An economic evaluation of community and residential aged care falls prevention strategies in NSW.

Jody Church[AB], Stephen Goodall[A], Richard Norman[A], Marion Haas[A]

[A]*Centre for Health Economics Research and Evaluation*
[B]*Corresponding author. Email: jody.church@chere.uts.edu.au*

Abstract

Objective:
The key objective was to evaluate the cost-effectiveness of strategies designed to prevent falls amongst people aged 65 and over living in the community and in residential aged care facilities (RACFs).

Methods:
A systematic review and meta-analysis of the literature was conducted. The results were used to populate a decision analytic model of costs and outcomes of potential interventions and/or strategies.

Results:
The results show that the most cost-effective falls prevention strategies in community-dwelling older people were expedited cataract surgery, psychotropic medication withdrawal, Tai Chi, home hazard modification and group-based exercise. The most cost-effective falls prevention strategies in residential aged care were medication review, vitamin D supplementation and hip protectors.

Background on falls prevention

A fall is defined as "an unexpected event in which an individual comes to rest on the ground, floor or lower level".[1] Falls are common among older people; up to one in four people aged 65 years and over fall at least once in a year, with many falling more than once. Falls are even more common among residents of aged care facilities, with up to half of all residents falling at least once in a year. [2,3]

Fall related injury is a major cause of morbidity and mortality for older people. In NSW each year, falls lead to approximately 30,000 hospitalisations and at least 300 deaths in people aged 65 years and over.[4] Even non-injurious falls can have negative impacts such as depression and mobility restrictions and reduced activities of daily living leading to reductions in quality of life. [5,6]. Projections indicate that without preventative action, and assuming that individuals continue to fall and be injured at the current rate, the costs to the health care system from injurious falls are likely to escalate reflecting the expected ageing population in NSW in the future. The estimated treatment cost associated with falls in NSW is $558.5 million, which includes all medical and associated costs occurring in the 12 months following injury and any RACF costs beyond the initial fall.[7]

A number of strategies have demonstrated effectiveness in preventing falls, these include: group-based exercise; home-based exercise; tai chi; home hazard assessment and modification; vitamin D and calcium supplementation; education; hip protectors; clinical medication review; vision and eye exam; expedited cataract surgery; cardiac pacing;

psychotropic medication withdrawal; and various multiple and multi-factorial interventions combinations of the above.

Methods

A systematic review and meta-analysis were conducted. The results were used to produce an economic evaluation comparing the costs and outcomes of the aforementioned falls prevention strategies.

Systematic review and meta-analysis:

A systematic review of the literature was undertaken in September 2008. Searches were conducted in a number of electronic databases including PubMed (Medline and PreMedline), EMBASE, the Cochrane Library, the Centre for Reviews and Dissemination (CRD) databases, Database of Abstracts of Reviews of Effects (DARE), National Health Service Economic Evaluation Database (NHS EED), Health Technology Assessment (HTA) database and Web of Science. Data were extracted from the included studies by one researcher and checked by a second researcher using standardised extraction tables developed a priori.

Descriptive statistics relating to the number of falls were extracted or calculated from each individual trial. A pooled measure of effectiveness was calculated for each falls prevention intervention identified using a random effects model. The analysis was based on an 'intention to treat' principle, and entered into Excel and transformed into the required input for statistical analysis. The pooled statistical analysis was conducted using Review Manager 5 (RevMan), a meta-analysis software available through the Cochrane Collaboration. A list of all references used in the meta-analysis can be found in a working paper on the CHERE website: (http://datasearch.uts.edu.au/chere/publications/index.cfm)

During the development of this study, a meta-analysis conducted by the Cochrane Collaboration entitled, "Interventions for preventing falls in older people living in the community" was released.[8] The results from this Cochrane review were used for the community-dwelling analysis, except in the case of home hazard assessment and modification and multiple interventions. Results of both meta-analyses are presented below in Table 1.

