Public Health England

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A Return on Investment Tool for the Assessment of Falls Prevention Programmes for Older People Living in the Community

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Published February 2018
PHE publications
gateway number: 2017761

PHE supports the UN
Sustainable Development Goals

Contents

Abbreviations

CCG	Clinical commissioning group
DSA	Deterministic sensitivity analyses
FaME	Falls Management Exercise
GP	General Practitioner
HAM	Home assessment and modification
HTA	Health technology assessment
ICER	Incremental cost-effectiveness ratio
IRR	Incidence rate ratio
LA	Local authority
NICE	National Institute of Health and Care Excellence
OT	Occupational therapy
PHE	Public Health England
PSI	Postural stability instructor
PSS	Personal social services
QALY	Quality-adjusted life-year
RCT	Randomised controlled trial
ROI	Return on investment
STP	Sustainability and transformation partnership
YHEC	York Health Economics Consortium

Glossary

Adapted from the [YHEC glossary]

Cost-effectiveness threshold: represents the opportunity cost of health foregone when deciding to reimburse/fund a new technology. The underlying economic principle is that given a fixed budget a decision to reimburse a new healthcare intervention implies that funds will not be available to fund some other intervention which would deliver health benefits, and that these health benefits would be obtained at the 'marginal' rate represented by the threshold. The threshold often represents a specific cost per additional QALY value (eg £60,000 per QALY), so if the ICER of an intervention is less than this value it is likely to be considered cost-effective.

Deterministic sensitivity analysis: allows a reviewer to assess the impact that changes in a certain input (parameter) will have on the output results of an economic evaluation – this may be referred to as assessing the robustness of the result to that parameter. The parameter of interest should be varied between plausible extremes, preferable justified by review of available evidence. This is the simplest form of sensitivity analysis since only one parameter is changed at one time, and correlations between parameters is not taken into account.

Discounting: Economic evaluations refer to a choice to be made between alternative interventions at a specific point in time, however the costs and health outcomes associated with each intervention occur at different points in time, present or future. Costs and health outcomes that are predicted to occur in the future are usually valued less than present costs, and so it is recommended that they be discounted in analysis. This is usually achieved by expressing the results as series (streams) of health outcomes and costs over time, applying a discounting factor to each value in the series and then aggregating to give a 'present value' of each stream. The discount factor increases over time, based on an underlying discount rate. If we apply a discount rate of 3.5% per year for costs than £100 spent in year 2 would have a 'present' value of £96.50 in year 1.

Incremental cost-effectiveness ratio (ICER): represents the economic value of an intervention, compared with an alternative. An ICER is calculated by dividing the difference in total costs (incremental cost) by the difference in the chosen measure of health outcome or effect (incremental effect) to provide a ratio of 'extra cost per extra unit of health effect' – for the more expensive therapy vs the alternative. In the UK the QALY is most frequently used as the measure of health effect, enabling ICERs to be compared across disease areas.

In decision-making ICERs are most useful when the new intervention is more costly but generates improved health effect. ICERs reported by economic evaluations are compared with a pre-determined threshold (see cost-effectiveness threshold) in order to decide whether choosing the new intervention is an efficient use of resources.

Net monetary benefit: is a summary statistic that represents the value of an intervention in monetary terms when a willingness-to-pay threshold for a unit of benefit (for example a measure of health outcome or QALY) is known. The use of NMB scales both health outcomes and use of resources to costs, with the result that comparisons without the use of ratios (such as in ICER). Incremental NMB measures the difference in NMB between alternative interventions, a positive incremental NMB indicating that the intervention is cost-effective compared with the alterative at the given cost-effectiveness threshold. In this case the cost to derive the benefit is less than the maximum amount that the decision-maker would be willing to pay for this benefit.

Opportunity cost: The opportunity cost of an intervention is what is foregone as a consequence of adopting a new intervention. In a fixed budget health care system where increased costs will displace other health care services already provided, the opportunity cost is measured as the health lost as a result of the displacement of activities to fund the selected intervention.

Quality-adjusted life year (QALY): is a summary outcome measure used to quantify the effectiveness of a particular intervention. Since the benefits of different interventions are multi-dimensional, QALYs have been designed to combine the impact of gains in quality of life and in quantity of life (ie life expectancy) associated with an intervention. In this case it is the incremental (ie differences between 2 or more alternatives) QALYs, compared with the incremental costs, that provides the measure of economic value.

If a wide range of aspects (domains) of quality of life is included in the quality component, the resulting QALYs should be comparable across disease areas, which is valuable for decision-making. More specifically, QALYs are based on utilities, which are valuations of health-related quality of life measured on a scale where full health is valued as 1 and death as 0. These valuations are the multiplied by the duration of time (in years) that a subject spends in a health state with that particular utility score, and aggregate QALYs are then summed over the time horizon of the analysis (often lifetime).

Executive summary

Objectives

To develop an interactive, easy-to-use tool that can be used to estimate the cost-effectiveness and potential return on investment (ROI) for falls prevention programmes aimed at elderly people based in the community.

Methods

The tool was developed in Microsoft Excel and incorporated 4 programmes where there was evidence of cost-effectiveness: Otago home exercise, Falls Management Exercise group programme, Tai Chi group exercise, and home assessment and modification. These interventions were identified following a systematic literature review that was informed by the NICE guidance on falls prevention and the 2012 Cochrane review on the same topic.

Two of the interventions identified in the literature review were not included. In one case this was due to there being insufficient data to base the costing of the intervention on (multifactorial risk assessment and management programme) and on the other case this was due to the intervention programme not being currently delivered in the UK (No Falls group exercise programme).

The analysis was undertaken from an NHS and Social Care perspective and covered a 2 year time horizon. Therefore, the total costs to implement and sustain each intervention for up to 2 years was calculated and data from relevant clinical trials used to estimate the total number of falls in this time period should each intervention be implemented with fidelity, in a pre-defined population.

The associated cost to the NHS and social care to manage these falls was then calculated by predicting the frequency of a number of possible downstream events following a fall (eg an inpatient stay due to a hip fracture, transfer to a nursing or residential care home). Usual care was assumed to be costless to operate and the falls rate for this cohort was also obtained from the clinical data.

As the efficacy of each intervention was examined in a unique population group the rate of falls for usual care was different for each separate comparison. The exercise intervention populations were made up of older people who had both fallen and not fallen in a previous time period. The home assessment and modification intervention (HAM) population was made up of older people who had all fallen in a previous time period. The difference in the cost of falls represents the benefit of the intervention compared with usual care.

The impact of each intervention on the quality of life of participants was also examined via the inclusion of quality-adjusted life years (QALYs) as an outcome measure. To achieve this, utility values were applied to participants depending on the events that were predicted to occur (eg lower utility and hence lower QALY score for people suffering hip fractures). Overall, a reduction in falls results in higher QALY scores across the population.

The estimated cost savings and gains in QALYs for each intervention, compared with usual care, were used to predict its ROI and cost-effectiveness, using established formulae. Separate financial (cost savings only) and societal (cost savings plus QALY gains) ROI values were estimated for each intervention.

The approach adopted for the analysis was informed by members of 2 advisor groups (the Steering Group and User Group), which contained relevant experts with knowledge of falls prevention services provision.

Results

The number of people receiving the different interventions can be defined by the user of the tool to take into account local commissioning and provision arrangements, priorities and resources. The tool is also able to calculate numbers based on a number of criteria including location in England, age group and willingness to participate. Results from an example population are presented. This is based on the York local authority area looking at all people aged 65 and over who are deemed at risk of future falls (34%).

The population group was further refined to account for a proportion of people who would be unwilling or unable to partake in falls prevention programmes (80%). This equates to a final population size of 2,519 for the 3 exercise programmes. In terms of HAM, the population size was further refined to 141 in order to focus on higher risk people only (ie explicitly those who had recently fallen).

When implemented in the defined population it is predicted that, based on the parameters applied for the analysis, all 4 interventions produce a reduction in the number of falls compared with usual care. This equates to all 4 interventions providing a societal ROI (ie cost savings and QALY gains outweigh cost of implementation) with one out of 4 also providing a financial ROI (ie cost savings outweigh cost of implementation). These results are summarised below. All interventions were also found to be cost-effective compared with usual care.

