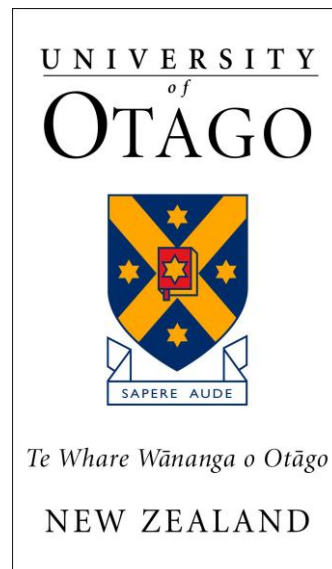


# Falling costs: the case for investment



Associate Professor M. Clare Robertson  
Professor A. John Campbell

Department of Medicine  
Dunedin School of Medicine  
University of Otago

December 2012

# Contents

About the authors .....	iii
Acknowledgements .....	iii
Purpose of this report.....	1
Key points and recommendations.....	1
Recommended strategies to reduce the costs of falls and fall injuries .....	1
Falls and injuries in older people are common, costly, and increasing.....	3
Effective strategies are available to reduce falls and injuries .....	5
Table 1: Important risk factors for falls .....	5
Table 2: Pooled rate ratios (all falls) for intervention versus control groups from randomised controlled trials of fall prevention interventions in older people living in the community .....	6
Table 3: Pooled rate ratios (all falls) for intervention versus control groups from randomised controlled trials of fall prevention interventions in residents of aged care facilities.....	7
Table 4: Pooled rate ratios (all falls) or risk ratios (fallers) for intervention versus control groups from randomised controlled trials of fall prevention interventions in older people in hospital.....	7
Preventing falls in the community.....	8
Preventing falls in aged care facilities .....	9
Preventing falls in older hospital patients.....	10
Potential health care cost savings from effective strategies .....	12
Falls prevention interventions.....	12
Hip protectors and safety flooring .....	12
Impact of effective strategies on health care organisations .....	14
Table 5: Impact of effective falls prevention interventions .....	14
Vitamin D supplementation .....	15
Home safety assessment and modification.....	15
Individually tailored multifactorial interventions.....	15
Recommendations.....	16
Case studies: best practice from a national perspective.....	17
Figure 1: Proportion of residents in MidCentral aged residential care facilities dispensed vitamin D.....	18
References.....	20
<b>Appendices</b>	
Appendix Figure A1: Cohort effect for hip fracture incidence between 1974 and 2007 in New Zealand women by year of birth .....	24
Appendix Figure A2: Period effect for hip fracture incidence in New Zealand women from 1974 to 2007 and predicted incidence in 2025 .....	24
Appendix Figure A3: Projected fall-related hospital admissions for people aged ≥65 years, New South Wales, Australia, 2008 to 2051.....	25

## About the authors

Associate Professor Clare Robertson and Professor John Campbell are internationally recognised falls prevention researchers based at the University of Otago. Their New Zealand based research includes studies of home safety, withdrawal of sedative medications, multifactorial interventions in the community and residential care, and they have been responsible for the design, development and testing of the internationally adopted Otago Exercise Programme. Clare Robertson is a co-author of the Cochrane reviews of interventions for preventing falls in older people in hospitals and nursing care facilities (2012) and older people living in the community (2012).

## Acknowledgements

The authors are grateful to Jan Adams, Greg Hamilton, Lee Henley, Shelley Jones, Andrew Lesperance, Claire Lord, Dr Shankar Sankaran, and Ken Stewart for their helpful input to this report.

### **Suggested citation**

Robertson MC, Campbell AJ. Falling costs: the case for investment. Report to Health Quality & Safety Commission. University of Otago: Dunedin, New Zealand, December 2012.

## Purpose of this report

This report contributes to the *Reducing Harm from Falls* national programme of the Health Quality & Safety Commission. The aim is to present the evidence for investment in strategies to prevent falls and fall injuries, so that effective strategies which will reduce the costs of falls can be integrated into routine health care for older New Zealanders.

## Key points and recommendations

- Injuries from falls are the most common and costliest injury event for older people. Investment in proven strategies to prevent falls and injuries is essential for maintaining independence and quality of life in the ≥65-year-old age group.
- Implementing specific falls prevention programmes saves health care costs within one year, and other proven falls prevention interventions provide good value for money, especially in the longer-term. The opportunities are largest in community living older people to reduce presentations to ED, hospital admissions and premature admissions to aged care facilities.
- Return on investment estimates reported for effective, carefully targeted falls prevention strategies range from 1.0 to 7.0. This means that for every \$100,000 invested by a DHB, the investment will be cost neutral or there could be up to \$700,000 available within one year to allocate to other effective and worthwhile budget items. The corresponding reduction in fall related hospital admissions for community dwelling older people ranges from 0.5 to 10.0 percent.
- Several different types of strategies reduce falls and should form part of integrated, timely care for older people. Falls prevention exercise programmes reduce falls by 30-40 percent in community dwelling older people. A home safety assessment and modification intervention, and individually targeted multifactorial interventions, prevent falls in those with specific risk factors. Vitamin D supplements reduce falls in older people with a risk factor for low vitamin D levels.
- Investment in an evidence based, national approach to reduce falls in older New Zealanders is feasible and will be welcomed by health care professionals, older people and their families.
- The following interventions would make the best investment for a comprehensive, nationwide, evidence based approach to reduce the rising costs of falls and fall injuries in older people:

## Recommended strategies to reduce the costs of falls and fall injuries

1. **Exercise programmes** designed specifically to prevent falls:
  - i) Otago Exercise Programme delivered at home to people aged ≥80 years (or ≥75 with a previous fall)
  - ii) **Group exercise classes** for people aged ≥75 years. Tai Chi classes for more active older people.
2. **Vitamin D supplementation** for all older people with a risk factor for a low serum vitamin D level (assume for housebound, requiring support services, resident in aged care facility, frail and dark skinned or obese).

3. **Home safety assessment and modification intervention** delivered by an experienced occupational therapist to older people at higher risk of falling, e.g. previous fallers recently discharged from hospital, those with severe visual impairment (eligible to register with the NZ Foundation of the Blind, e.g. visual acuity 6/24 or worse).
4. **Multifactorial interventions** based on the person's risk factors for older people in the clinical setting, that is, receiving primary health care, presenting to ED with a fall, attending a falls clinic, admitted to hospital, or resident in an aged care facility.

# Falls and injuries in older people are common, costly, and increasing

Falls are the most common and costliest cause of injury in older people. Around 30 to 60 percent of people aged  $\geq 65$  years fall each year and 10 to 20 percent of these events result in injury such as hip fracture, hospitalisation or death.<sup>1</sup> Falls can result in fear of falling with subsequent avoidance of physical activity and decline in health, and they are an independent predictor of premature admission to residential aged care, even if there is no injury.<sup>2,3</sup>

Fall events and their associated complications increase exponentially with age. In a representative sample of New Zealanders  $\geq 70$  years living at home or in residential care, in only one year there were 47 falls per 100 people aged 70 to 74, increasing to 122 for every 100 people aged  $\geq 80$  years.<sup>4</sup> Medical attention was sought for 24 percent of falls that occurred at home.

In environments designed for safety such as aged care facilities and hospitals, fall events are not only traumatic for the older person and family, they are distressing for the staff. In New Zealand aged care facilities around 40 percent of residents fall each year and 65 percent of these falls result in an injury.<sup>5</sup> About 41 percent of falls occur during transfers and 36 percent when walking.<sup>6</sup> An incidence of 3.4 falls per person year has been reported in geriatric rehabilitation hospital wards, and 6.2 falls per person year in psychogeriatric wards.<sup>7</sup>

In 2010 the cost of treatment and rehabilitation in all age groups for fall injuries, plus lost economic contribution and human costs, was \$1,855.8 million or 18 percent of the total costs for all injuries.<sup>8</sup> The high susceptibility of older people to injury from falls results in major costs to ACC. The average cost to ACC from a falls claim in 2010/11 was \$561, but claims exceeded an average of \$1000 for people aged  $\geq 85$  years.<sup>9</sup> A fall can result in substantially lower quality of life for the older person.<sup>10</sup> The cost for quality adjusted life years lost for non-fracture falls is unexpectedly high compared with falls with a fracture, mainly due to fear of falling.<sup>11</sup>

The incontrovertible rationale for investing health care expenditure in effective, cost-effective falls prevention strategies includes the rising costs and the serious consequences of falls in older New Zealanders.