Insert table 1 here

Economic evaluation:

A decision analytic model was developed to assess the cost-effectiveness of falls prevention strategies. The rationale for the model is that falls prevention strategies lead to reductions in the number of individuals who fall, which consequently reduces the number of individuals injured or hospitalised due to a fall. Falls resulting in injury and hospitalisation can lead to a reduction in both length of life and quality of life. Consequently, a reduction in the number of fall related injuries will result in improvements measureable in terms of quality-adjusted life years (QALYs).

QALYs are the most commonly used and convenient outcome measure used in economic evaluations. They combine quality of life and life expectancy into one metric and therefore allow comparison of multiple strategies across different interventions and settings. Such an approach, termed a cost-utility analysis, was adopted in this project. The usual approach to economic evaluation is first to determine the incremental effectiveness and incremental costs are estimated. Finally the incremental cost-effectiveness ratio (ICER) can be calculated using the following ratio:

$$ICER = \frac{(Cost_{New}) - (Cost_{Comparator})}{(Effectiveness_{New}) - (Effectiveness_{Comparator})}$$

Model

The decision analytic model was designed to capture the transition of people between various health states. Five Markov states, were assigned as follows: 1) *low risk* (individuals who have never fallen); 2) *medium risk* (individuals who have previously fallen but incurred no injury); 3) *high risk* (previously injured individual who fell); 4) *residential aged care*; and 5) *death*. Individuals move between each state by following a multiple event decision tree.

The Markov model is summarised in Figure 1. The Markov model was built using TreeAge Pro Suite 2009 and a decision tree was embedded between each Markov state, see Figure 2. Within the decision tree, the probability of transitioning to another state depends on the occurrence of various events, such as presenting at the emergency department and being admitted to hospital. Costs and outcomes were incorporated into the model as a mean value per state per cycle. Expected values for costs and outcomes in the intervention and control are calculated by summing the costs and outcomes accrued by everyone in the model under both intervention and comparator, then dividing by the number of people in the model to produce a mean cost and outcome for each intervention. The cycle length of the model was one year.

Insert figure 1 here

Insert figure 2 here

Model Inputs

The data used in the model were obtained from different sources including published literature on falls prevention, expert opinion, the Australian Bureau of Statistics, Australian Institute of Health and Welfare and NSW Government released reports, specifically a report by Dr. Wendy Watson from Injury Risk Management Research Centre, UNSW.[7] In the absence of suitable data, assumptions were made and tested in the model. Some specifics of how we derived inputs are presented below. For further details, please see the CHERE Working Paper (http://datasearch.uts.edu.au/chere/publications/index.cfm).

Transition probabilities

The initial population distributions between the low, medium and high risk states were derived from Lord et al (1993) and the probability of falling derived from Professor Stephen Lord’s expert opinion, broken down by age, as can be seen in Table 2.[9] The transition probabilities to emergency, other medical, hospital, RACF, respite care or death due to a fall were taken from the report by Watson et al. (2009), as seen in Table 3.[7] All cause mortality was taken from the Australian Bureau of Statistics life tables and the probability of entering RACF from ‘all causes’ was estimated from a study by Wang et al. (2001). [10,11]

Insert table 2 here

Insert table 3 here

Effectiveness

The effectiveness of each intervention was based on the pooled rate ratio obtained from the CHERE meta-analysis and the Cochrane review.[8] Only interventions with a statistically significant reduction in the risk of falling were included in the model. The results from the Cochrane review were used unless otherwise specified from the community-dwelling analysis. The estimated rate ratio was used to adjust the probability of falling for each intervention compared to no intervention.

Costs

The cost of each intervention was estimated from published literature (if available), personal correspondence with NSW Health and online sources, outlined in Table 4. The majority of intervention costs were taken from Day et al. (2009) “Modelling the impact, costs and benefits of falls prevention measures to support policy-makers and program planners.”[12] All health care related costs were taken from Watson et al. (2009).[7] For example, the average cost of a fall-related hospitalisation for older people aged 75-79 is $10,410.