Intervention	Financial ROI	Societal ROI
Otago	£0.95 : £1.00	£2.20 : £1.00
FaME group exercise	£0.99 : £1.00	£2.28 : £1.00
Tai Chi	£0.85 : £1.00	£1.97 : £1.00
Home assessment and modification	£3.17 : £1.00	£7.34 : £1.00

The outputs from the sensitivity analysis indicate that the results of the analysis are sensitive to changes in a small number of input parameters. In particular, the returns on investment are substantially reduced if the effectiveness of each intervention in reducing the number of falls (as measured by incidence rate ratio) is lower. This finding is as expected.

Discussion

One out of the 4 interventions (HAM) produce a financial return on investment; however, the majority of these returns are not expected to be cash releasing but rather are opportunity cost savings (eg freeing up hospital beds due to a reduction in inpatient admissions).

The analysis was undertaken using efficacy data sourced from randomised controlled trials and systematic reviews, which should provide robust estimates of the effectiveness of each intervention. All inputs adopted in the analysis were also validated by relevant experts in the field of falls prevention services provision. Each intervention was compared with usual care with a different baseline rate of falls adopted for each comparison to account for differences in the populations recruited in the clinical trials that underpin the analysis. Therefore, it is not possible to compare interventions to one another, which would have been informative.

It is important to note that the generalisability of the results of this analysis will depend on the similarity of the population group receiving an intervention to that of the participants enrolled in the clinical trials (eg in terms of age range and history of falls). Similarly, each intervention should be delivered with fidelity to best practice protocols (eg delivered by trained professionals with sufficient equipment). If the quality of the delivered interventions is consummately lower than those delivered as part of the underlying clinical trials then the reduction in the number of falls is expected to be lower in clinical practice, which would reduce the financial and societal returns (as illustrated by the results of the sensitivity analysis).

Conclusions

An ROI tool has been developed incorporating 4 falls prevention programmes that have previously been found to be cost-effective in a community-based elderly population. Based on an example analysis undertaken in the York local authority population, all 4 interventions were found to be cost-effective, thus producing a positive societal ROI (ie when the impact on quality of life is formally quantified).

One out of 4 interventions was also found to have a positive financial ROI (ie cost savings outweigh the cost of implementation). The estimated returns are only expected if each intervention is implemented in clinical practice with fidelity, and delivered to a consistent quality, such that the effectiveness of each intervention at reducing the number of falls is similar to the reduction measured in the clinical studies that underpin the analysis. Further, if, the interventions are targeted at population groups that are similar to those enrolled in the clinical studies just discussed, the results will be more valid.

Acknowledgements

York Health Economics Consortium would like to thank all members of the Steering Group and User Group for their useful contributions throughout the project.

1. Introduction

Public Health England (PHE) has commissioned York Health Economics Consortium (YHEC) to develop a user friendly tool for use by various stakeholders, including NHS clinical commissioning groups (CCGs) and local authorities (LAs), to assess the potential return on investment (ROI) of falls prevention programmes targeted at older people living in the community.

This report presents the methods and results of the ROI tool.

1.1 Background

People aged 65 years and older have a higher risk of falling, with 30% of people older than 65 and 50% of people older than 80 falling at least once a year. With 8.7 million people living in England aged 65 and over in 2011 this equates to over 3 million falls annually across the UK [1]. The consequences for people who have fallen, and their families, can be serious [2] [3] .

For example, falls can result in fractures, head injuries, pain, impaired function, loss of confidence in carrying out everyday activities, a fear of future falls, loss of independence/autonomy, and even death [4]. Falls are the most common cause of death from injury in people who are over 65 years old [5].

Falls account for more than 4 million hospital bed days, which causes a significant burden to the NHS [6] [7]. Hip fractures are particularly problematic as there has been shown to be a high mortality risk of 9.4% at 30 days and 31.2% at 1 year and within the first year they are also associated with a median hospital stay of 20.5 days [8]. Incident hip fractures alone were estimated to cost the NHS £1.1 billion annually between 2003 and 2013 [8].

Hospital costs are not the only components of care that arise - a substantial proportion of people who fall will be unable to return to independent living, being discharged into a residential care or nursing home. Losing independence and a fear of falling can lead to increased inactivity, loss of strength and a greater risk of future falls which require further resources from many different stakeholders, including families and carers, the NHS and local authorities.

Falls are a major population health problem that will increase with aging demographics, which in turn will result in increased pressures on the NHS and social services to provide relevant treatments and ongoing care. The number of people aged 65 years and over is projected to increase by an average of 20% between mid-2014 and mid-2024 [9]. Moreover, a higher proportion of this population will have multimorbidity (the presence of 2 or more disorders), poorer functional status, lower quality of life and more will take multiple medications, all significant risk factors for falls [10].

Due to the burden just described, it is important to identify actions that can reduce falls and, therefore, reduce the burden of falls for these individuals, their families and commissioners. Assisting people with healthy ageing will reduce the future costs of health and social care, avoid distress to families and carers and help to create opportunities for older people to feel healthy, safe and connected.

1.2 Falls prevention interventions

There is evidence that some falls can be prevented, using interventions that are evidence-based and effective [11]. To justify implementation in the elderly population these interventions should also be a cost-effective use of scare resources. A structured literature review undertaken by YHEC in 2016, analysed 26 economic evaluations and identified 4 interventions that were evidenced as being clinically and cost-effective in preventing falls and fragility fractures in older people living in the community and thus were recommended for inclusion in the ROI tool. Two of the interventions identified in the literature review were not included. In one case this was due to there being insufficient data to base the costing of the intervention on (multifactorial risk assessment and management programme) and on the other case this was due to the intervention programme not being currently delivered in the UK (No Falls group exercise programme).

It should be noted that the YHEC literature review search strategy sought to identify interventions recommended in the National Institute for Health and Care Excellence (NICE) Guidance and also those included in an update to the 2012 Cochrane review [7, 12]. Therefore, interventions that were not included in these sources were not identified as part of the YHEC review (eg non-health and social care interventions such as handyperson services). Further, interventions that failed to demonstrate clinical-effectiveness at the time of the NICE guidelines were specifically excluded (eg use of vitamin D, hip protectors and cognitive/behavioural interventions). The 4 interventions with evidence supporting their cost-effectiveness that generalised to the UK setting are described below.

1. The Otago programme is a home based exercise programme in which participants are encouraged to perform exercises 3 times a week at home and also walk indoors and outdoors at a moderate pace. Otago is recommended for at least one year and participants receive support from trained staff through home visits and follow up telephone calls [13].
2. The Falls Management Exercise (FaME) programme is a community based group programme delivered by a postural stability instructor (PSI). The programme consists of weekly classes lasting between 45 and 75 minutes with additional home exercises lasting at least 6 months [13].

3. Tai Chi or Tai Ji Quan (Tai Chi henceforth) exercises combine deep breathing and relaxation with flowing movements. It can be performed either in a community based group or at home on a regular basis [14].
4. Home assessment and modification (HAM) is a service in which relevant professionals risk assess a person's usual residence to identify environmental hazards and carries out actions to reduce these. Typical environmental hazards are loose mats, poor lighting and no handrails [15].

Multifactorial risk assessment and management (MFRAM) was also identified as a cost effective intervention. MFRAM is performed by healthcare professionals who assess participants for the presence of a range of falls risk factors including: falls history, muscle weakness, balance impairment, visual impairment, polypharmacy and home hazards [7]. Interventions are then delivered to reduce this risk, such as exercise programmes, medication adjustment, or vision correction, as part of ongoing care. This intervention was not included in the ROI tool as there was insufficient data to inform the cost of the intervention.

Results from the preFit study [54], a large-scale RCT that is investigating the efficacy and cost-effectiveness of Otago and a multifactorial falls prevention programme in a UK setting, are due to be published in Summer 2018. Following the publication of this study we will assess the feasibility of using the findings to inform the return on investment of MFRAM and may be able to update the ROI tool to include this intervention.

It is important to note the differences in the studies used in terms of primary and secondary falls prevention (see the baseline characteristics tables in Section 2). Primary falls prevention involves reducing the number of people falling over in the first place. Secondary falls prevention involves reducing the number of people who have already fallen from falling over again. The populations in the physical activity intervention studies contained a mix of older people who had fallen and who had not fallen and so none of these can be viewed as being purely primary or secondary prevention. The home assessment and modification study population had all experienced at least one previous fall and so can be viewed as secondary prevention interventions.