The main cost drivers for the substantial burden of falls to the health system are hospital admissions (49 percent of total costs of falls) and long-term care (41 percent).<sup>12</sup> De Raad estimated that the health service cost of a fall with minor injuries in New Zealand in 2010 was \$600, a hip fracture with three weeks in hospital \$47,000, and a hip fracture with complications and discharge to an aged residential care facility \$135,000.<sup>9</sup>

Hip fracture is a good indicator of the incidence and costs of fall injuries because it is the most common injury related to falls in older people resulting in hospitalisation. A decline in hip fracture incidence between 1974 and 2007 in successive cohorts born in New Zealand from 1873 is consistent with improving health in later birth cohorts (see Appendix Figure A1).<sup>13</sup> However, the relative rate of decline in hip fracture incidence has levelled off over the last 10 to 15 years and the effect of birth cohort in future incidence will be minimal.

In contrast, there is a steadily increasing period effect.<sup>13</sup> There is an increased number of fractures if say, 1000 people aged 80-84 in 2005 to 2009 are compared with 1000 people aged 80-84 in 1990 to 1994. This is probably because we have, with modern preventive measures, an increased number of frail people at particular risk of fracture surviving. If this period effect increases at its current rate, a 95 percent increase in incidence of hip fracture for women and a 205 percent increase for men are predicted by 2025 (see Appendix Figure A2).<sup>13</sup>

The population in New Zealand aged  $\geq 65$  years is projected to grow nearly three times by 2050, while those  $\geq 85$  years will grow six times. With increasing numbers of older people and increasing incidence of serious fractures such as hip fracture, associated health care costs will continue to rise. This is demonstrated in projections of fall-related hospital admissions in New South Wales to 2051 (see Appendix Figure A3).<sup>14</sup>

The incontrovertible rationale for investing health care expenditure in effective, cost-effective falls prevention strategies includes the rising costs and the serious consequences of falls in older New Zealanders.

## Effective strategies are available to reduce falls and injuries

The risk factors for falls in older people are well established (see Table 1) and there is strong evidence from systematic reviews that strategies addressing these risk factors prevent falls.

There is a wealth of information available from randomised controlled trials, the gold standard method for evaluating new interventions, particularly for people living independently in the community (159 trials).<sup>15</sup> The evidence is more limited for residents in aged care facilities (43 trials)<sup>16</sup> and older patients in hospital (17 trials).<sup>16</sup> Tables 2 to 4 show the size of effect in terms of percentage of falls prevented or increased by the different strategies in each of these three settings. No trials testing falls prevention interventions in Māori or Pacific peoples were found, but in one epidemiological study, fewer Māori aged between 80 and 90 years than non-Māori aged 85 years reported falling in the previous year.<sup>17</sup>

The definition used for a fall in these studies was not always reported. The recommended definition is “A fall is an unexpected event in which the participants come to rest on the ground, floor, or lower level”, and study participants should be asked, “In the past month, have you had any fall including a slip or trip in which you lost your balance and landed on the floor or ground or lower level?”<sup>18</sup>

Table 1: Important risk factors for falls\*

Risk factor	Mean relative risk/odds ratio	Range
Muscle weakness	4.9	1.9 to 10.3
Balance deficit	3.2	1.6 to 5.4
Gait deficit	3.0	1.7 to 4.8
Visual deficit	2.8	1.1 to 7.4
Mobility limitation	2.5	1.0 to 5.3
Cognitive impairment	2.4	2.0 to 4.7
Impaired functional status	2.0	1.0 to 3.1
Postural hypotension	1.9	1.0 to 3.4

\*Summary of 16 controlled studies; adapted from Rubenstein L et al, 2006<sup>1</sup>



Table 2: Pooled rate ratios (all falls) for intervention versus control groups from randomised controlled trials of fall prevention interventions in older people living in the community\*

Intervention	Number of trials	Number of participants	Percentage reduction/increase in falls	Rate ratio	95% confidence interval
<b>Exercise programmes (multiple-component)</b>					
Group classes	16	3622	29%	0.71	0.63 to 0.82
Home based	7	951	32%	0.68	0.58 to 0.80
<b>Tai Chi classes</b>	5	1563	28%	0.72	0.52 to 1.00
<b>Vitamin D supplementation, all trials</b>					
Selected for lower levels†	2	260	53%	0.57	0.37 to 0.89
Not selected for lower levels†	5	9064	+2%	1.02	0.93 to 1.13
<b>Home safety, all trials</b>					
Higher risk of falling‡	3	851	38%	0.62	0.50 to 0.77
Not selected on fall risk‡	3	3357	6%	0.94	0.84 to 1.05
Delivered by OT§	4	1443	31%	0.69	0.55 to 0.86
Not OT§	4	3075	9%	0.91	0.75 to 1.11
<b>Cardiac pacing</b>	3	349	27%	0.73	0.57 to 0.93
<b>Medication</b>					
Review and modification	1	186	+1%	1.01	0.81 to 1.25
Psychotropic medication withdrawal	1	93	66%	0.34	0.16 to 0.73
<b>Vision</b>					
Assessment and intervention	1	616	+57%	1.57	1.19 to 2.06
Assessment and referral	1	1090	9%	0.91	0.77 to 1.09
Cataract surgery (first eye)	1	306	34%	0.66	0.45 to 0.95
Provision of single focal lens glasses (subgroup active outside only)	1	261	40%	0.60	0.42 to 0.87
<b>Podiatry including foot and ankle exercises (disabling foot pain)</b>	1	305	36%	0.64	0.45 to 0.91
<b>Multifactorial interventions, all trials</b>					
Assessment and active intervention¶	11	6338	26%	0.74	0.61 to 0.89
Assessment and referral or information¶	9	3376	18%	0.82	0.71 to 0.95

\*Adapted from Campbell AJ & Robertson MC, 2013<sup>61</sup>; data from Gillespie LD et al, 2012<sup>15</sup>

OT = occupational therapist

Test for subgroup differences † $P = 0.01$ , ‡ $P = 0.0009$ , § $P = 0.07$ , ¶ $P = 0.36$ . A  $P$  value  $<0.05$  represents a significant difference between the two subgroups, i.e. one subgroup benefited significantly more than the other.

Table 3: Pooled rate ratios (all falls) for intervention versus control groups from randomised controlled trials of fall prevention interventions in residents of aged care facilities\*

Intervention	Number of trials	Number of participants	Percentage reduction/increase in falls	Rate ratio	95% confidence interval
<b>Exercise programmes, all facilities</b>	8	1844	+3%	1.03	0.81 to 1.31
Rest homes†	4	1219	20%	0.80	0.57 to 1.13
Hospital level nursing care (or mixed, i.e. rest home and hospital level)†	4	625	+29%	1.29	0.93 to 1.79
<b>Vitamin D supplementation</b>	5	4603	37%	0.63	0.46 to 0.86
<b>Multifactorial interventions, all facilities</b>	7	2876	22%	0.78	0.59 to 1.04
Rest homes‡	3	670	36%	0.64	0.50 to 0.83
Hospital level nursing care (or mixed, i.e. rest home and hospital level)‡	4	2206	12%	0.88	0.59 to 1.29

\*Data from Cameron ID et al, 2012<sup>16</sup>

†Test for subgroup differences  $P = 0.05$ , residents receiving intermediate levels of care benefited more than those in high level care; ‡ $P = 0.19$ , no significant difference in effectiveness of multifactorial interventions by levels of care.