Insert table 4 here

Utility

The baseline utility estimates used in the model were based on the UK Population Norms for the EQ-5D.[13] For example, the utility of a 75 year is 0.731. A utility decrement was incurred once an individual attended ED (-0.014), was admitted to hospital (-0.144), entered residential care (-0.06) or had a previous fracture in the year following a fall (-0.072). These utility measures were estimated from a variety of published literature based on the utility loss of a wrist fracture, vertebral fracture, hip fracture, previous fracture and residential aged care.[14,15,16,13,17] A utility decrement for the fear of falling (-0.045) was also included in the model regardless of any injury or hospitalisation, estimated from Iglesias et al. (2009).[18]

Results

Each of the interventions was analysed for a 10-year period to a cohort of individuals aged 75 years. This is the average age of those older than 65 in NSW and was used as our base case. Exercise, Tai Chi, home hazard assessment and modification, psychotropic medication withdrawal, multiple and multi-factorial interventions were all assumed to incur the cost and benefits of the intervention in year one only. Expedited cataract surgery and cardiac pacing were assumed to incur costs in year one only, but the benefits would be experienced for as long as the model was run. Interventions such as hip protectors, vitamin D and medication review were assumed to be re-occurring interventions and both the costs and benefits would be incurred for as long as the model was run.

Outcomes from the model were measured in terms of falls avoided, hospitalisations avoided and QALYs. Table 5 and 6 summarise the cost-effectiveness results which show the additional cost of providing the intervention. This includes the actual cost of providing the intervention minus the cost of avoided medical treatment due to falls averted. In this respect, the ‘do nothing’ option against which all interventions are compared is not costless because this option incurs the maximum fall-related treatment costs.

Insert table 5 here

Insert table 6 here

Sensitivity analysis

Using group-based exercise as an example (with the comparator defined as best standard care), each possible parameter was tested using the confidence interval, and if unavailable, using the best estimate of possible ranges or by adjusting the parameter up and down by 25%. The tornado plot is presented in Figure 3. The fear of falling is the main driver in the model. This is expected because each time a fall is avoided the QALY decrement associated with a fall is also avoided. The effectiveness of the intervention and cost of the intervention are also drivers in the model.

Insert figure 3 here

Discussion

Incremental cost per fall avoided or hospitalisation avoided were presented in this analysis. However, using surrogate outcomes such as these makes it difficult to judge whether an intervention represents value for money in terms of the total health care budget. In order to make this decision it is necessary to either value society's willingness-to-pay to avoid a fall or hospitalisation; or alternatively, a generic outcome measure, such as life years gained or quality adjusted life years gained, can be used. The advantage of using the latter approach is that interventions targeting different health conditions (not just falls prevention) can be compared, and the most cost-effective interventions can be adopted.

Currently there is debate in Australia regarding whether a cost-effectiveness threshold exists. An implicit threshold of between $50,000 and $60,000 per QALY gained is often mentioned as being appropriate. Between 1994 and 2003, the highest cost per QALY at which a drug was recommended for listing by the Pharmaceuticals Benefits Advisory Committee was $52,400.[19] If this threshold does represent society's willingness-to-pay for a QALY gained, the following community-dwelling interventions would be considered cost effective: expedited cataract surgery, psychotropic medication withdrawal, Tai Chi and home hazard assessment and modification. Group-based exercise would be approaching cost-effective. The following residential aged care interventions would be considered cost-effective: medication review, hip protectors and vitamin D supplementation.

The results presented in this analysis compare each intervention to the 'do nothing' option. For those interventions given to the general population, the incremental cost per QALY needs to be ranked against the next best option. The results of this analysis deem home hazard assessment as the most cost-effective community-dwelling intervention, at $53,052 per QALY and Tai Chi as the next best option at $66,660 per QALY. The results for strategies aimed at specific populations do not require the similar incremental analysis.