1.3 Steering and user groups

Two expert groups were recruited because stakeholder engagement was seen as an essential component of the project. The 'Steering Group' was assembled first and contained national experts in the field of falls prevention, including: those with direct experience of implementing falls prevention programmes; representatives from the National Osteoporosis Society and the Chartered Society of Physiotherapy; and relevant public health experts and health economists. Members of the Steering Group were consulted via regular meetings and provided input on many aspects of the project, including:

- Advised on the structure of the literature review;
- Commented on a draft of the literature review report;
- Commented on the protocol for the ROI tool, which outlined the modelling approach, including key assumptions and input parameters;
- Provided feedback on an initial draft of the ROI tool, including the values applied for the tool input parameters (eg unit costs for each intervention).
- Provided feedback on an initial draft of the project report.

A 'User Group' was also recruited to gain the perspective of end users of the tool on its usability and relevance to their setting. Members also advised on a number of input parameters that were included in the tool (ie what values could be used to reflect real clinical practice).

Members of the Steering Group and User Group are listed in Appendix A.

1.4 Objectives

The aim of this analysis was to develop an easy-to-use, interactive tool for use by various stakeholders, including NHS clinical commissioning groups (CCGs) and local authorities (LAs). The objective of the tool, as requested by PHE, is to assist decision makers commissioning community-based falls prevention programmes by highlighting which programmes have the potential to be cost-effective and provide a tool to enable them to compare the return on investment of different interventions.

2. Methods

2.1 ROI tool overview

The ROI tool was developed using Microsoft Excel®, as this software should be accessible to all relevant stakeholders, with each of the 4 cost effective interventions included. An incremental approach was adopted whereby the ROI for each intervention was calculated by comparing each intervention's total costs and savings to usual care. This was assumed to be no specific falls prevention programme, in a relevant population. A 2 year time horizon was adopted in line with evidence around the duration of benefit for such interventions (see Section 2.6). An NHS and Social Care perspective was adopted and thus all costs relevant to the providers of such services are included.

In brief, the tool estimates the total costs to implement and sustain each intervention for up to 2 years and uses data from the clinical trial(s) to estimate the total number of falls for a given population. The associated costs to the NHS and social care to manage these falls are then calculated. Usual care is assumed to be costless to operate and the falls rate for this cohort is also obtained from the clinical data. The difference in the cost of falls represents the benefit of the intervention. These are compared to its costs using the formula:

$$\frac{\Sigma \text{Total discounted benefits}}{\Sigma \text{Total discounted costs}}$$

Where 'Σ' means 'the sum of'.

This approach to ROI differs from the approach used by the NICE, which uses total net discounted benefits minus total discounted costs, divided by total discounted costs. The approach taken in measuring ROI for this tool is therefore technically a cost benefit ratio with benefits divided by costs, as opposed to net benefits divided by costs. This approach is consistently used in ROI tools published by PHE.

The ROI values show the estimated value generated for every £1 spent on the intervention. If the ROI value is less than £1 for every £1 spent, this indicates that the cost of the intervention is greater than the value generated. A second analysis attributes value to improved quality of life from avoided falls to calculate a societal ROI.

Details of the inputs and assumptions required for this modelling process are provided in the remainder of this section. Sources that inform the values of parameters used in the tool include the original clinical studies and related economic evaluations, additional targeted literature searches and discussions with relevant experts in the field. However, the tool has been designed so that the majority of inputs can be updated by users to reflect their own implementation strategies and local costs.

The ROI results are presented for a central case using values for all parameters which were validated by members of the Steering Group and User Group. However, the ROIs are indicative only and users should input the cost and other values appropriate to their setting to establish the potential ROI for interventions commissioned in that local area.

As noted previously, the interventions included in the tool were based on the findings from a systematic review undertaken in 2016, which identified interventions where there was evidence of cost-effectiveness. A number of different economic evaluations were identified as part of this search, which reported results for each of the included interventions. As these studies had previously found the interventions to be cost-effective the same sources for effectiveness data that were adopted in those evaluations where also adopted for this analysis, where possible. A summary of the data sources for effectiveness data is provided below, based on the findings from the systematic review:

1. FaME: the efficacy data adopted here was extracted straight from the economic evaluation identified by the systematic review (Iliffe 2014) [13]. It should be noted that the Iliffe (2014) study enrolled inactive older people with no specific falls history and focuses on primary prevention. Earlier, Skelton and colleagues (2005) showed FaME reduced falls in women with a history of at least 3 or more falls in the past year (much higher risk), but no economic evaluation was undertaken [16]. The data from this analysis was not considered here but provides an example of FaME for secondary prevention.
2. Otago: a number of economic evaluations were identified for this intervention. Therefore, the efficacy data was taken from a systematic review & meta-analysis (Robinson 2002), as opposed to one single study, as the outputs from a meta-analysis are generally more robust [19].
3. Tai Chi: as with Otago a number of different economic evaluations were identified so the efficacy of the intervention was based on results from a systematic review & meta-analysis (Gillespie 2012) [11].
4. Home assessment and modification: a number of economic evaluations were identified. As with Otago and Tai Chi the effectiveness data in the analysis was therefore based on the findings from a systematic review & meta-analysis (Gillespie 2012) [11].

The remainder of this section is arranged as follows:

- Population – an explanation of how specific population groups can be selected to be modelled within the tool;
- Cost of falls – a description of all falls-related events included in the tool and how these are costed to estimate the mean cost per serious fall;
- Outcomes – a description of the other outcomes included in the tool in order to estimate the impact of each intervention of the quality of life of participants;
- Intervention effectiveness & costs: an explanation of how the effectiveness of each intervention at reducing the number of falls is estimated along with a description of how the cost of implementing each intervention is calculated, within the defined population.

2.2 Population

The number of people receiving the different interventions can be defined by the user of the tool to take into account local commissioning and provision arrangements, priorities and resources. The tool is also pre-set to calculate numbers using data on geographical location, age and willingness to participate. The sensitivity analysis undertaken from the analysis (see Section 2.6 and Section 3.7) indicates that the ROI for particular interventions is not significantly affected by changes in the number of people receiving that intervention and so the selected geographical area is not a driver of the results of the analysis but can be used to present values that are relevant to specific local areas.

To enable analyses to be undertaken within specific population groups, the population size for individual clinical commissioning groups (CCG), local authorities (LA) or sustainability and transformation partnerships (STPs) can be selected. The resulting populations are informed by national datasets [22, 23]. Within each geographical area, the population size is restricted to those aged 65 years and over as the interventions are not evidenced in younger populations. The populations can be further restricted to people aged 80 years and over as certain interventions may deliver greater value for money in this population. Rather than adopt a specific geographical area, commissioners can also model a defined number of people (eg 1,000) to receive each intervention and compare results for different numbers.

It is also unnecessary to give each intervention to all people aged 65 (or 80) and over. Therefore, the population included in the tool is further restricted to those people deemed to be at risk of falls. For 3 of the interventions this has been defined based on information published by the Department of Health who estimated that 34% of people aged 65 and over and 45% of people aged 80 and over are at risk of falling each year [24].

Given the HAM intervention is aimed at higher risk individuals there will be a smaller proportion deemed at risk. It has been assumed that 2% of people aged 65 and over and 5% of those aged 80 and over would be eligible for HAM each year. This is based on analysis on the proportion of individuals who fall and are admitted to hospital reported in the Craig et al. (2013) paper [26] and Public Health Outcomes Framework emergency admissions data. Finally, it is expected that a proportion of the elderly population will not be willing/able to partake in falls prevention services. To account for this the tool has a default setting of 20% of the invited population taking part in the selected intervention. This value is based on research into the costs of implementing falls care bundles in Scotland (Craig, unpublished). Local areas are able to change this figure in line with their own data and intelligence.

2.3 Cost of falls

The main outcome measure included in the analysis is the total number of falls in the defined population with each intervention versus usual care. Therefore, for fall events it is important to capture all resources relating to the initial treatment and any subsequent care in order to accurately estimate the average cost of a fall to the NHS and personal social services (PSS).

Once a person has fallen he or she may require medical attention, depending on the severity of the fall. If so, care may be limited to a General Practitioner (GP) attendance or, alternatively, a long hospital stay may be necessary. The percentage of people who fall requiring each form of care informs the average cost of a fall. Hence establishing the probability of different progressions along the care pathway is vital and it is expected that there may be a number of different downstream events that ultimately impact on the overall cost of care. This pathway has been designed based on previous research by Craig et al. (2013) [26], an analysis of hospital episode statistics data undertaken by PHE [27] and discussions with relevant experts.