Table 4: Pooled rate ratios (all falls) or risk ratios (fallers) for intervention versus control groups from randomised controlled trials of fall prevention interventions in older people in hospital\*

Intervention	Number of trials	Number of participants	Percentage reduction/increase in falls or fallers	Rate/risk ratio†	95% confidence interval
<b>Exercise (additional physiotherapy)</b>	2	83	64%	0.36 [RR]	0.14 to 0.93
<b>Vitamin D supplements</b>	1	203	18%	0.82 [RR]	0.59 to 1.14
<b>Carpet flooring versus vinyl flooring</b>	1	54	+147%	14.73	1.88 to 115.35
<b>Low-low beds</b>	1	11,099	+39%	1.39	0.22 to 8.78
<b>Identification bracelets</b>	1	134	+15%	1.15	0.72 to 1.84
<b>Multifactorial interventions, all trials</b>	4	6478	31%	0.69	0.49 to 0.96
Unit specialising in geriatric orthopaedic care after hip fracture surgery‡	1	199	62%	0.38	0.19 to 0.74

\*Data from Cameron ID et al, 2012<sup>16</sup>

†Rate ratio (all falls) unless risk ratio [RR] (number of fallers) specified

‡Control group received conventional care in an orthopaedic ward

## Preventing falls in the community

There is strong evidence from 159 randomised controlled trials with 79,193 participants that falls can be prevented in community dwelling older people using several different types of strategies.<sup>15</sup>

### Exercise programmes

Group and home based exercise programmes designed specifically to prevent falls reduce falls overall by 29 percent and 32 percent respectively.<sup>15</sup> Specific targeting of the home based Otago Exercise Programme to those 80 years and older can reduce falls by 40 percent.<sup>19</sup> Tai Chi classes reduce the risk of falling by 29 percent and are more effective (a 41 percent reduction) in people not at a high risk of falls (more likely to be fitter and less frail).<sup>15</sup>

There is some evidence that exercise programmes designed to reduce falls can reduce fractures, however this evidence comes from only six of the 50 randomised controlled trials testing an exercise programme.<sup>15</sup>

Although the strong message is that falls prevention exercise should target both the general community and those at high risk for falls, one home exercise programme did not prevent falls in those recently discharged from hospital.<sup>20</sup> This fits with the findings from a meta-analysis that exercise programmes had a lesser effect in those at higher risk of falling than in the general population.<sup>21</sup>

### Home safety assessment and modification programmes

Overall, home safety interventions reduce falls by 19 percent. However, these interventions are more effective in people at higher risk of falling, e.g. previous fallers recently discharged from hospital or those with severe visual impairment (38 percent reduction), and when delivered by an occupational therapist (31 percent reduction).<sup>15</sup>

### Vitamin D supplementation

Taking vitamin D supplements does not prevent falls in all older people living in the community, but may do so in people who have lower vitamin D levels (evidence from two trials only).<sup>15</sup> Low levels of vitamin D can be assumed without a blood test for older people who are housebound, requiring support services, resident in an aged care facility, are frail, have dark skin, or are obese.

### Improving vision

Expedited first eye cataract surgery reduces falls by 34 percent compared with remaining on the waiting list.<sup>22</sup>

An important message is that older people may be at increased risk of falling while adjusting to new glasses or major changes in lens prescription. In one study a multifaceted intervention to treat vision problems resulted in a significant *increase* in falls, possibly for this reason, or because improving vision might lead to changes in behaviour that increase exposure to fall-prone situations.<sup>23</sup> In another study, regular wearers of multifocal glasses were given single lens glasses for wearing outdoors.<sup>24</sup> All falls were reduced in the subgroup that regularly engaged in outside activities, but there was an *increase* in falls outside the home in those who did not.

### Medication review

There is evidence for the effectiveness of interventions targeting medications: 1) gradual withdrawal of psychotropic medications (66 percent reduction),<sup>25</sup> and 2) an educational programme for GPs and their patients to improve prescribing practices (39 percent reduction).<sup>26</sup>

## Feet and footwear

In one study falls were reduced by 36 percent in people with disabling foot pain receiving customised orthoses, footwear review, foot and ankle exercises, and fall prevention education in addition to “usual podiatry”.<sup>27</sup>

## Pacemakers

For people with carotid sinus hypersensitivity, and a history of syncope and/or falls, cardiac pacing reduces falls by 27 percent.<sup>15</sup>

## Multifactorial interventions

Individually targeted multifactorial interventions reduce falls in community living older people by 24 percent.<sup>15</sup> These are complex interventions with components based on the individual’s risk profile and usually involve a multidisciplinary team. They differ in the types of assessment, treatment combinations, and referral processes used. Examples of multifactorial programmes are provided later in this report.

## Interventions with no current robust evidence

There is no evidence of effect for cognitive behavioural interventions on falls, and the evidence for the provision of educational materials alone is inconclusive. Most trials in the Cochrane review excluded people with cognitive impairment. The review did not include trials of interventions following stroke or in people with Parkinson’s disease.

All community dwelling older people will benefit from a falls prevention exercise programme. A home safety intervention, vitamin D supplementation, and individually targeted multifactorial interventions prevent falls in those with specific risk factors.

All community dwelling older people will benefit from a falls prevention exercise programme. A home safety intervention, vitamin D supplementation, and individually targeted multifactorial interventions prevent falls in those with specific risk factors.<sup>15</sup>

## Preventing falls in aged care facilities

The 43 trials (30,373 participants) in care facilities provided somewhat conflicting evidence for preventing falls and only limited evidence for any one intervention.<sup>16</sup> The diversity of case mix, registered nurse staffing levels, carer training, the size and configuration of facilities, and lighting and environmental hazards may all contribute to variations in the rate of falls between units and facilities.

### Exercise programmes

Overall, there was no difference between exercise and control groups in rate of falls. However, analysis by level of care suggested that exercise programmes may reduce falls by 20 percent in rest home level facilities, but *increase* falls by 29 percent in facilities providing high levels of nursing care to residents with greater disability.

### Vitamin D supplements

Vitamin D supplementation, which is thought to improve muscle strength, reduces falls by 37 percent in aged care facilities, probably because most residents have low vitamin D levels.

### Medication review by a pharmacist

The results from two studies investigating the effect of medication review by a pharmacist in aged care facilities were conflicting. In one study the intervention targeted psychoactive medication prescribing and included monthly medication reviews for one year. The authors reported a significant reduction in the use of psychoactive medications but the rate of falls was significantly

increased by 43 percent. Zermansky (2006) investigated the impact of a single clinical medication review that resulted in a significant 38 percent reduction in the rate of falls.<sup>28</sup>

Vitamin D supplementation prevents falls in residential aged care facilities. Evidence from some individually targeted multifactorial interventions demonstrated effectiveness in reducing falls while others did not.

### Multifactorial interventions

In aged care facilities, pooled results for multifactorial interventions showed a possible benefit, although this was not conclusive. Individually, three trials demonstrated a significant reduction in falls,<sup>29-31</sup> whereas one intervention<sup>32</sup> increased falls. The study design of these trials did not allow evaluation of the individual components of the multifactorial interventions. The interpretation of these results is complex because of the variation in programme components, frailty of the sample, and duration and intensity of the intervention.

### Interventions with no current robust evidence

The evidence was not conclusive but suggested possible benefits for an intervention targeting incontinent residents in high level nursing care facilities that included exercise, offering regular fluids, and toileting.<sup>33</sup> No conclusions could be drawn from one trial in rest homes that tested the soothing effects of lavender patches as an intervention to ameliorate behavioural and psychological factors, although there was a 43 percent reduction in falls.<sup>34</sup> This is possibly a Hawthorne effect as there is no physiological basis for this intervention.

Five trials in aged care facilities targeted staff training or implemented a service model change. None of these interventions reduced falls. The interventions included staff education on fall and fracture prevention, guideline implementation (falls, urinary tract infection, and pressure ulcers), and a risk assessment tool versus nurses' judgement.<sup>16</sup> More research is needed for these approaches.

Vitamin D supplementation prevents falls in residential aged care facilities. Evidence from some individually targeted multifactorial interventions demonstrated effectiveness in reducing falls while others did not.<sup>16</sup>

## Preventing falls in older hospital patients

The 17 trials (29,972 participants) carried out in hospitals provided some evidence for interventions targeting multiple risk factors to reduce falls in acute and subacute wards.<sup>16</sup>

### Additional physiotherapy

Receiving additional physiotherapy in addition to usual care reduced the number of people falling in rehabilitation wards.

### Environment

Carpeted floors compared with existing vinyl floors in subacute hospital wards resulted in a statistically significant *increase* in the rate of falls, possibly due to increased postural sway while walking on carpet.

### Service model change

One effective approach was to admit patients receiving care after hip fracture surgery to a unit specialising in geriatric orthopaedic care.<sup>35</sup> These patients had 66 percent fewer falls than those randomised to a standard orthopaedic ward.

## Multifactorial intervention

Multifactorial interventions reduced the rate of falls by 31 percent in hospital patients, but no recommendations can be made regarding any particular component of these programmes. In a subacute setting, risk assessment and targeted interventions (exercise, educational sessions from an occupational therapist, hip protectors) reduced falls and fractures; this was not obvious until after 45 days in hospital.<sup>36</sup>

Additional physiotherapy and individually targeted multifactorial interventions prevent falls in older people in hospital.