Acknowledgments

The authors would like to thank NSW Health for their contribution to the project, Professor Stephen Lord from the Prince of Wales Medical Research Institute and Dr. Wendy Watson from the Injury Risk Management Research Centre.

References

1. Delbaere K, Lord S, Close J. Falls prevention in older people: A review of the evidence. Sydney: Prince of Wales Medical Research Institute; 2007.

2. NSW Department of Health. Report on Adult Health from the New South Wales Population Health Survey. Sydney: NSW Health Department; 2007.

3. Norton R, Butler M. Prevention of Falls and fall-related injuries among institutionalised older people. Wellington: University of Auckland; 1997.

4. NSW Department of Health. In; 2010.

5. Boyd R, Stevens JA. Falls and fear of falling: burden, beliefs and behaviours. Age and ageing 2009;38(4):423-8.

6. Masud T, Morris RO. Epidemiology of falls. Age and ageing 2001;30 Suppl 4:3-7.

7. Watson W, Clapperton A, Mitchell R. The cost of fall injuries among older people in NSW, 2006-07. NSW Injury Risk Management Research Centre, University of New South Wales 2009.

8. Gillespie LD, Robertson MC, Gillespie WJ, Lamb SE, Gates S, Cumming RG, et al. Interventions for preventing falls in older people living in the community. Cochrane Database of Systematic Reviews (Online) 2009(2):CD007146.

9. Lord SR, Ward JA, Williams P, Anstey KJ. An epidemiological study of falls in older community-dwelling women: the Randwick falls and fractures study. Australian journal of public health 1993;17(3):240-5.

10. Australian Bureau of Statistics. Life Tables Australia 2005-2007, Catalogue No. 3302055001DO001_20052007. Canberra: Commonwealth of Australia; 2008.

11. Wang JJ, Mitchell P, Smith W, Cumming RG, Leeder SR. Incidence of nursing home placement in a defined community. Medical journal of Australia 2001;174(6):271-5.

12. 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.; 2009.

13. Brazier JE, Green C, Kanis JA. A Systematic Review of Health State Utility Values for Osteoporosis Related Conditions. Osteoporosis International 2002;13:768-776.

14. Honkanen LA, Mushlin AI, Lachs M, Schackman BR. Can hip protector use cost-effectively prevent fractures in community-dwelling geriatric populations? Journal of the American Geriatrics Society 2006;54(11):1658-65.

15. Peel N, Steinberg M, Williams G. Home safety assessment in the prevention of falls among older people. Australian and New Zealand journal of public health 2000;24(5):536-9.

16. Strom O, Borgstrom F, Sen SS, Boonen S, Haentjens P, Johnell O, et al. Cost-effectiveness of alendronate in the treatment of postmenopausal women in 9 European countries--an economic evaluation based on the fracture intervention trial. Osteoporosis international 2007;18(8):1047-61.

17. Zethraeus N, Borgstrom F, Strom O, Kanis JA, Jonsson B. Cost-effectiveness of the treatment and prevention of osteoporosis--a review of the literature and a reference model. Osteoporosis international 2007;18(1):9-23.

18. Iglesias CP, Manca A, Torgerson DJ. The health-related quality of life and cost implications of falls in elderly women. Osteoporosis international 2009;20(6):869-78.

19. Henry DA, Hill SR, Harris A. Drug prices and value for money: the Australian Pharmaceutical Benefits Scheme. JAMA 2005;294(20):2630-2.

20. Sherrington C, Lord S, Close J. Best practice recommendations for physical activity to prevent falls in older adults (unpublished report to the NSW Department of Health). 2008.