In short, every fall is separated into ‘serious’ and ‘non-serious’. Non-serious falls (80% of all falls) are assumed to require no input from medical or social care services and hence there are no costs for these events [26]. In reality, non-injurious falls can have an impact on people’s lives, such as increasing anxiety, functional decline and social isolation. However, it was deemed that there was insufficient data to quantify these outcomes in the analysis, hence the focus on serious falls. People who suffer a serious fall (20% of all falls) are assumed to require a general practitioner (GP) appointment (51%), an ambulance call-out (61%) or attendance at an accident & emergency (A&E) department (80%). Some people who fall may require more than one service (eg an ambulance is called which takes the person to an A&E department). For those who do attend A&E, a proportion (65%) are assumed to return to their usual residence, whilst the remaining people (35%) are admitted as an inpatient. Of these inpatients, it is assumed that 31% of admissions are due to a hip-fracture [26].

Data from the PHE analysis indicates that 2.39% of inpatients die before discharge [27]. Further, these data indicate that there are 5 main locations once people have been discharged following an inpatient stay:

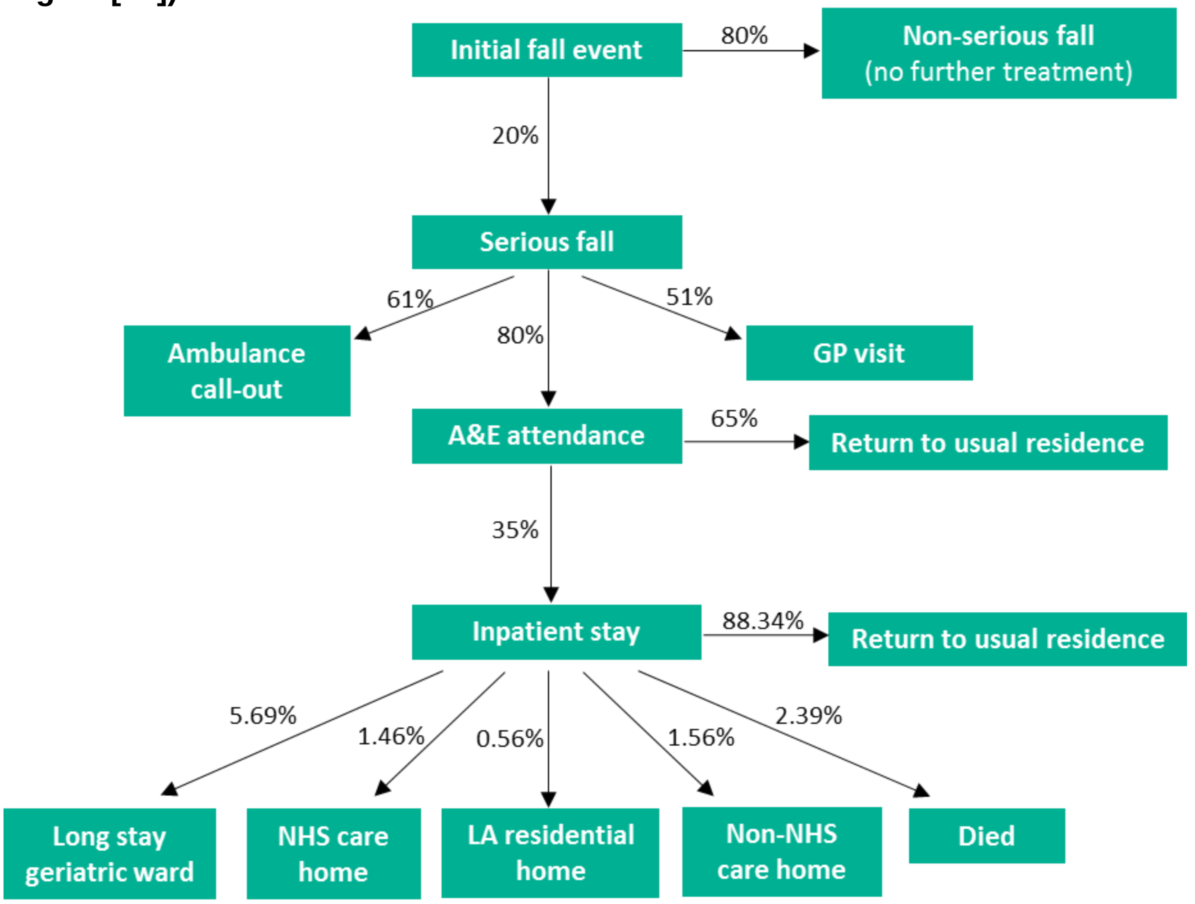
- Discharge to usual residence (88.34%)
- Admitted to a long stay geriatric ward (5.69%)
- Discharge to an NHS care home (1.46%)
- Discharge to a local authority residential home (0.56%)
- Discharge to a non-NHS care home (1.56%)

The full pathway is summarised in Figure 1. This pathway contains primary, secondary and social care and is expected to capture all aspects of care for the treatment and management of serious falls over the 2 year time horizon of the analysis. A number of other discharge locations are possible following an inpatient admission (eg hospice care, psychiatric hospital) but the available data suggests the occurrence of these events is very low (ie <0.5% of total admissions) and, therefore, these have not been considered in the analysis [27].

In order to estimate the average cost of each fall it is necessary to assign unit costs to each of the events included in the pathway just described. These unit costs are summarised in Table 1 for primary/secondary care and Table 2 for social care. All of the unit costs applied in the analysis are based on 2015/16 prices and older prices reported in the literature have been updated using the hospital & community health services index, where necessary [28]. For the primary/secondary care resources these are all expected to be one-off costs that capture all elements of care for each particular event. Moreover, all of these costs are expected to be incurred in the year of the fall, with the exception of the inclusion of second year follow-up costs for people who have a hip fracture [8].

In the population included in this analysis, social care costs are expected to be incurred over a longer time period then primary/secondary care. The cost of a care home stay is only included in the analysis if the person did not reside in such a home before the hospital admission. Previous research indicates that the mean length of stay in a care home in Scotland, over the last 10 years, is approximately 2.5 years [29]. Relevant England-specific data could not be identified and, therefore, it is assumed that a person who is discharged to a care home, having previously lived in their own home, will remain there for 2.5 years on average [29]. Therefore, the total cost of a care home in the analysis is based on a 2.5 year stay in either an NHS care home or local authority residential home.

Figure 1: Summary of care pathway following a fall (Craig et al. 2013 [26], NHS Digital [27])



As shown in Figure 1, people may be discharged to 3 different types of care home: NHS care home, LA residential care home and non-NHS care home. It is assumed that non-NHS care home placements are funded either privately or by the voluntary sector and, as such neither the NHS nor LAs will fund any of the costs and these are not considered further. For NHS care homes there will be 2 components of each stay: the cost of the person residing in the care home (ie residential costs) and the cost of providing nursing care (ie nursing costs). The nursing cost (£113 per week) is incurred by the NHS whilst the residential costs (£550 per week) is incurred by LAs [30]. However, previous research indicates that one third of residential costs are self-funded [30]; therefore, only £367 of these costs are borne by LAs.

This means, when combined with the nursing care element, the total cost per person per week is £480. For LA residential care home stays (£555 per person per week) no nursing care is provided and with one third of the full weekly cost self-funded, the LA incurs weekly costs of £372 per person [30]. Over the 2.5 year time horizon the total cost of care home stays incurred by NHS and LAs is estimated to be £62,400 and £48,360 for NHS care homes and LA residential care homes respectively.

For people who are discharged to their usual residence following an inpatient episode it is assumed that they will receive a care package in the community [26]. This package comprises of a shared assessment by a social care worker and community therapist, one visit to a GP and ongoing 'low cost' care at home for 8 weeks. This equates to a total cost of £1,906 per person.