## Knowledge

Increasing patients' awareness of their falls risk and teaching risk reduction strategies may reduce the risk of falling in hospital wards. An educational session based on identified risk factors and usual fall prevention care in an acute medical ward reduced risk of falling.<sup>37</sup> Educational materials alone and educational materials with professional follow-up did not reduce falls overall in acute and subacute wards, but there was a significant reduction of falls in participants with no cognitive impairment.<sup>38</sup>

## Interventions with no current robust evidence

There was no significant reduction in falls for vitamin D supplementation, providing one low-low bed per 12 existing beds in acute and subacute wards, wearing a blue identification bracelet, or using bed exit alarms, providing staff training, or a behavioural advisory service.<sup>16</sup> Further research may well show these interventions are beneficial.

Additional physiotherapy and individually targeted multifactorial interventions prevent falls in older people in hospital.<sup>16</sup>

## Potential health care cost savings from effective strategies

Economic evaluations are used to compare the value for money of two or more alternative health services or treatments. They help decision makers assess whether one approach will achieve more efficient use of resources than another. A cost effectiveness analysis compares the costs and consequences of alternative treatments or approaches with the same clinically relevant outcome (e.g. falls). A cost utility analysis compares cost outcomes in terms of quality adjusted life years (QALYs) gained. The results of these analyses are expressed as a ratio of the difference in the costs incurred and/or saved and the difference in the benefits for alternative treatments (cost effectiveness ratio, cost utility ratio).

### Falls prevention interventions

In the two recent Cochrane systematic reviews, results were summarised from any comprehensive economic evaluations (cost effectiveness analysis, cost utility analysis) incorporated in the included studies.<sup>15, 16</sup> The following contains excerpts related to economic outcomes in the randomised controlled trials included in these two reviews.

There is evidence that falls prevention strategies in the community can be cost saving.<sup>15</sup> The results from three studies demonstrated the potential for cost savings from delivering the intervention to particular subgroups of older people at high risk of falling. One trial of the Otago Exercise Programme showed cost savings in those aged  $\geq 80$  years resulting from fewer hospital admissions.<sup>39</sup> Cost savings were also demonstrated for a home safety programme when delivered to the participants with a previous fall, and a multifactorial intervention for those with one or more of the eight targeted risk factors.<sup>15</sup>

Cost effectiveness was established (presented here at 2008 New Zealand prices) for exercise programmes (\$418 to \$2291 per fall prevented), a home safety assessment and modification programme delivered to those with severe vision loss (\$738 per fall prevented), multifactorial programmes (\$3,670 per fall prevented), and first eye cataract surgery within one month after randomisation compared with the (then) routine 12-month wait (\$11,901 per fall prevented).<sup>40</sup> The perspectives taken, the cost items measured and methods for valuing the items varied, making comparison of incremental cost effectiveness ratios for the interventions (incremental cost per fall prevented) difficult.

In addition, cost utility analyses were reported for the studies that tested first and second eye expedited cataract surgery, resistance training programmes, and a multifactorial programme. For both first and second eye cataract surgery the incremental cost per QALY gained at one year was above a currently accepted UK threshold of willingness to pay per QALY gained of £30,000. If, however, the timeframe of the analyses was extended to the person's expected lifetime, the incremental cost per QALY gained was below this threshold at £13,172 and £17,299 respectively (2004 prices).

No randomised controlled trials of falls prevention interventions in aged care facilities or hospitals included a cost effectiveness or cost utility analysis. Therefore very little information on value for money is available in these two settings. An exercise and incontinence programme in aged care facilities significantly improved functional outcomes but did not reduce falls or the costs of treating the acute episodes that the intervention aimed to prevent.<sup>33</sup> Recommendations by pharmacists resulted in an increase in changes of medications and a significant reduction in the rate of falls, with no change in the cost of medications.<sup>28</sup>

### Hip protectors and safety flooring

The evidence for effectiveness in preventing hip fracture indicates that hip protectors should be offered on an individual basis in residential care facilities and hospitals, but compliance has been estimated at only 25-30 percent.<sup>41</sup> In a New Zealand study of the circumstances and consequences of falls in residential care, there were no hip fractures when residents fell wearing hip protectors, but over the 18 month period there were 12 hip fractures in the 917 falls without a hip protector in place.<sup>5</sup>

An innovative new flooring material invented in New Zealand specifically to absorb energy on impact has the potential to reduce the number of fractures and other injuries as a result of falls in hospitals and residential care facilities. Unlike carpet, there is no adverse effect on gait.<sup>42</sup> This strategy has the advantage of being a long-term approach plus avoiding individual compliance issues.<sup>43</sup> For residential care facilities this flooring material is more cost effective than supplying hip protectors and has the potential to be cost saving.<sup>44</sup> The New Zealand flooring is currently being tested in a nursing home in Sweden with no fall injuries after one year.<sup>45</sup>



## Impact of effective strategies on health care organisations

Health care service providers and funders in New Zealand are increasingly focusing on preventive and health promoting activities to improve quality of care and reduce both short- and longer-term health care costs. In developing the NZ Injury Prevention Strategy, falls were chosen as one of the six national injury prevention priority areas based on current statistics.

Effective strategies would result in fewer presentations to ED, fewer claims to ACC, lower hospital admission rates and premature admission to aged care facilities, and help to keep older people living independently in their own homes. Reducing falls in aged care facilities would also reduce admissions to hospitals following a fall. Fewer hospital admissions following a fall, and fewer falls in hospital, would translate to fewer resource bed days occupied by the older age group. Action to prevent fractures also requires management of osteoporosis (see for example *Bone Care 2020* published by Osteoporosis New Zealand, [www.bones.org.nz](http://www.bones.org.nz)) but this topic is beyond the scope of this report.

The biggest opportunities for cost savings occur in community living older people where the major cost drivers are hospital and aged care facility admissions.

The biggest opportunities for cost savings occur in community living older people where the major cost drivers are hospital and aged care facility admissions.

The aim is to invest in health care services that incorporate the strategies proven to be effective and cost-effective in reducing these common events. Three falls prevention programmes have been shown to be cost saving to the health system in the first year of delivery and several others show good value for money.<sup>46</sup> Return on investment has been estimated for several programmes delivered to specific subgroups and this ranges from 1.0 to 7.0 (Table 5). This means that for every \$100,000 invested by a DHB, the investment will be cost neutral or there could be up to \$700,000 available within one year to allocate to other effective and worthwhile budget items. Estimations for reduction in hospital admissions for these programmes range from 0.5 percent to 10.0 percent.

Table 5: Impact of effective falls prevention interventions

Intervention	Target group	Reduction in number of falls	Cost per client (NZ\$2008) <sup>40</sup>	Return on investment	Reduction in hospital admissions*
Otago Exercise Programme	Community dwelling aged ≥80 years	40% <sup>19</sup>	\$213-\$549	1.9 <sup>47</sup>	10.0%
Vitamin D supplements	Aged care facility residents	37% <sup>15</sup>	Minimal	7.0+	Not available
Home safety assessment and modification by OT	On discharge from hospital to community, previous faller aged ≥65 years	36% <sup>15</sup>	\$251-\$369	Not available	4.7%
Tai Chi classes	Community dwelling aged ≥70 years	28% <sup>15</sup>	\$303-\$373	1.6 <sup>48</sup>	0.5%
Multifactorial interventions	Aged ≥65 years presenting to ED after a fall	59% <sup>49</sup>	\$1870	1.0 <sup>50</sup>	2.0%
Stepping On	Community dwelling aged ≥70 years with fall in previous year	31% <sup>51</sup>	\$885	1.0 <sup>48</sup>	Not available

\*"Reduction in fall related hospital admissions for community dwelling 65+ years (%)"<sup>52</sup>

†ACC perspective only (personal communication, August 2012)

OT = occupational therapist

There is strong evidence for effectiveness, acceptability, feasibility, and providing value for money for the **Otago Exercise Programme**. This home based programme was equally effective when delivered by a physiotherapist or nurses, trained and closely supervised by a physiotherapist.<sup>39, 53, 54</sup> The Otago Exercise Programme has been shown to reduce moderate and serious injuries by 40 percent.<sup>19</sup> A study from Norway calculated that providing the Otago Exercise Programme to women 80 years and older would save \$1.89 for every \$1 spent on delivering the Programme (i.e. return on investment 1.9). The Otago Exercise Programme has been shown to improve executive function (cognitive processes)<sup>55</sup> and to reduce deaths.<sup>56</sup>

Physiotherapists in New Zealand are familiar with the Otago Exercise Programme as it was previously funded nationally by ACC. An instructor's manual is available free of charge and no training is needed for a physiotherapist to deliver the Programme. After a fall injury claim ACC subsidises rehabilitation care which can include prescription of the Otago Exercise Programme. This is helpful to rural providers in particular.