21. Campbell AJ, Robertson MC, La Grow SJ, Kerse NM, Sanderson GF, Jacobs RJ, et al. Randomised controlled trial of prevention of falls in people aged > or =75 with severe visual impairment: the VIP trial. BMJ 2005;331(7520):817.

22. 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. Journal of the American Geriatrics Society 2003;51(3):306-13.

Table 1. Results of community-dwelling meta-analysis – Rate ratio (95% C.I.)

Intervention	CHERE community-dwelling results	Cochrane Community-dwelling results	CHERE RACF results
Group-based exercise	**0.79 (0.70, 0.86)**	**0.78 (0.71, 0.86)**	0.79 (0.56, 1.11)
Home-based exercise	0.81 (0.58, 1.14)	**0.66 (0.53, 0.82)**	**-**
Tai Chi	**0.66 (0.57, 0.77)**	**0.63 (0.52, 0.78)**	0.96 (0.79, 1.17)
Vitamin D and calcium	0.95 (0.85, 1.07)	0.95 (0.80, 1.14)	**0.86 (0.83, 0.90)**
Education	0.85 (0.73, 1.00)	-	-
Home hazard assessment and modification	**0.70 (0.56, 0.88**)	0.90 (0.79, 1.03)	-
Hip protectors	1.23 (1.12, 1.36)	-	**0.78 (0.73, 0.84)**
Psychotropic medication withdrawal	**0.40 (0.23, 0.70)**	**0.34 (0.16, 0.73)**	**-**
Clinical medication review	Not estimable	Not estimable	**0.59 (0.49, 0.70)**
Expedited cataract surgery	**0.66 (0.49, 0.90)**	**0.66 (0.45, 0.75)**	**-**
Vision and eye exam	1.57 (1.39, 1.76)	-	-
Cardiac pacing	**0.33 (0.28, 0.38)**	**0.42 (0.23, 0.75)**	
Multiple interventions	**0.80 (0.70, 0.90)**	**-**	**0.76 (0.59, 0.97)**
Exercise and home hazard	**0.76 (0.65, 0.90)**	-	-
Exercise and falls advice	0.86 (0.71, 1.03)	-	-
Exercise and supplementation	0.57 (0.27, 1.20)	-	-
Multi-factorial interventions	**0.72 (0.62, 0.83)**	**0.75 (0.65, 0.86)**	**0.76 (0.59, 0.97)**
Assessment and referral	**0.81 (0.72, 0.92)**	**0.84 (0.72, 0.98)**	1.34 (1.06, 1.69)
Assessment and active intervention	**0.67 (0.52, 0.85)**	**0.70 (0.55, 0.90)**	**0.68 (0.53, 0.87)**

Note: the numbers in bold indicate that the intervention produced a statistically significant reduction in the number of people falling

Table 2. Probability of falling by age group

	Low risk	Medium risk	High risk
Community-dwelling			
65-69	0.18	0.25	0.39
70-74	0.18	0.25	0.39
75-79	0.23	0.35	0.50
80-84	0.26	0.40	0.57
85+	0.31	0.50	0.68
Residential aged care			
65-69	0.26	0.36	0.57
70-74	0.26	0.36	0.57
75-79	0.32	0.50	0.72
80-84	0.37	0.57	0.82
85+	0.44	0.71	0.97

Based on estimate that the absolute risk of being a faller if you fell in the past year was 71% and 32% if you had not fallen in the past year.