Table 1: Primary/Secondary care unit costs (2015/16 prices)

Event/Resource	Unit cost	Reference
GP visit	£36.00	NHS Reference Costs 2016 [31]
A&E attendance – no admission	£100.53	NHS Reference Costs 2016 [31]
A&E attendance - admission	£90.29	NHS Reference Costs 2016 [31]
Ambulance call-out	£236	NHS Reference Costs 2016 [31]
Inpatient stay – non-hip fracture	£7,949	Craig 2013 (inflated to 2015/16 prices) [26]
Inpatient stay – hip fracture	£8,955	Leal 2016 (inflated to 2015/16 prices) [8]
Hip fracture – 1st year follow-up	£527	Leal 2016 (inflated to 2015/16 prices) [8]
Hip fracture – 2nd year follow-up	£2,212	Leal 2016 (inflated to 2015/16 prices) [8]
Geriatric long stay	£14,659	ISD Scotland 2016 [32]*

*The mean number of weeks per stay (7.85) calculated by dividing the total number of inpatient weeks (47,011) by the number of discharges (5,992). This was then multiplied by the net cost per inpatient week (£1,868) to estimate the total unit cost.

Table 2: Social care unit costs (2015/16 prices)

<table>
<tr><th colspan="2">Event/Resource</th><th>Weekly unit cost</th><th>No. of units</th><th>Total cost</th><th>Reference</th></tr>
<tr><td colspan="2">NHS care home</td><td>£480</td><td>130</td><td>£62,400</td><td>Unit cost database 2016 [30]</td></tr>
<tr><td colspan="2">Local authority residential care</td><td>£372</td><td>130</td><td>£48,360</td><td>Unit cost database 2016 [30]</td></tr>
<tr><td rowspan="3">Usual residence care package</td><td>Share Assessment</td><td>£90</td><td>1</td><td rowspan="3">£1,906</td><td rowspan="3">Craig 2013 (inflated to 2015/16 prices) [26]</td></tr>
<tr><td>GP visit</td><td>£39</td><td>1</td></tr>
<tr><td>Ongoing care</td><td>£222</td><td>8</td></tr>
</table>

2.4 Outcomes of participants

Increases in health and social care costs are not the only consequences of falls and, in particular, they can have a significant impact on the quality of life of people who have fallen. Therefore, to capture this impact, utility has been incorporated as an outcome measure within the analysis. Utility is a measurement of quality of life using a scale of 0 to 1 in which 0 is equivalent to death and 1 is equivalent to perfect health. When utility is measured over a specific time period it is possible to estimate the quality-adjusted life-year (QALY) score of a person. Therefore, a QALY score of 1 is equivalent to one year of life in perfect health (ie a utility score of 1 through the full year).

Alternatively, one QALY could equal 2 years of life with a utility score of 0.5. The inclusion of QALYs in the analysis allows for a consistent and standardised measure of quality of life across different populations and interventions.

For the analysis, utility scores have been applied to the population, with utility values varying depending on the events that have occurred. These utility values are summarised in Table 3. Everyone who does not suffer from a fall, or suffers from a non-serious fall, is assigned a utility score of 0.73 [33, 34]. This is the utility score in the general population for people aged 75 and over. This utility score is also applied to those people who attend their GP or an A&E department but are not admitted to hospital. For people who are admitted, it is assumed that their quality of life is reduced and utility scores of 0.582 and 0.699 are applied to people with hip fractures and non-hip fractures respectively [35].

Similarly, there is evidence that quality of life declines by 0.06 with a move to a care home and this decrement is applied to a person's value at discharge (resulting in a utility score of 0.522 or 0.639 depending on whether they suffered from a hip fracture or not) [36]. There is also evidence that people who have a serious fall experience a fear of future falls which impacts negatively impact on their quality of life. To capture this a utility decrement of 0.045 is applied to all people who have had a serious fall [36, 37]. Finally, a utility score of 0 is applied to those who die.

Table 3: Utility scores included in the analysis

Parameter	Utility value	Reference
Utility of general population aged ≥75	0.730	[33, 34]
Utility with a hip fracture	0.582	[35]
Utility with a non-hip fracture	0.699	[35]
Utility decrement following care home admission	0.060	[36]
Utility decrement following a fall due to fear of a future fall	0.045	[36, 37]

2.5 Intervention effectiveness and costs

The key outcome measure in the analysis is the total number of falls. Therefore, it is important to accurately estimate the total number of falls in the selected population group with usual care and then the effectiveness of each intervention in reducing this number of falls. The number of falls with usual care is estimated using the rate of falls for the control group (ie usual care) and then an incident rate ratio (IRR) is applied to this baseline rate to estimate the number of falls with each intervention. It is important to note that the IRR is specific to each intervention and is also based on the assumption that each intervention is implemented with fidelity (eg use of appropriately trained staff who deliver the intervention at the same frequency and duration as adopted in the clinical studies) and delivered to a consistent quality.

In terms of the rate of falls for the control group, one option would be to apply the same rate for all interventions as they share the same comparator (ie usual care). However, a specific baseline rate of falls for usual care has been adopted for each intervention, which is taken from the relevant clinical study. This is because each clinical study enrolled specific populations with specific baseline risks. This precludes adopting a single baseline rate. For example, if the enrolled participants had a high risk of falls at baseline in one study then the overall number of falls would also be high in that study. Therefore, applying the effectiveness data (ie IRR) from that study to a population group that is at lower risk would not be valid as it may overestimate the number of falls avoided.

This difference in baseline risk characteristics across trials is important for clinical practice. In order to achieve the observed IRR the population receiving the intervention in practice should have similar characteristics to those enrolled in the clinical trial. Hence for each intervention a description of the characteristics of the people enrolled in the relevant clinical trial(s) is provided (see Table 5, Table 7, Table 11, Table 14). As discussed above, if the interventions are targeted at participants with substantially different characteristics then the results of this analysis will be invalid as the key effectiveness data will not generalise to those participants. For example, if the mean age in the underlying clinical trials was 75 years, with a range of 70 to 86, then if the intervention is given to people aged less than 70, the effectiveness data from the study will not be applicable as younger people generally have a lower risk of falls.

It is also useful to note the differences in the studies used in terms of primary and secondary falls prevention (see the baseline characteristics tables in section 2). Primary falls prevention involves reducing the number of people falling over in the first place. Secondary falls prevention involves reducing the number of people who have already fallen from falling over again. Those have had a previous fall are at higher risk of having a subsequent fall. The populations in the physical activity intervention studies contained a mix of older people who had and who had not fallen and so none of these can be viewed as being purely primary or secondary prevention. The home assessment and modification study population had all experienced at least one previous fall and so can be viewed as secondary prevention interventions.

Another key driver of the ROI is the cost of implementing each intervention. For each intervention a number of different elements that impact on the overall cost (eg staff time, training, equipment) have been costed separately to ensure a valid estimation of the total cost is generated. In addition, 5% of the cost of each intervention has been included to meet the cost of data collection and evaluation (defined as the ‘evaluation cost’ henceforth). This is PHE policy and informed by OECD guidance, which notes that such an evaluation should be undertaken to assess the intervention against a number of factors, including: sustainability and impact [38].

One key component of the cost for all interventions is the unit cost for staff. Altogether 5 different types of staff are assumed to be involved across the 4 interventions, based on feedback from the Steering Group. The cost per hour for these staff are summarised in Table 4. These unit costs include the following elements: wages/salary, employer’s national insurance and overheads (eg office space, utilities, conference attendance). They are also the average cost across the whole of England. There is variation in costs across England, in particular those occurring in London versus outside London. For more details about the make-up of the unit costs, including how adjustments can be made to account for London-specific prices, please see the Unit costs of Health and Social Care 2016 [28].

Table 4: Summary of staff costs (2015/16 prices)

Staff type	Cost per hour	Reference
Physiotherapist (Band 6)	£42.00	[28]
Occupational therapist (Band 6)	£42.00	[28]
Technical assistant (Band 4)	£30.00	[28]
Leisure service exercise instructors	£15.40	Information from Steering Group
Self-employed exercise instructors	£30.00	Information from Steering Group

The inputs for all other effectiveness and cost data are discussed for each intervention individually below. It is important to note that, for each intervention, the cost per participant will not alter as the population size changes with the exception of staff training costs. This is because the number of staff required will change depending on the size of the selected population and this impacts on the overall cost of training. Therefore, in the remainder of this section the total training costs per participant are reported for the York local authority area. This is seen as representative of costs across England and the value is not expected to change significantly when alternative geographical areas are selected.

2.5.1 Otago strength and balance exercise

Note on UK Implementation: Otago implementation is widespread in the UK with 54% of falls services reporting its use. However, fidelity to the original intervention is often poor [39].