Group exercise classes that include strength and balance training should be available in the community to provide choice, and Tai Chi classes for more mobile older people. High risk older people should not be prescribed brisk walking programmes.<sup>21</sup> To be effective, exercise programmes should provide a moderate or high challenge to balance and be undertaken for at least two hours per week on an ongoing basis.<sup>21</sup> The benefits of exercise are wide and not just related to falls prevention.

## Vitamin D supplementation

Vitamin D supplementation is recommended for all older people with a risk factor for a low serum vitamin D level. This can be assumed for those who are housebound, requiring support services, resident in an aged care facility, frail and dark skinned or obese, without the need for a blood test. The recommended starting dose is 2 x 50,000 IU tablets (2.5 mg) vitamin D3, followed by one 50,000 IU tablet (1.25 mg) vitamin D3 each month. Aged care facility staff, residents, GPs, and pharmacists can work collaboratively to implement this intervention.

## Home safety assessment and modification

Occupational therapists require minimal further training to deliver a home safety assessment and modification programme to prevent falls. These programmes were effective overall in community dwelling older people but provide better value for money when delivered to high risk groups, for example previous fallers recently discharged from hospital and those with severe impairment of sight living in the community.

## Individually tailored multifactorial interventions

Older patients in the clinical setting, for example presenting to ED with a fall, admitted to hospital, or resident in an aged care facility, should be assessed for individual fall risk factors and treated, or referred for treatment. Risk assessment could include a falls history (circumstances of latest fall), physical exam, postural dizziness/hypotension, cognitive screening, medication review, feet and footwear, use of mobility aids, and a vision check.<sup>57</sup>

Many hospitals provide a falls clinic with multidisciplinary staff including geriatricians, nurses, occupational therapists, and physiotherapists. In one successful trial, patients aged  $\geq 65$  years presenting to ED with a fall had a detailed medical and occupational therapy assessment with referral to relevant services if indicated.<sup>49</sup>

For the effective approach where patients were admitted to a unit specialising in geriatric orthopaedic care after hip fracture surgery, there was close cooperation between orthopaedic surgeons and geriatricians in the medical care of the patients.<sup>35</sup> The team for the 24 bed ward included nurses (approximately one per bed), physiotherapists (2FTE), occupational therapists (2FTE), a dietician (0.2FTE), and geriatricians.

Interdisciplinary team meetings were held twice a week to implement actions to prevent new falls and fractures and included global ratings of the patients' fall risk.

The components of successful multifactorial approaches in aged care facilities have included educating staff on falls prevention, implementing exercise programmes, modifying the environment, supplying and repairing aids, reviewing drug regimens, providing free hip protectors, and having admission, regular and post-fall problem solving conferences.<sup>29, 31</sup>

## Recommendations

Based on the current evidence for effectiveness and return on investment of falls prevention interventions, the following strategies should form part of a comprehensive approach to falls prevention in older New Zealanders.

### Recommendation 1

Exercise programmes designed specifically to prevent falls:

- i) Otago Exercise Programme delivered at home to people aged  $\geq 80$  years (or  $\geq 75$  with a previous fall)
- ii) Group exercise classes for people aged  $\geq 75$  years. Tai Chi classes for more active older people.

### Recommendation 2

Vitamin D supplementation for all older people with a risk factor for a low serum vitamin D level (assume for housebound, requiring support services, resident in aged care facility, frail and dark skinned or obese). See ACC publication ACC4697 for vitamin D prescribing criteria.

### Recommendation 3

Home safety assessment and modification intervention delivered by an experienced occupational therapist to older people at higher risk of falling, e.g. previous fallers recently discharged from hospital, those with severe visual impairment (eligible to register with the NZ Foundation of the Blind, e.g. visual acuity 6/24 or worse).

### Recommendation 4

Multifactorial interventions based on the person's risk factors for older patients in the clinical setting, that is, receiving primary health care, presenting to ED with a fall, attending a falls clinic, admitted to hospital, or resident in an aged care facility.

## Case studies: best practice from a national perspective

Proven strategies to prevent falls and injuries already form part of routine health care provision in New Zealand and throughout the world. These approaches are combined with management of osteoporosis when appropriate.

### New Zealand

- A national strategy for preventing falls in older people, led by ACC, was achieved in New Zealand and received international acclaim.<sup>58</sup> The strategy included:
  - i) **Otago Exercise Programme** delivered to ≥80 years olds (or ≥75 if a previous faller) at home for six months by physiotherapists contracted to ACC between 2003 and 2009. Health care cost savings resulting from reduced hospital and aged residential care admissions accrued to DHBs, rather than directly to ACC as the programme funder. Funding from ACC ceased in 2009.<sup>47 59</sup>

Otago Exercise Programme instructor's manual: [www.acc.co.nz/otagoexerciseprogramme](http://www.acc.co.nz/otagoexerciseprogramme)

- ii) **Tai Chi classes** (modified 10-form Sun style) for those aged ≥65 years with a falls risk, one-hour classes once a week for 20 weeks. Funding from ACC ceased in 2010.
  - iii) **Vitamin D supplementation** in aged care facilities – this programme is ongoing and being extended to community dwelling older people. From 2007 ACC collaborated with DHBs to disseminate an education programme for aged care facility staff, residents, GPs, and pharmacists. See ACC publication ACC4697 for vitamin D prescribing criteria.
- Age Concern Otago provides the **Steady As You Go** falls prevention programme which includes once weekly **strength and balance classes**, or twice-weekly **Tai Chi**. An innovative approach has been to organise falls prevention exercise classes taught by volunteer peer leaders.<sup>60</sup>

Steady as You Go: [www.ageconcern.org.nz/health/healthy-body/preventing-falls](http://www.ageconcern.org.nz/health/healthy-body/preventing-falls)

- Canterbury DHB capacity funded 'Community Falls Champions' (physiotherapists or nurses) deliver a 12-month **home exercise programme** to frail elderly people. The DHB proactively supports **vitamin D supplementation** in rest homes. When an older person is **admitted to hospital**, staff will:
  - i) ask about falls over the last year; ii) assess risk of falling in hospital; iii) ensure falls risk management is in place; iv) discuss the findings and prevention strategies with the person and their family; and v) discuss falls prevention strategies for when they return home.
- MidCentral DHB began working with ACC in 2010 to improve the use of vitamin D in aged care residents in the MidCentral District. The DHB's Pharmacy Advisor used existing networks to promote vitamin D to prescribers and facility staff. The project resulted in an increase in vitamin D supplementation rates within MidCentral aged residential care facilities (see Figure 1). This increase was accompanied by a 32 percent reduction in presentations to ED and 41 percent reduction in admissions to MidCentral Health. It is likely that the increase in vitamin D use has contributed, at least in part, to the reduced use of MidCentral Health resources by this population.

bpac<sup>nz</sup>: Falls in older people: causes and prevention: [www.bpac.org.nz/magazine/2010/march/falls.asp](http://www.bpac.org.nz/magazine/2010/march/falls.asp)

Figure 1: Proportion of residents in MidCentral aged residential care facilities dispensed vitamin D\*



\*Report from Pharmacy Advisor, Planning and Support to Community and Public Health Advisory Committee, MidCentral DHB, 7 August 2012

## USA

- The Centers for Disease Control and Prevention (CDC) is taking a national approach to preventing falls and is in the process of implementing (see Resources section below for web addresses):
  - i) **Otago Exercise Programme** delivered at home and **Tai Chi classes**
  - ii) **Stepping On**
  - iii) **STEADI**.

The **Otago Exercise Programme** is currently being rolled out in three states. A training programme for physical therapists for delivering the Programme is available through the Otago Exercise Programme Forum website.

Otago Exercise Programme Forum (USA):

[www.phconnect.org/group/otago-falls-prevention-exercise-program-forum](http://www.phconnect.org/group/otago-falls-prevention-exercise-program-forum)

**Stepping On**, developed in Sydney, aims to improve fall self-efficacy, encourage behavioural change, and reduce falls.<sup>51</sup> Key components are for improving lower limb balance and strength, improving home and community environmental and behavioural safety, encouraging regular eye tests and encouraging medication review. The programme consists of two-hour sessions conducted weekly for seven weeks, with a follow-up home visit by an occupational therapist.