Table 3. Transition probabilities after a fall by age group

	Emergency	Other Medical	Admitted to Hospital	Death due to a fall	Discharge to RACF	Discharge to Respite
Community-dwelling						
65-69	0.09	0.13	0.26	0.008	0.008	0.004
70-74	0.14	0.21	0.18	0.01	0.02	0.01
75-79	0.18	0.22	0.19	0.02	0.03	0.02
80-84	0.25	0.31	0.28	0.03	0.05	0.03
85+	0.35	0.31	0.30	0.06	0.09	0.04
Residential aged care						
65-69	0.04	0.44	0.57	0.01	-	-
70-74	0.07	0.40	0.46	0.01	-	-
75-79	0.10	0.39	0.46	0.02	-	-
80-84	0.13	0.32	0.44	0.03	-	-
85+	0.15	0.27	0.44	0.06	-	-

Table 4. Cost of falls prevention interventions

Intervention	Costs	Source
Community-dwelling interventions		
Group-based exercise	$534	Sherrington et al (2008)[20]
Home-based exercise	$1,019	Day et al (2009)[12]
Tai Chi	$648	Estimated from Sherrington et al (2008) [20]
Home hazard assessment	$502	Day et al (2009)[12]
Psychotropic medication withdrawal	$604	Day et al (2009)[12]
Cardiac pacing	$13,526	Day et al (2009)[12]
Expedited cataract surgery	$2,050	DRG hospital data, MBS code 23, MBS code 10900
Multiple intervention	$1034	Campbell et al (2005)[21], NSW Health personal correspondence, Sherrington et al (2008)[20] and Day et al (2009)[12]
Multi-factorial – assessment and referral	$855	Day et al (2009)[12]
Multi-factorial – assessment and active	$1244	Day et al (2009)[12]
Residential aged care interventions		
Vitamin D	$138	www.pharmacyonline.com.au
Hip protectors	$166 / $117	www.hipsaver.com.au
Clinical medication review	$228	MBS code 903, Pharmacy Guild
Multiple intervention	$775	Based on Becker et al (2003)[22], Department of Veterans' Affairs, Vitamin D and hip protectors (as above), Kainos printing, NSW Health Award Wage rates
Multi-factorial – assessment and active	$1244	Day et al (2009)[12]

Table 5. Community-dwelling cost-effectiveness results^

Intervention	Incremental cost per fall avoided	Incremental cost per hospitalisation avoided	Incremental cost per QALY
General population			
Group-based exercise	$5,076	$146,250	$76,387
Home-based exercise	$6,940	$201,837	$104,464
Tai Chi	$3,492	$101,321	$52,401
Home hazard modification*	$3,153	$98,095	$46,525
Multiple – Exercise and home hazard modification*	$9,204	$286,970	$135,764
Multi-factorial – referral	$11,581	$361,098	$170,830
Multi-factorial – active	$8,832	$275,395	$130,289
Specific populations			
Expedited cataract surgery	$4,964	$70,170	$38,569
Psychotropic medication withdrawal	$1,413	$44,041	$20,848
Cardiac pacing	$5,009	$97,141	$87,613

**Estimates of effectiveness were taken from the CHERE meta-analysis*

^ All incremental results are relative to standard care

Table 6. Residential aged care cost-effectiveness results

Intervention	Incremental cost per fall avoided	Incremental cost per hospitalisation avoided	Incremental cost per QALY
Medication review	dominant	dominant	dominant
Hip protectors	$109	$2,422	$1,999
Vitamin D	$418	$9,161	$7,714
Multiple – Exercise and home hazard modification	$1,485	$32,595	$27,332
Multi-factorial – active	$3,714	$81,507	$68,398

