reactive protein; TFTs – thyroid function tests; PTH – parathyroid hormone;

Decision aid for falls prevention interventions – CONFABS study

Risk factor	**Interventions and/or investigations**
Polypharmacy: Use of more than 4 medications.	Medication review as part of the comprehensive geriatric assessment. Advice to the General Practitioner on the cessation of any medications considered unnecessary. Counselling to participant on the cessation of any medications considered unnecessary. In-home pharmacist medications review if further counselling on medication cessation required, or additional or obsolete medications reported to be in the participant's home. Compliance with medication changes at each CONFABS clinic assessment.
Falls risk increasing medication Any of antipsychotics, antidepressants, benzodiapezines or other sedative hypnotics, and antihypertensives.	Medication review as part of the comprehensive geriatric assessment. Advice to the General Practitioner on the cessation of any medications considered unnecessary. Counselling to participant on the cessation of any medications considered unnecessary. Geriatrician supervised dose reduction and cessation of psychotropic drugs – especially targeting BZDs, antipsychotics and antidepressants. Consultation with and advice to specialist physicians or psychiatrists who may also be involved in the prescription of such medications, on the cessation of any medications considered unnecessary. Compliance with medication changes at each CONFABS clinic assessment.

STS-5 – sit to stand test; TUGT – timed up and go test; GDS – Geriatric Depression Scale; SSRI – selective serotonin reuptake inhibitor; MMSE – Mini-mental scale examination; BMD – bone mineral density; DEXA – dual energy densitometry; FBC – full blood count; EUC – electrolytes, urea, creatinine; LFTs – liver function tests; CMP – calcium magnesium phosphate; CRP – C-reactive protein; TFTs – thyroid function tests; PTH – parathyroid hormone;

Decision aid for falls prevention interventions – CONFABS study

Risk factor	Interventions and/or investigations
Postural hypotension: - History suggestive of postural hypotension. - Demonstrated 20mmHg drop in systolic blood pressure on standing from supine. - Demonstrated 10mmHg drop in diastolic blood pressure on standing from supine.	Medication review as part of the comprehensive geriatric assessment, specifically targeting medications which contribute to postural hypotension, such as antihypertensives, diuretics and anticholinergics. Cessation of any medications contributing to postural hypotension. Counselling to participant on the cessation of any medications considered unnecessary. Tailored advice on the management of postural symptoms from the following recommendations – slowed rising on standing from lying or sitting, ankle pump exercises, use of lower limb compression stockings, increased morning fluid intake, increased overall fluid intake, avoidance of caffeinated drinks, increased dietary salt intake if increased fluid intake not successful and specific treatment with fludrocortisone. Additional specific investigations as for the assessment of syncope (see below) if persistent symptoms despite maximum therapy.
Syncope or recurrent unexplained falls: - Documented syncopal episode. Unexplained falls with a history of loss of consciousness or confusion.	Medication review as part of the comprehensive geriatric assessment. Advice to the General Practitioner on the cessation of any medications considered unnecessary. Counselling to participant on the cessation of any medications considered unnecessary. Additional investigations: 24hour ambulatory blood pressure monitor. Transthoracic echocardiogram. 24- hour ambulatory holter monitor. Referral to specialist syncope services for assessment and additional investigations such as event recorder, implantable loop recorder, tilt table testing and/or carotid hypersensitivity testing (carotid sinus massage (CSM)), cardiac electrophysiology studies.

STS-5 – sit to stand test; TUGT – timed up and go test; GDS – Geriatric Depression Scale; SSRI – selective serotonin reuptake inhibitor; MMSE – Mini-mental scale examination; BMD – bone mineral density; DEXA – dual energy densitometry; FBC – full blood count; EUC – electrolytes, urea, creatinine; LFTs – liver function tests; CMP – calcium magnesium phosphate; CRP – C-reactive protein; TFTs – thyroid function tests; PTH – parathyroid hormone;

Decision aid for falls prevention interventions – CONFABS study

Risk factor	Interventions and/or investigations
Home environmental hazards: - If falls caused by home hazard. - If home hazards identified during in-home baseline assessment.	Occupational Therapist (OT) home environmental hazard assessment. Dedicated community based OT service. Trained in-home falls hazard assessment. Home modifications – 1. Recommendations made by OT. 2. Referral to existing community based services for installation of home modifications through existing Aged Chronic Care & Rehabilitation process for the Inner West of Sydney. 3. No additional funds provided for modifications. Advice on appropriate aids and appliances – no additional funds provided for purchase of aids or appliances – equipment could be obtained on short-term loan through Sydney Local Health District equipment loan pool. Application for a personal alarm.
Visual impairment: - Legally blind - Visual acuity <6/9 on Snellen chart Demonstrated visual field defect	Optometrist referral if change in lens prescription required. Optometrist referral if no recent assessment and poor visual acuity on testing. Single vision lens use for outdoor mobilizing. Ophthalmologist referral if recent significant deterioration in vision, or cataracts / glaucoma not reviewed in the past 12 months Referral to ophthalmologist for expedited first cataract extraction. OT home environmental assessment for those with severe visual impairment.