Stepping On: [www.steppingon.com](http://www.steppingon.com)

**STEADI** (Stopping Elderly Accidents, Deaths, and Injuries) is a falls prevention tool kit that contains resources for health care providers for assessing and addressing fall risk factors in a clinical setting.<sup>57</sup> It is designed to help health care providers incorporate falls risk assessment and individualised interventions into routine clinical care and to link clinical care with community based falls prevention programmes.

STEADI resources (information on medications linked to increased fall risk will be added in the near future): [www.cdc.gov/homeandrecreationalSafety/Falls/steady/index.html](http://www.cdc.gov/homeandrecreationalSafety/Falls/steady/index.html)

- The American Geriatrics Society, British Geriatrics Society guidelines [www.americangeriatrics.org/health\\_care\\_professionals/clinical\\_practice/clinical\\_guidelines\\_recommendations/2010/](http://www.americangeriatrics.org/health_care_professionals/clinical_practice/clinical_guidelines_recommendations/2010/)

Panel on Prevention of Falls in Older People, American Geriatrics Society, British Geriatrics Society. Summary of the updated American Geriatrics Society/British Geriatrics Society clinical practice guideline for prevention of falls in older persons. *J Am Geriatr Soc* 2011;59(1):148-57.

- US Task Force guidelines [www.uspreventiveservicestaskforce.org/uspstf/uspsfalls.htm](http://www.uspreventiveservicestaskforce.org/uspstf/uspsfalls.htm)

Moyer VA, on behalf of the US Preventive Services Task Force. Prevention of falls in community-dwelling older adults: US Preventive Services Task Force recommendation statement. *Ann Intern Med* 2012;157(3):197-204.

- Centers for Disease Control and Prevention website [www.cdc.gov/HomeandRecreationalSafety/Falls/index.html](http://www.cdc.gov/HomeandRecreationalSafety/Falls/index.html)  
[www.cdc.gov/HomeandRecreationalSafety/Falls/fallcost.html](http://www.cdc.gov/HomeandRecreationalSafety/Falls/fallcost.html)  
[www.cdc.gov/HomeandRecreationalSafety/Falls/compendium.html](http://www.cdc.gov/HomeandRecreationalSafety/Falls/compendium.html)

## Australia

- Guidelines for preventing falls in three settings (community, aged care facilities, hospitals) have been developed by the Australian Commission on Quality and Safety in Healthcare: [www.safetyandquality.gov.au/our-work/falls-prevention/falls-prevention-community/](http://www.safetyandquality.gov.au/our-work/falls-prevention/falls-prevention-community/)  
[www.safetyandquality.gov.au/our-work/falls-prevention/falls-prevention-rac/](http://www.safetyandquality.gov.au/our-work/falls-prevention/falls-prevention-rac/)  
[www.safetyandquality.gov.au/our-work/falls-prevention/falls-prevention-hospitals/](http://www.safetyandquality.gov.au/our-work/falls-prevention/falls-prevention-hospitals/)
- NSW Falls Prevention Network resources <http://fallsnetwork.powmri.edu.au/resources/resources.php>

## Canada, UK, Europe

The Otago Exercise Programme has been taken up widely in these countries.

## References

1. Rubenstein LZ. Falls in older people: epidemiology, risk factors and strategies for prevention. *Age Ageing* 2006;35 Suppl 2:ii37-ii41.
2. Tinetti ME, Williams CS. Falls, injuries due to falls, and the risk of admission to a nursing home. *N Engl J Med* 1997;337:1279-84.
3. Yardley L, Smith H. A prospective study of the relationship between feared consequences of falling and avoidance of activity in community-living older people. *Gerontologist* 2002;42(1):17-23.
4. Campbell AJ, Borrie MJ, Spears GF, Jackson SL, Brown JS, Fitzgerald JL. Circumstances and consequences of falls experienced by a community population 70 years and over during a prospective study. *Age Ageing* 1990;19:136-41.
5. Butler M, Kerse N, Todd M. Circumstances and consequences of falls in residential care: the New Zealand story. *N Z Med J* 2004;117(1202):U1076.
6. Rapp K, Becker C, Cameron ID, Konig HH, Buchele G. Epidemiology of falls in residential aged care: analysis of more than 70,000 falls from residents of Bavarian nursing homes. *J Am Med Dir Assoc* 2012;13(2):187 e1-6.
7. Nyberg L, Gustafson Y, Janson A, Sandman PO, Eriksson S. Incidence of falls in three different types of geriatric care. A Swedish prospective study. *Scand J Soc Med* 1997;25(1):8-13.
8. O'Dea D, Wren J. New Zealand estimates of the total social and economic cost of injuries For all injuries, and the six priority areas. For each of years 2007 to 2010. In June 2010 dollars. Report to New Zealand Injury Prevention Strategy. Wellington, New Zealand, July 2012.
9. de Raad J-P. Towards a value proposition: scoping the cost of falls. Wellington: NZIER, August 2012.
10. Salkeld G, Cameron ID, Cumming RG, Easter S, Seymour J, Kurrle SE, et al. Quality of life related to fear of falling and hip fracture in older women: a time trade off study. *BMJ* 2000;320(7231):341-6.
11. Iglesias CP, Manca A, Torgerson DJ. The health-related quality of life and cost implications of falls in elderly women. *Osteoporos Int* 2009;20(6):869-78.
12. Scuffham P, Chaplin S, Legood R. Incidence and costs of unintentional falls in older people in the United Kingdom. *J Epidemiol Community Health* 2003;57(9):740-4.
13. Langley J, Samaranayaka A, Davie G, Campbell AJ. Age, cohort and period effects on hip fracture incidence: analysis and predictions from New Zealand data 1974-2007. *Osteoporos Int* 2011;22(1):105-11.
14. Watson WL, Li Y, Mitchell RJ. Projections of hospitalised fall-related injury in NSW, Australia: impacts on the hospital and aged care sectors. *J Safety Res* 2011;42(6):487-92.
15. Gillespie LD, Robertson MC, Gillespie WJ, Sherrington C, Gates S, Clemson LM, et al. Interventions for preventing falls in older people living in the community. *Cochrane Database Sys Rev* 2012(9): Art. No.: CD007146.
16. Cameron ID, Gillespie LD, Robertson MC, Murray GR, Hill KD, Cumming RG, et al. Interventions for preventing falls in older people in care facilities and hospitals. *Cochrane Database Sys Rev* 2012(12): Art. No.: CD005465.
17. Falls and injury in older Māori and non-Māori. Australian and New Zealand Falls Prevention Society 5th Biennial Conference; October 2012; Adelaide, Australia.
18. Lamb S, Jorsted-Stein E, Hauer K, Becker C, on behalf of the Prevention of Falls Network Europe and Outcomes Consensus Group. Development of a common outcome data set for fall injury prevention trials: the Prevention of Falls Network Europe Consensus. *J Am Geriatr Soc* 2005;53:1618-22.