Figure 1. Markov model

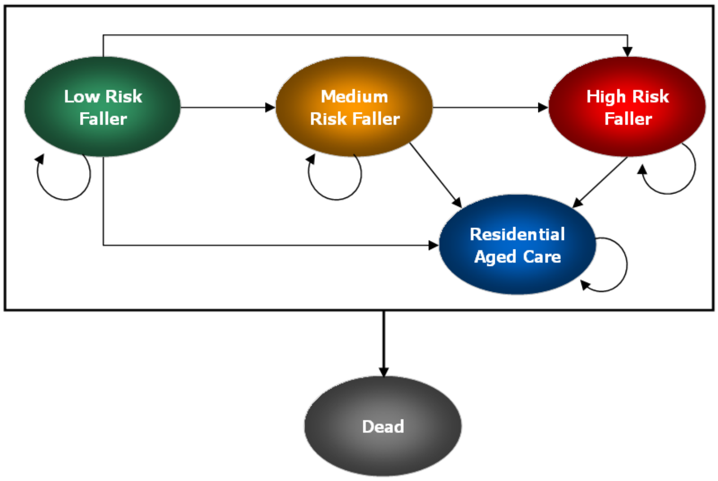

Figure 2. Decision tree

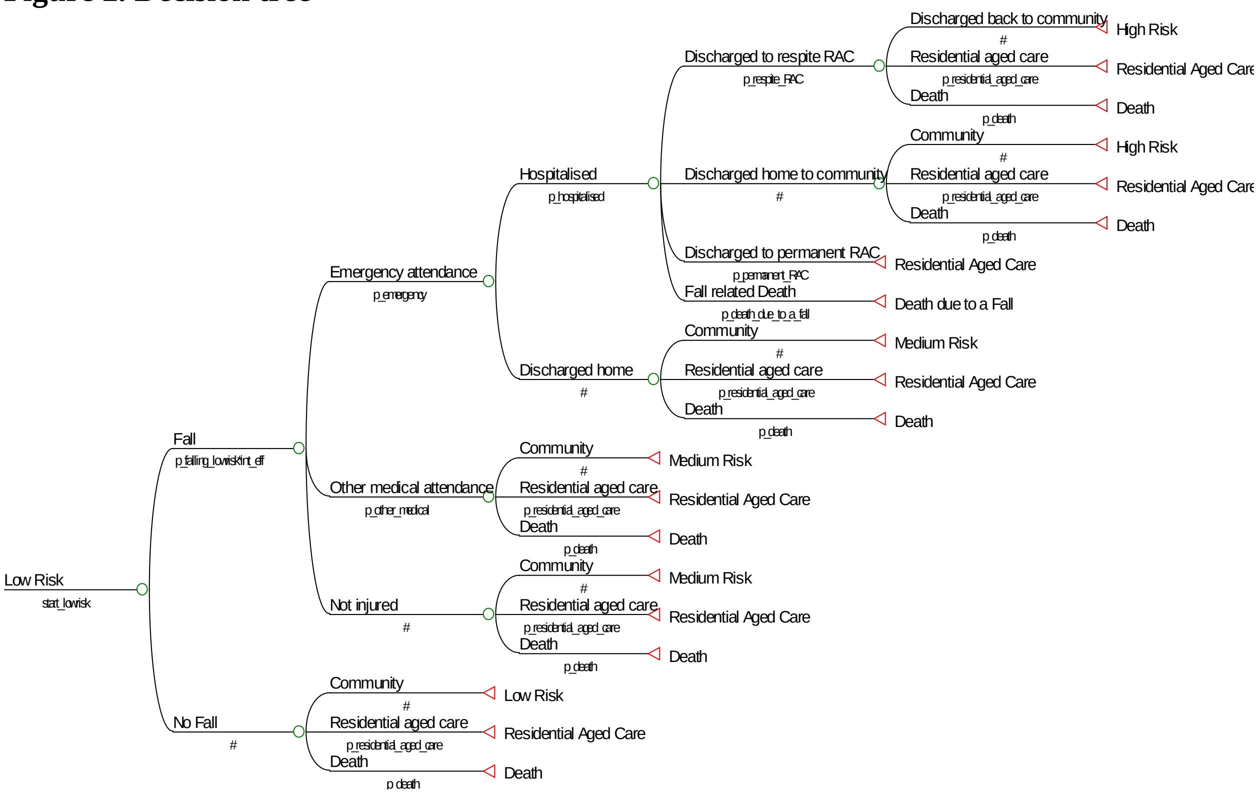

Figure 3. Tornado plot of group-based exercise vs. standard care (base case ICER = $76,387)