Decision aid for falls prevention interventions – CONFABS study

Risk factor	Interventions and/or investigations
Depression: - GDS score >11 / 15 accompanied by symptoms of depression	Consider use of antidepressants – SSRI as first line agent. Referral to psychiatrist for review.
Cognitive impairment: - MMSE score < 25/30	Interventions according to other risk factors identified. Referral for community services for assistance with ADLs if necessary. Referral to specialist cognitive disorders clinic for further assessment.
Inappropriate footwear: - Any shoes which were ill-fitting, did not have a non-slip sole, or without a secure fastening.	Advice on appropriate footwear. Podiatrist referral if orthotics required.
Foot problems: - Conditions which alter the gait pattern or cause pain on walking or standing.	Podiatrist referral. Advice on appropriate footwear. Specialist referral for treatment if necessary such as orthopaedic surgeon or vascular surgeon.

STS-5 – sit to stand test; TUGT – timed up and go test; GDS – Geriatric Depression Scale; SSRI – selective serotonin reuptake inhibitor; MMSE – Mini-mental scale examination; BMD – bone mineral density; DEXA – dual energy densitometry; FBC – full blood count; EUC – electrolytes, urea, creatinine; LFTs – liver function tests; CMP – calcium magnesium phosphate; CRP – C-reactive protein; TFTs – thyroid function tests; PTH – parathyroid hormone;

Decision aid for falls prevention interventions – CONFABS study

Risk factor	Interventions and/or investigations
Fear of falling: Answers positively when asked "Are you afraid of falling".	Falls prevention education booklet. Personal alarm if not already available.
Risk of osteoporosis: - Family history of osteoporosis - Oral corticosteroid use - Rheumatoid arthritis - Hyperthyroidism / hyperparathyroidism - Coeliac disease - Chronic liver or kidney disease - Current smoker - Excess alcohol intake - Low Vitamin D exposure - Low dietary calcium intake - Sedentary lifestyle	Investigations: Screening blood tests – FBC / EUC / LFTs / CMP / Haematinics / CRP / TFTs / 25-Hydroxy Vitamin D / PTH DEXA scanning. Thoracic / lumbar / sacral x-rays – if BMD on DEXA scan is spuriously high or if significant degenerative spine changes clinically. Serum and urine protein electrophoresis (and testosterone level in males) if suspected secondary osteoporosis suspected. International Osteoporosis Foundation calcium intake calculator. Treatment: Calcium supplements to ensure daily intake 1200mg / day. Vitamin D supplements – ergocalciferol 1000IU daily maintenance for insufficient range; 4000IU daily x 1 month then 1000IU daily. maintenance for deficient range; alfacalcidol 0.25 microgram daily in renal disease. If osteoporosis diagnosed: Oral risedronate 35mg weekly Zoledronic acid 4mg annual infusion for those intolerant of oral bisphosphonates; or those with deteriorating BMD despite treatment

STS-5 – sit to stand test; TUGT – timed up and go test; GDS – Geriatric Depression Scale; SSRI – selective serotonin reuptake inhibitor; MMSE – Mini-mental scale examination; BMD – bone mineral density; DEXA – dual energy densitometry; FBC – full blood count; EUC – electrolytes, urea, creatinine; LFTs – liver function tests; CMP – calcium magnesium phosphate; CRP – C-reactive protein; TFTs – thyroid function tests; PTH – parathyroid hormone;

Decision aid for falls prevention interventions – CONFABS study

Risk factor	**Interventions and/or investigations**
Known osteoporosis	Investigations to be completed if not performed in the preceding 2 years: Screening blood tests – FBC / EUC / LFTs / CMP / Haematinics / CRP / TFTs / 25-Hydroxy Vitamin D / PTH level DEXA scanning. Thoracic / lumbar / sacral x-rays – if BMD on DEXA scan is spuriously high or if significant degenerative spine changes clinically. Serum and urine protein electrophoresis (and testosterone level in males) if suspected secondary osteoporosis suspected. International Osteoporosis Foundation calcium intake calculator. Treatment: Calcium supplements to ensure daily intake 1200mg / day. Vitamin D supplements – ergocalciferol 1000IU daily maintenance for insufficient range; 4000IU daily x 1 month then 1000IU daily. maintenance for deficient range; alfacalcidol 0.25 microgram daily in renal disease. If osteoporosis diagnosed: Oral risedronate 35mg weekly Zoledronic acid 4mg annual infusion for those intolerant of oral bisphosphonates; or those with deteriorating BMD despite treatment