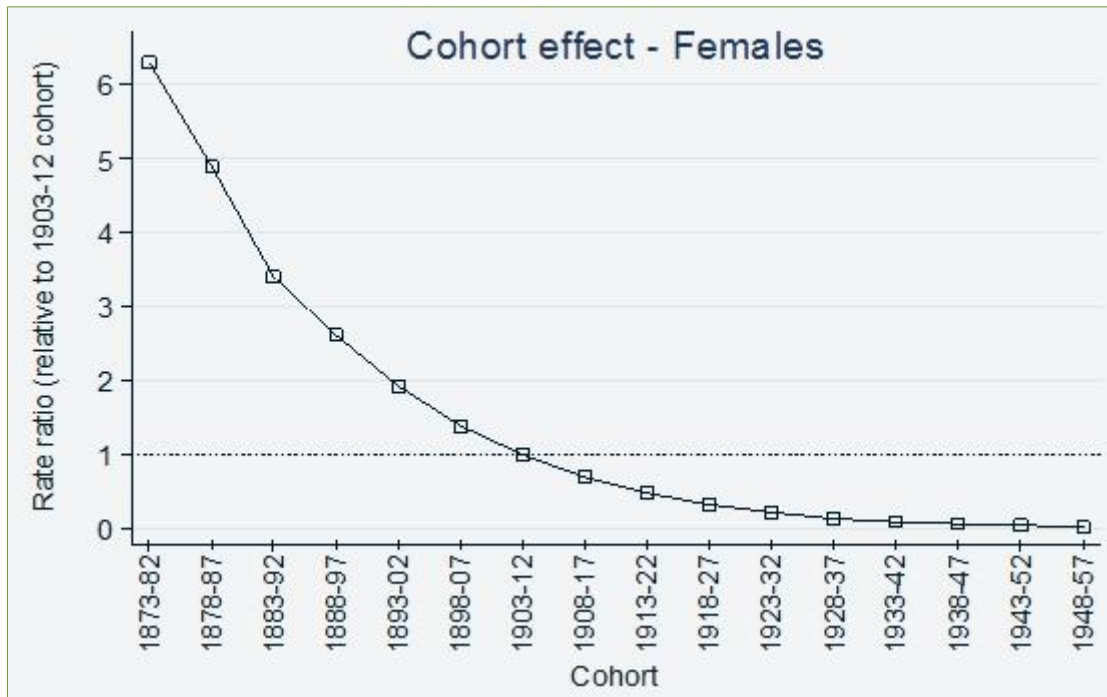
19. Robertson MC, Campbell AJ, Gardner MM, Devlin N. Preventing injuries in older people by preventing falls: a meta-analysis of individual-level data. *J Am Geriatr Soc* 2002;50(5):905-11.
20. Sherrington C, Lord SR, Vogler CM, Close JCT, Howard K, Dean CM, et al. Attempting to prevent falls in people after recent hospital stays: the WEBB post-hospital trial. *Australian and New Zealand Falls Prevention Society 5th Biennial Conference*. Adelaide, Australia, October 2012.
21. Sherrington C, Tiedemann A, Fairhall N, Close JCT, Lord SR. Exercise to prevent falls in older adults: an updated meta-analysis and best practice recommendations. *N S W Public Health Bull* 2011;22:78-83.
22. Harwood RH, Foss AJ, Osborn F, Gregson RM, Zaman A, Masud T. Falls and health status in elderly women following first eye cataract surgery: a randomised controlled trial. *Br J Ophthalmol* 2005;89(1):53-9.
23. Cumming RG, Ivers R, Clemsen L, Cullen J, Hayes MF, Tanzer M, et al. Improving vision to prevent falls in frail older people: a randomized trial. *J Am Geriatr Soc* 2007;55:175-81.
24. Haran MJ, Cameron ID, Ivers RQ, Simpson JM, Lee BB, Tanzer M, et al. Effect on falls of providing single lens distance vision glasses to multifocal glasses wearers: VISIBLE randomised controlled trial. *BMJ* 2010;340:c2265.
25. Campbell AJ, Robertson MC, Gardner MM, Norton RN, Buchner DM. Psychotropic medication withdrawal and a home-based exercise program to prevent falls: a randomized, controlled trial. *J Am Geriatr Soc* 1999;47(7):850-3.
26. Pit SW, Byles JE, Henry DA, Holt L, Hansen V, Bowman DA. A Quality Use of Medicines program for general practitioners and older people: a cluster randomised controlled trial. *Med J Aust* 2007;187(1):23-30.
27. Spink MJ, Menz HB, Fotoohabadi MR, Wee E, Landorf KB, Hill KD, et al. Effectiveness of a multifaceted podiatry intervention to prevent falls in community dwelling older people with disabling foot pain: randomised controlled trial. *BMJ* 2011;342:d3411.
28. Zermansky AG, Alldred DP, Petty DR, Raynor DK, Freemantle N, Eastaugh J, et al. Clinical medication review by a pharmacist of elderly people living in care homes—randomised controlled trial. *Age Ageing* 2006;35(6):586-91.
29. Becker C, Kron M, Lindemann U, Sturm E, Eichner B, Walter-Jung B, et al. Effectiveness of a multifaceted intervention on falls in nursing home residents. *J Am Geriatr Soc* 2003;51(3):306-13.
30. Dyer CA, Taylor GJ, Reed M, Robertson DR, Harrington R. Falls prevention in residential care homes: a randomised controlled trial. *Age Ageing* 2004;33:596-602.
31. Jensen J, Lundin-Olsson L, Nyberg L, Gustafson Y. Fall and injury prevention in older people living in residential care facilities. A cluster randomized trial. *Ann Intern Med* 2002;136(10):733-41.
32. Kerse N, Butler M, Robinson E, Todd M. Fall prevention in residential care: a cluster, randomized, controlled trial. *J Am Geriatr Soc* 2004;52(4):524-31.
33. Schnelle JF, Kapur K, Alessi C, Osterweil D, Beck JG, Al-Samarrai NR, et al. Does an exercise and incontinence intervention save healthcare costs in a nursing home population? *J Am Geriatr Soc* 2003;51(2):161-8.
34. Sakamoto Y, Ebihara S, Ebihara T, Tomita N, Toba K, Freeman S, et al. Fall prevention using olfactory stimulation with lavender odor in elderly nursing home residents: a randomized controlled trial. *J Am Geriatr Soc* 2012;60(6):1005-11.
35. Stenvall M, Olofsson B, Lundstrom M, Englund U, Borssen B, Svensson O, et al. A multidisciplinary, multifactorial intervention program reduces postoperative falls and injuries after femoral neck fracture. *Osteoporos Int* 2007;18(2):167-75.
36. Haines TP, Bennell KL, Osborne RH, Hill KD. Effectiveness of targeted falls prevention programme in subacute hospital setting: randomised controlled trial. *BMJ* 2004;328:676.



37. Ang E, Mordiffi SZ, Wong HB. Evaluating the use of a targeted multiple intervention strategy in reducing patient falls in an acute care hospital: a randomized controlled trial. *J Adv Nurs* 2011;67(9):1984-92.
38. Haines TP, Hill AM, Hill KD, McPhail S, Oliver D, Brauer S, et al. Patient education to prevent falls among older hospital inpatients: a randomized controlled trial. *Arch Intern Med* 2011;171(6):516-24.
39. Robertson MC, Gardner MM, Devlin N, McGee R, Campbell AJ. Effectiveness and economic evaluation of a nurse delivered home exercise programme to prevent falls. 2: Controlled trial in multiple centres. *BMJ* 2001;322(7288):701-4.
40. Robertson MC, Campbell AJ. Optimisation of ACC's fall prevention programmes for older people. Dunedin, New Zealand: University of Otago, November 2008.
41. Chan DK, Hiller G, Cooke R, Monk R, Mills J, Hung WT. Effectiveness and acceptability of a newly designed hip protector *Arch Gerontol Geriatr* 2000;30:25-34.
42. Robertson MC, Milburn PD, Carman AB, Campbell AJ. Safety flooring: energy absorption, postural stability, and gait patterns. *Australian and New Zealand Falls Prevention Society Conference*. Melbourne, Australia, October 2008.
43. Drahota A, Gal D, Windsor J. Flooring as an intervention to reduce injuries from falls in healthcare settings: an overview. *Quality Ageing* 2007;8(1):3-9.
44. Njogu F, Brown P. Cost effectiveness of impact absorbent flooring in reducing fractures among institutionalized elderly. Auckland, New Zealand: School of Population Health, University of Auckland, February 2008.
45. Gustavsson J, Nilson F, Andersson R. Preventing fall injuries among elderly by shock absorbing flooring. *Inj Prev* 2012;18(Suppl 1):A20.
46. Davis JC, Robertson MC, Ashe MC, Liu-Ambrose T, Khan KM, CA M. Does a home-based strength and balance programme in people aged  $\geq 80$  years provide the best value for money to prevent falls? A systematic review of economic analyses of falls prevention interventions. *Br J Sports Med* 2010;44:80-9.
47. Hektoen LF, Aas E, Luras H. Cost-effectiveness in fall prevention for older women. *Scand J Public Health* 2009;37(6):584-9.
48. Carande-Kulis VG, Stevens J, Beattie BL, Arias I. The business case for interventions to prevent fall injuries in older adults. *Inj Prev* 2010;16(Suppl 1):A249.
49. Close J, Ellis M, Hooper R, Glucksman E, Jackson S, Swift C. Prevention of falls in the elderly trial (PROFET): a randomised controlled trial. *Lancet* 1999;353:93-97.
50. Close JCT, Patel A, Hooper R, Glucksman E, Jackson SHD, Swift CG. PROFET – improved clinical outcomes at no additional cost. *Age Ageing* 2000;29(Suppl 1):48.
51. Clemson L, Cumming RG, Kendig H, Swann M, Heard R, Taylor K. The effectiveness of a community-based program for reducing the incidence of falls in the elderly: a randomized trial. *J Am Geriatr Soc* 2004;52(9):1487-94.
52. Day L, Hoareau E, Finch C, Harrison J, Segal L, Bolton T, et al. Modelling the impact, costs and benefits of falls prevention measures to support policy-makers and program planners. Melbourne, Australia: Monash University Accident Research Centre, September 2008.
53. Campbell AJ, Robertson MC, Gardner MM, Norton RN, Tilyard MW, Buchner DM. Randomised controlled trial of a general practice programme of home based exercise to prevent falls in elderly women. *BMJ* 1997;315(7115):1065-9.
54. Robertson MC, Devlin N, Gardner MM, Campbell AJ. Effectiveness and economic evaluation of a nurse delivered home exercise programme to prevent falls. 1: Randomised controlled trial. *BMJ* 2001;322(7288):697-701.