Effectiveness

The effectiveness of Otago is based on a meta-analysis undertaken by Robertson et al. (2002) who collated the results of 4 clinical trials that evaluated Otago [19]. The baseline characteristics of the participants enrolled into these 4 studies are presented in Table 5. The annual rate of falls in the control group participants was 1.06 per year, which is the rate of falls adopted for usual care in the analysis. The IRR for Otago was 0.65 (95% CI: 0.57 to 0.75), which indicates that the number of falls in the Otago group was 35% less than the control group.

Table 5: Baseline characteristics of Otago participants

Characteristic	Value
Mean age (Standard deviation)	82 (4.6)
Age range	65 to 97
Gender	75% female
Previous falls history	43% had fallen in previous 12 months
Mobility	Mobile in home

Cost

Otago is an exercise programme that is undertaken by individuals in their usual place of residence. Supervision is provided by a person trained to deliver Otago, who teaches participants the programme, and monitors their progress. There is an initial assessment, generally performed by a physiotherapist or postural stability instructor, of the start level of exercise for each participant. The tool, informed by the clinical studies, assumes a total of 10 contact hours, over a one year period, which constitutes the following:

- 1 initial visit of 1.5 hour (includes 0.5 hours travel time).
- 4 follow-up visits of 1.0 (includes 0.5 hours travel time).
- 9 catch-up call of 0.5 hours each during months with no scheduled home visit (so 4.5 hours per participant).

It is assumed that the programme is delivered by a mix of staff comprising physiotherapist (50%), technical assistant (40%) and leisure service employees (10%), trained in Otago delivery. These assumptions are based on information presented by Robertson (2001), which is the largest of the 4 trials included in the meta-analysis [40].

Staff training and travel costs are also accounted for within the analysis. In terms of training, no evidence was identified relating to the proportion of the staff who are already sufficiently trained in the provision of each exercise programme, including Otago, and therefore would not need to receive relevant training. In the absence of any data it has been assumed that 50% of staff require specific training in the provision of Otago at a cost of £343 each (course cost of £410 [3 day] or £310 [2 day] and it is assumed two thirds attend the shorter course) [41]. It is also assumed that there is a cost per journey of £10 for staff to travel to home sessions. Therefore, travel costs are £50 per person and training costs will change depending on the total number of staff required to administer the programme given the selected population size. These assumptions were again informed by members of the Steering Group, who have first-hand experience of Otago provision.

All participants also require an adjustable set of ankle weights and a home exercise booklet (or DVD) to complete the programme in their usual residence, with a cost per person of £20.47 and £2.70 respectively. This equipment would be retained by the participant at the end of the programme.

Based on the resources just described, the total costs per participant are £441. This is summarised in Table 6**.**

Table 6: Summary of total costs for Otago, per participant

Resource	**Cost per participant**
Staff time	£345.40
Staff training*	£1.73
Staff travel costs	£50.00
Equipment costs	£23.18
Evaluation costs†	£21.02
Total	**£441.33**

*Based on York LA area to represent the average population size.
† Based on 5% of the total cost of the programme, see page 19 for more information

2.5.2 FaME Group Exercise

Note on UK Implementation: FaME implementation is widespread in the UK, with 54% of falls services reporting its use. However, fidelity to the original intervention is often poor [39].

Effectiveness

The effectiveness of FaME is estimated based on information reported by Iliffe et al. (2014) [13]. The baseline characteristics of the participants in this study are reported in Table 7. The authors reported outcomes for 2 time periods: the intervention period (months 0 to 6) and the follow up period (months 6 to 18). In terms of the baseline annual rate of falls (ie the rate of falls in the usual care arm in the study), rates of 0.87 and 0.71 falls per person years were reported for the intervention and follow-up periods respectively. Therefore, to estimate the value of the first year the mean of these values was calculated, equating to a baseline rate of 0.79.

Similarly, IRRs for FaME were reported separately for the intervention (0.91; 95% CI: 0.54 to 1.52) and follow-up (0.74; 95% CI: 0.55 to 0.99) periods. Again a mean value was estimated (0.825) for the first 12 months and this value was adopted for the analysis. For the other 5 effective interventions included in this report, data were not available following the initial 12 month period. However, as follow-up in the Iliffe (2014) study extended to 18 months, IRR data was also available for months 6 to 18 (0.74) and this value was applied within the analysis for this time period.

Note: Although not presented in the ROI tool, as no cost analysis was performed, the original 9 month FaME intervention in women with a history of 3 or more falls in the past year showed a 31% reduction in the number of falls during the whole trial period for the exercise group compared with the control group – IRR = 0.69, 95% CI 0.50–0.96 [16].

Table 7: Baseline characteristics of FaME participants

Characteristic	Value
Mean age (Standard deviation)	73
Age range	65 to 94
Gender	62% female
Previous falls history	22% had fallen in previous 12 months
Mobility	Physically able to attend group exercise

Cost

The FaME group exercise programme comprises of weekly one hour sessions for 24 weeks, which equates to total contact time of 24 hours per cohort plus 12 hours of travel time (30 minutes per session), over a 6 month period, with each cohort containing 10 participants [13]. It was assumed that each participant would attend a one hour session for an initial assessment of ability.

Steering Group members advise it could be delivered by the following staff mix (all with relevant postural stability instructor training): 20% physiotherapist, 45% technical assistant, 25% leisure service exercise instructor, 10% self-employed exercise instructor. Based on relevant unit costs for staff time, this equates to total staff costs per cohort of £1,078 for all sessions.

It is assumed that 50% of staff require training to administer FaME at a cost of £650 per staff [42]. Similarly, it is again assumed that the cost per journey was £10.

As FaME constitutes group sessions it is necessary to hire a community hall for each session and again an hour rate of £15 was assumed. The FaME programme also requires a set of equipment with the cost of this equipment summarised in Table 8. Based on feedback from the User Group it is assumed that the TheraBands and home exercise booklets are kept by participants once the programme has finished and, therefore, new purchases are required for each cohort. Floor mats are assumed to be reusable by a total of 20 cohorts before replacement. The total cost per cohort for community hall hire and equipment purchase is estimated to be £538 per cohort. When all other costs are taken into account the total cost per cohort are £2,209. This equates to a cost per participant of £221. These costs are summarised in Table 9.

Table 8: Equipment costs per cohort for FaME programme

Resource	Units required per cohort	Cost per unit	No. of cohorts using resource	Cost per cohort
TheraBand*	10	£8.13	1	£81
Home exercise booklet	10	£2.70	1	£27
Floor mat	10	£6.99	20	£70
Total equipment costs	N/A	N/A	N/A	**£178**

*At least 3 increasing resistance bands per participant. Members of the Steering Group have advised that if less than 3 bands are given to each participants then they will be unable to progress, which reduces the overall effectiveness of the intervention.

Table 9: Summary of total costs for FaME, per participant

Resource	Cost per cohort	Cost per participant
Staff time	£1,216	£121.60
Staff training*	£40.89	£4.09
Staff travel costs*	£375	£37.53
Equipment/hall hire costs	£472	£47.22
Evaluation costs†	£105	£10.52
Total	**£2,210**	**£220.96**

*Based on York LA area to represent the average population size
†Based on 5% of the total value of the programme, see page 19 for more information

2.5.3 Tai Chi Physical Activity

Practising Tai Chi is in line with Chief Medical Office physical activity guidelines for older adults (65+ years). These note that Tai Chi can improve balance and coordination and there is evidence that Tai Chi reduces the risk of falling. However there are a wide range of movements that are taught and carried out which are described as Tai Chi and no clinically agreed quality standards or systems of quality assurance in this area. Tai Chi is not currently recommended as a clinical falls prevention intervention in England. Tai Chi should be considered as a type of physical activity rather than a clinical falls prevention intervention.

Effectiveness

A number of different clinical trials were identified that considered the efficacy of Tai Chi and variants such as Tai Chi Chua (referred to as Tai Chi in the report). Therefore, rather than selecting a specific study, the effectiveness of Tai Chi in this analysis is based on the results of a Cochrane systematic literature review and meta-analysis [11]. This review identified a total of 5 relevant studies and a meta-analysis was undertaken by the authors of the review to estimate the IRR of Tai Chi (0.72; 95% CI: 0.52 to 1.00).

The baseline rate of falls was not reported by the authors of the review. Therefore, the individual papers informing the meta-analysis were obtained and the baseline rate of falls for the control group was extracted from each. A weighted average baseline rate of falls was then estimated, based on the weights applied in the meta-analysis. These calculations are summarised in Table 10.