STS-5 – sit to stand test; TUGT – timed up and go test; GDS – Geriatric Depression Scale; SSRI – selective serotonin reuptake inhibitor; MMSE – Mini-mental scale examination; BMD – bone mineral density; DEXA – dual energy densitometry; FBC – full blood count; EUC – electrolytes, urea, creatinine; LFTs – liver function tests; CMP – calcium magnesium phosphate; CRP – C-reactive protein; TFTs – thyroid function tests; PTH – parathyroid hormone;

Appendix B

Standardised advice letter for General Practitioners on falls risk assessment and advice on investigations and falls prevention interventions.

CONFABS study

Concord Falls and Bone Service study

[Date]

Dr [insert GP name and address]

Dear Dr [insert GP name],

Re: [insert participant name, address and date of birth]

The above named [lady/gentleman] has agreed to participate in the CONFABS study clinical trial. As part of the clinical trial [s/he] has had an in-home fall and clinic based risk and osteoporosis assessment. The falls [he/she] describes occur generally when [give details].

The risk factors identified during this assessment are:

- Gait and/or balance impairment – [give details of specific neurological, muscular or vestibular issues affecting gait or balance].
- Polypharmacy – more than 4 medications
- Use of fall risk increasing medications – [name]
- Symptoms of postural hypotension
- Demonstrated postural hypotension – [give details of systolic and / or diastolic blood pressure drop].
- Cognitive impairment – MMSE [x/30]
- Home environmental hazards
- Visual impairment – [give details if known]
- Use of inappropriate footwear
- Fear of falling
- Depressive symptoms with score of x out of 5 on Geriatric Depression Scale (GDS)-5
- Known depression
- Risk of Osteoporosis due to [insert risk factors]
- Known Osteoporosis [insert additional risk factors if any]

I have arranged the following investigations and fall prevention interventions to address these issues: [delete as necessary]

1. Screening bloods – FBC / EUC / LFTs / CMP / / TFTs / Vitamin D / PTH / Serum electrophoresis.
2. Bone Mineral Density scanning.
3. CT Brain to assess for lesions which may influence gait.
4. 24h ABPM to assess blood pressure control and / or postural hypotension.
5. An education booklet on falls risk prevention has been supplied to [Insert participant's name].
6. Referral to the [HBT team for strength and balance exercises / Day Hospital for group strength and balance exercises / Day Hospital for Tai Chi classes].
7. The following medication changes should be pursued – [delete as necessary]
    a. Benzodiazepine dose gradually reduced and stopped. [give details of specific drug and reason to recommence]
    b. Antidepressant dose gradually reduced and stopped. [give details of specific drug and reason to recommence]
    c. Antipsychotic dose gradually reduced and stopped. [give details of specific drug and reason to recommence]
    d. Antihypertensive dose gradually reduced and stopped. [give details of specific drug and reason to recommence]
    e. Diuretic dose gradually reduced and stopped. [give details of specific drug and reason to recommence]
8. Treatment of postural hypotension – [delete as necessary] advice given on care to avoid postural symptoms including fluid and salt management, / dose reduction / discontinuation of medication contributing to postural hypotension, / trial of fludrocortisone / midodrine / and additional investigations.
9. Occupational Therapist home assessment of environmental hazards.
10. Review by optometrist / ophthalmologist for assessment of visual acuity / cataracts / glaucoma / macular degeneration / prescription of new or single vision lenses. Single vision lenses when walking outside the home have been advised.
11. Please arrange referral to a podiatrist.
12. Advice given on appropriate footwear.
13. Consider the use of antidepressants for the treatment of depression.

Based on the results of these investigations further treatment of Osteoporosis may be required and I will discuss with [Insert participant's name] at [his /her] next visit. Additional changes to medications will be determined according to the results of the remaining tests. Please assist in arranging referrals to [give details such as podiatrist if non-diabetic]. [He / she] declined other interventions and investigations – [give details]. [Insert participant's name] will be followed up by our research team monthly through the use of a falls diary, on a 4-monthly basis by telephone, and will have a final assessment at the end of the 12-month follow-up period. A follow-up clinic appointment has been arranged in 6 weeks.

Further information can be obtained from the research team – XXXX(research Geriatrician) or XXXX(research RN) on **XXX**