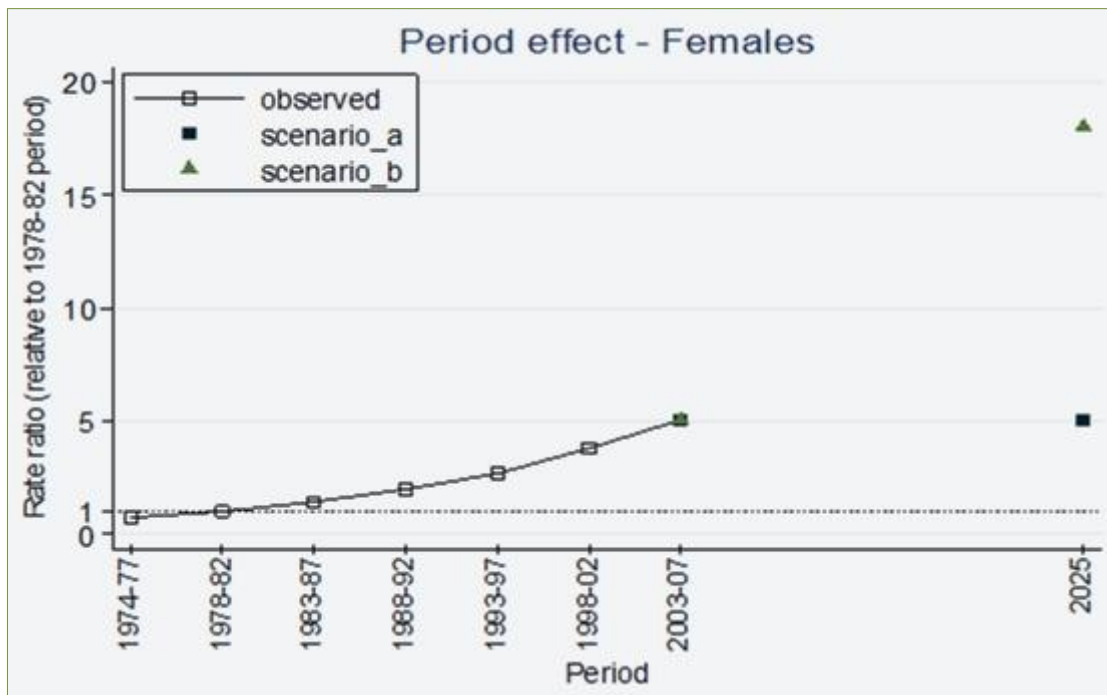
55. Liu-Ambrose T, Donaldson MG, Ahamed Y, Graf P, Cook WL, Close J, et al. Otago home-based strength and balance retraining improves executive functioning in older fallers: a randomized controlled trial. *J Am Geriatr Soc* 2008;56(10):1821-30.
56. Thomas S, Mackintosh S, Halbert J. Does the 'Otago exercise programme' reduce mortality and falls in older adults?: a systematic review and meta-analysis. *Age Ageing* 2010;39:681-87.
57. Stevens JA, Phelan EA. Development of STEADI: A Fall Prevention Resource for Health Care Providers. *Health Promotion Practice* 2012.
58. Campbell AJ, Robertson MC. Comprehensive approach to fall prevention on a national level: New Zealand. *Clin Geriatr Med* 2010;26(4):719-31.
59. Hale L, Taylor D, Waters DL. Exercise is a proven fall prevention strategy: it should be embedded into usual physiotherapy practice. *Physiotherapy NZ* 2012;40(2):45-47.
60. Waters DL, Hale LA, Robertson L, Hale BA, Herbison P. Evaluation of a peer-led falls prevention program for older adults. *Arch Phys Med Rehabil* 2011;92(10):1581-6.
61. Campbell AJ, Robertson MC. Fall prevention: single or multiple interventions? Single interventions for fall prevention. *J Am Geriatr Soc* 2013;61:281-4.

Appendix Figure A1: Cohort effect for hip fracture incidence between 1974 and 2007 in New Zealand women by year of birth\*



\*From Langley J et al 2011<sup>13</sup>

Appendix Figure A2: Period effect for hip fracture incidence in New Zealand women from 1974 to 2007 and predicted incidence in 2025\*

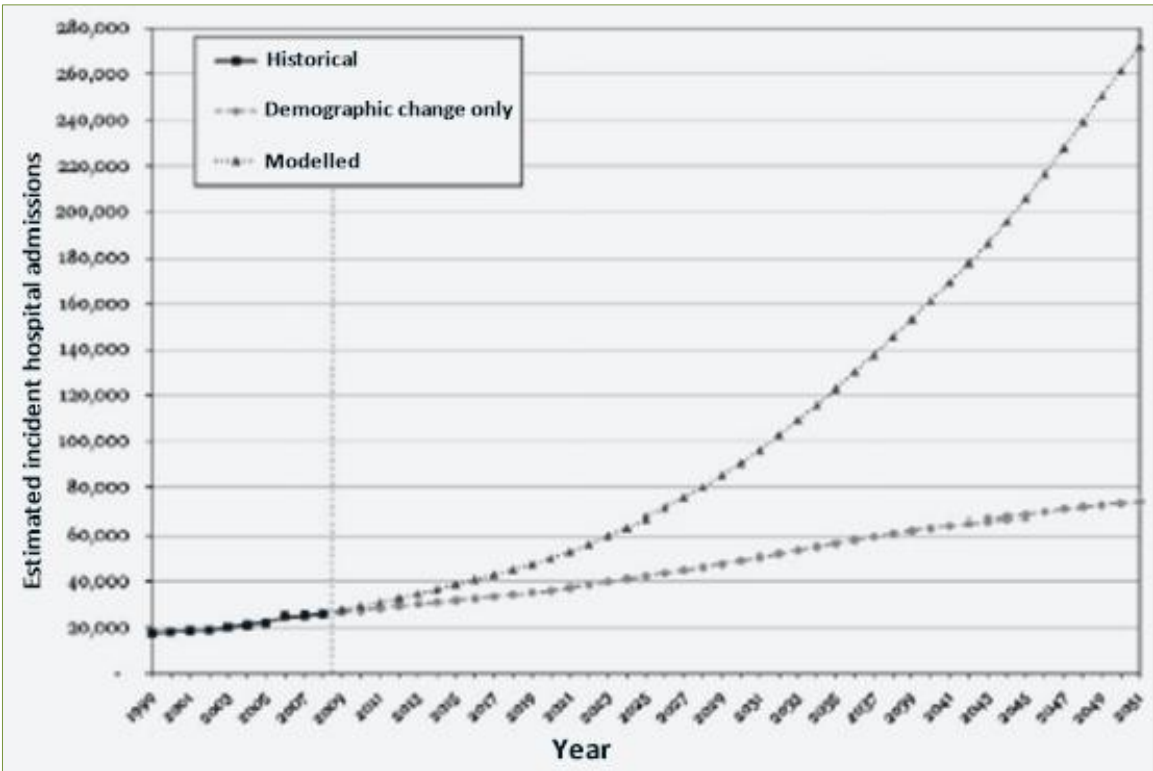


\*From Langley J et al 2011<sup>13</sup>

Scenario a assumes the 2007 period effect continues until year 2025.

Scenario b assumes the present increasing trend in period effect continues until year 2025.

Appendix Figure A3: Projected fall-related hospital admissions for people aged ≥65 years, New South Wales, Australia, 2008 to 2051\*



\*From Watson WL et al 2011<sup>14</sup>