Table 10: Baseline rate of falls for Tai Chi programme

Study	**Weight in Cochrane review**	**Baseline rate of falls**
Logghe 2009 [43]	22.90%	0.85
Voukelatos 2007 [44]	20.60%	0.81
Wolf 2003 [45]	20.60%	1.31
Wolf 1996 [46]	17.20%	1*
Li 2005 [47]	18.80%	1.08
Weighted average		**1.006**

*The baseline rate of falls could not be estimated for this study and, therefore, the rate was assumed to be 1 for the purpose of the weighting calculations.

As the effectiveness of Tai Chi is based on a meta-analysis of 5 separate studies there is no single set of participant characteristics. Nevertheless, the baseline characteristics for participants enrolled in the Logghe (2009) [43] are presented in Table 11. This study was given the greatest weight in the meta-analysis undertaken by Gillespie and colleagues [11].

Table 11: Baseline characteristics of Tai Chi participants

Characteristic	Value
Mean age (Standard deviation)	78
Age range	69 - 90
Gender	70% female
Previous falls history	62% had fallen in previous year
Mobility	37% required use of a walking aid

Cost

As noted above, 5 separate studies inform the effectiveness of Tai Chi in the analysis. The total contact hours was calculated as a weighted average of the contact hours delivered in each study and applying the weightings shown in Table 10. This equates to 49 contact hours in total and it is assumed these are given as 49 separate, hour long sessions, with 2 sessions per week, for each cohort. Again, it is assumed staff would travel a total of 30 minutes per session, equating to travel time of 24.5 hours per cohort. Steering Group members advise it could be delivered by the following staff mix, with relevant training in Tai Chi provision: 20% physiotherapist, 20% technical assistant and 60% self-employed. Based on relevant unit costs for staff time, this equates to total staff costs per cohort of £1,917 for all 49 sessions.

Another important factor is the number of participants per cohort as this impacts on the total cost across the full population (ie the lower the number of participants the more cohorts required, resulting in increased costs). Only 2 of the 5 studies reported the number of participants per cohort (Logghe (2009) [43], Voukelatos (2007) [44]). They reported group sizes of 7 to 14 and 8 to 15. Therefore, to remain conservative, and keep consistent with the group size adopted for FaME, it was assumed that each cohort contains 10 participants.

It is necessary for staff to be proficient in Tai Chi provision, having undergone relevant training. A targeted review of the literature indicates that a variety of different instructor training courses are available in the UK with prices varying from approximately £400 to £700. Therefore, it is assumed that the average cost of training is £550 and, as with the other exercise programmes, 50% of staff would require training. Similarly, it is again assumed that the cost per journey was £10.

As Tai Chi constitutes group sessions it is necessary to hire a community hall for each session and again an hour rate of £15 is assumed. The Tai Chi programme also gives each participant a DVD with instructions for home exercises, assumed to cost £5 each. The total cost per cohort for community hall hire and equipment purchase is estimated at £785 per cohort. When all costs for Tai Chi implementation are accounted for the total cost per cohort is estimated to be £3,750. The equivalent costs for each participant are £375. This is summarised in Table 12.

Table 12: Summary of total costs for Tai Chi, per participant

Resource	Cost per cohort	Cost per participant
Staff time	£2,383	£238.33
Staff training*	£34.60	£3.46
Staff travel costs	£368	£36.78
Equipment/hall hire costs	£786	£78.56
Evaluation costs†	£179	£17.86
Total	**£3,750**	**£374.99**

*Based on York LA area to represent the average population size
†Based on 5% of the total value of the programme, see page 19 for more information

2.5.4 Home assessment and modification

Note on UK Implementation: Home assessment and modification programmes are widely implemented.

Effectiveness

As with Tai Chi, the effectiveness of HAM is based on the results of a Cochrane systematic review and meta-analysis [11]. Gillespie and colleagues report the results of this intervention, which included 2 sub-group analyses: the impact of enrolling only high risk participants and the impact of using different delivery personnel (ie OT-specific or not). The results indicate that HAM only produces a statistically significant reduction in the rate of falls if either all participants are high risk or if the programme is delivered exclusively by an OT. To ensure that both high and low risk people can be included within the tool it is assumed that the programme is delivered exclusively by OTs.

The results of this sub-group analysis indicate that HAM is associated with an IRR of 0.69 (95% CI: 0.55 to 0.86). In terms of the annual baseline rate of falls for usual care, as with Tai Chi, this rate is estimated based on the rate of falls recorded for the control groups in each of the studies that informed the meta-analysis by Gillespie (2014) [11]. The meta-analysis included 4 studies. The rate of falls for the comparators in these studies, and the weightings estimated by Gillespie and colleagues, are presented in Table 13. Based on these values, a weighted average of 2.13 for the annual baseline rate of falls is estimated for HAM.

Table 13: Baseline rate of falls for HAM

Study	Weight in Cochrane SR	Baseline rate of falls
Campbell 2005	22.7%	1.65
Cumming 1999	35.1%	2.24
Nikolaus 2003	24.1%	1.24
Pighills 2011	18.1%	3.72
Weighted average		**2.13**

The baseline characteristics from the Cumming (1999) study are summarised in Table 14 [48]. This study was given the largest weight in the Cochrane systematic review. It should be noted that the Campbell (2005) study, which was given a weight of 22.7% by Gillespie and colleagues, enrolled only people with severe visual impairments and this limits the generalisability of the results from that specific study.

Table 14: Baseline characteristics of HAM participants

Characteristic	Value
Median age	76.4 years
Age – interquartile range	62 to 91
Gender	56% female
Previous falls history	All had at least one fall in the previous 12 months
Mobility	Mobile in home

Cost

The HAM programme consists of an initial safety assessment of a person’s home, undertaken by an OT, who recommends required modifications. Follow-up visits may then be arranged to check the modifications have been made. It is assumed that all assessments are undertaken by an OT, in order to match the conduct of the trials informing the effectiveness data. The total time for assessments was estimated by generating a weighted value from the time reported for each of the clinical studies.

This is summarised in Table 15. A travel time of 30 minutes per assessment is also assumed. Given the cost per hour for an OT is £42 (Band 6) this equates to a total cost per person of £151 for the assessment.

Table 15: Total time for initial assessment with HAM

Study	Weight	Details of assessments	Total time
Campbell 2005	22.7%	1 initial visit, plus 1 follow-up visit and 1 follow-up call. Time per visit/call not provided; therefore assumed each visit is 1 hour and call is 0.5 hours.	2.5 hours
Cumming 1999	35.1%	1 initial visit lasting 1 hour, plus 1 follow-up visit and 1 follow-up call. Time for follow-ups not provided; therefore assumed this visit was 1 hour and call is 0.5 hours.	2.5 hours
Nikolaus 2003	24.1%	1 initial visit plus a mean of 2.6 follow-up visits. A further follow-up visit noted after 12 months. The time per visit not provided; therefore, assumed each visit lasted 1 hour.	4.6 hours
Pighills 2011	18.1%	1 initial visit lasting 1.5 to 2 hours plus 2 follow-up calls (2 hours adopted in the tool). The time per call not provided; therefore, assumed each lasted 0.5 hours.	3.0 hours
Weighted average			**3.1 hours**

A list of possible modifications was drafted based on the modifications reported by Cumming 1999 and Nikolaus (2003) (the specific recommendations made during the Campbell [2005] and Pighills [2011] studies were not reported) and also advice from the User Group. Each recommendation was only made to a small proportion of total participants and the recommendations were not always followed. Therefore, it is important to consider the proportion of participants that each modification is recommended for and the take-up rate. These are presented in Table 17, along with the estimated cost per modification. It is also important to consider what proportion of modifications is self-funded as this impacts on the total cost of implementation to the NHS and LAs.

User Group members advised that 100% of the following modifications would be self-funded meaning the cost is not considered within the analysis: new footwear, painting rooms lighter and new lightbulbs. No data are available to inform the proportion of other modifications which are self-funded, hence it is assumed that 50% are self-funded. This may be a conservative assumption if in practice more modifications are self-funded, in which case the overall cost of the programme would be lower. Based on the resources just described the total costs per participant for HAM are £236. This is summarised in Table 16.

Table 16: Summary of total costs for HAM, per participant

Resource	Cost per participant
Initial assessment	£151.20
Modifications	£84.43
Evaluation costs†	£11.78
Total	**£247.41**

†Based on 5% of the total value of the programme, see page 19 for more information

Table 17: The cost of modifications recommended as part of HAM

Modification	Recommended for	Take-up rate	Reference	Cost per modification	Notes	Reference
Use non-slip bathmat	24%	54%	Cumming 1999 [48]	£6.49	Cost of equipment only	[49]
Add rail to stairs	12%	19%	Cumming 1999 [48]	£56.25	Based a 3m rail with costs of £10/m for labour and £8.75/m for materials	[50]
Move electrical cord	12%	67%	Cumming 1999 [48]	£10	Assumes 1 hour of labour time	Assumption
Add grab rails	15%	78%	Nikolaus 2003 [51]	£28	Labour costs of £10 (1 hour) and material costs of £18	[50]
Use a raised toilet seat	24%	54%	Nikolaus 2003 [51]	£15.54	Cost of equipment only	[49]
Add shower seat	13%	83%	Nikolaus 2003 [51]	£39.95	Assumes fitted seat with labour costs of £10 (1 hour)	[49]
Use of a rollator	20%	58%	Nikolaus 2003 [51]	£55	Cost of equipment only	[49]
Wet room conversion	10%	20%	User Group advice	£7,500	Cost of a wet room estimated to be £5,000 - £10,000; therefore, midpoint adopted	[52]

2.6 Other modelling elements

Time horizon

The majority of clinical studies informing the effectiveness assumptions adopted a 12 month follow-up period. The Steering Group debated how best to extrapolate this rate over a longer period given the absence of direct evidence. A targeted review of the literature was also undertaken for long-term evaluations of falls prevention programmes. This review identified limited evidence of benefit after 2 years for falls prevention services. Therefore, within the analysis it is assumed that there is no benefit from an intervention at the end of 2 years (ie the rate of falls returns to the baseline rate for usual care), and this was accepted by the Steering Group. It is unclear what will happen after these 2 years. It is expected that participants may continue to benefit from certain interventions that allow for permanent lifestyle changes (eg home modifications). Alternatively, for others interventions benefits are likely to stop once the formal programme has ceased, in particular deconditioning will occur shortly after exercise stops so participants must remain active for benefits to remain.

This approach is modelled by assuming the effectiveness of each intervention in year 2 is 50% of the observed rate in year 1. However, as noted in Section 0, the IRR for FaME is reported for months 12 to 18. Therefore, if a 50% reduction in effectiveness for the rest of the year is assumed this equates to an IRR of 0.87 for months 18 to 24. The mean of these 2 values was then estimated (0.805) to estimate the IRR for year 2 of the analysis for FaME.

As there is no difference in the rate of falls between each intervention and usual care from the end of year 2 the number of falls, and their associated costs, are only modelled until the end of the second year of the analysis. The exception to this is the cost of care home stays because, as noted previously, the mean length of stay for people newly transferred to a care home is 2.5 years; therefore, the cost of impact of this full 2.5 year stay is captured.

Discounting

As costs and benefits are predicted into the future it is necessary to apply a discount rate after the first year. This is to account for the human time preference, whereby a greater weight is given to consumption that occurs in the present rather than the future. A discount rate of 3.5% for costs and 1.5% for QALYs is applied in the tool, being the rates adopted by PHE for all appraisals.

Metrics of the analysis

The main metric of the analysis is the ROI for each intervention compared with usual care. The equation for ROI is presented in Figure 2. As illustrated, it is the ratio of the benefits to costs for each intervention with the return for each £1 invested shown. If the benefit (the number on the left of the ratio) is lower than £1 then this indicates there is a net loss. Alternatively, if the benefit is higher than £1 then there is a net gain on the initial investment. For example, if the ratio shown is £1.30 : £1.00 this indicates that for every £1.00 spend on an intervention then there are savings of £1.30, which equates to net benefits of £0.30. The value of the ROI ratio is the same when expressed per person or for the total population.

The approach taken in measuring ROI for this analysis is technically a cost benefit ratio with benefits divided by costs, as opposed to net benefits divided by costs. This approach is consistently used in ROI tools published by PHE.

Two forms of ROI are estimated in the analysis: financial and societal. For the financial ROI, the benefits relate specifically to monetary benefits (ie cost savings due to a reduction in the number of falls). Therefore, the intervention will only generate a positive ROI if the savings exceed the cost of implementing the intervention. For the societal ROI, the benefits include both savings and the value of any improved quality of life (as measured by QALYs) delivered by interventions. In order to include QALYs into the ROI equation it is necessary to convert them into a financial value. For this conversion, each additional QALY generated by an intervention is valued at £60,000 based on guidance from the Department of Health [53].

Figure 2: Return on investment equation

$$\text{Return on investment} = \frac{\Sigma \text{ Total discounted benefits}}{\Sigma \text{ Total discounted costs}}$$

The incremental cost-effectiveness ratio (ICER) per person and net monetary benefit (NMB) per person are also estimated. These are metrics commonly used in economic evaluations to assess the cost effectiveness of technologies. The equations for the ICER and NMB are shown in Figure 3. As with the societal ROI equation, these values include quality of life by assuming £60,000 per additional QALY. This cost-effectiveness threshold is higher than the value typically applied by NICE for the technology appraisals programme (£20,000 to £30,000) but is relevant for public health interventions such as those considered here. Therefore, if an intervention produces an ICER of between £0 and £60,000 per person then it would be considered cost-effective versus usual care. An intervention may also dominate usual care if it is both more effective (ie produces more QALYs) and is cost saving.

For NMB, a positive value indicates that the intervention is cost-effective versus usual care, given the value of a QALY of £60,000, whilst a negative value indicates that usual care is more cost-effective.

Figure 3: ICER and NMB equations per person

$$ICER = \frac{Cost_{Intervention} - Cost_{Usual\ care}}{QALYs_{Intervention} - QALYs_{Usual\ care}}$$

$$NMB = (QALY_{intervention} - QALY_{usual\ care}) \times threshold - (Cost_{intervention} - Cost_{usual\ care})$$

Sensitivity analysis

To account for first-order uncertainty relating to the data used for input parameter values one-way deterministic sensitivity analysis (DSA) has been undertaken. DSA involves altering the value used for individual parameters, within realistic ranges, to see the impact on the results. This process highlights the parameters that have the greatest impact on the results.

3. Results

The return on investment with each intervention, versus usual care, is summarised in Table 18. Please note, it is not possible to directly compare each of the included interventions due to differences in the clinical trials that inform this analysis, as discussed previously. The results for each intervention are also presented individually below.

For this analysis, York was selected as a representative area to inform the results. Therefore, the results are based on an analysis in the York local authority area and these should be representative of analyses in other specific local areas. Within the York LA area there are 37,037 people aged 65 and over in 2015. When adjusting for the proportion of the population deemed at risk of a fall (34%) and those willing to take part in falls prevention programmes (20%) the final population included in the analysis is 2,509 people.

Given the differences in the relevant population for the HAM intervention, as described in Section 2.2, the population size is reduced to 141 for the analysis of HAM. Therefore, the total costs and QALYs reported for HAM relate to a smaller population than the other 3 interventions (ROI should not be affected). The results of implementing each intervention in the populations just described are presented, along with results on a per person basis.

Table 18: Summary of return on investment with each intervention

Intervention	Financial ROI	Societal ROI
Otago	£0.95 : £1.00	£2.20 : £1.00
FaME group exercise	£0.99 : £1.00	£2.28 : £1.00
Tai Chi	£0.85 : £1.00	£1.97 : £1.00
Home assessment and modification	£3.17 : £1.00	£7.34 : £1.00

3.1 Otago Home Exercise

Following the implementation of Otago in the specified population (ie people in the York local authority area deemed at risk of falls and willing to participate) the estimated number of falls over 2 years is 3,938 compared with 5,339 for usual care. The total number of serious falls is estimated at 788for Otago, compared with 1,068 for usual care, a reduction of 280.

The cost components and total cost of Otago, usual care and the differences are presented in Table 19, for both the selected population area (ie York LA) and on a per person basis. This table also reports the financial ROI (financial savings relative to costs) for the selected population. Further, a breakdown of Otago's cost impact on the total population is presented in Figure 4. Overall, financial savings are £0.05 lower than costs for every £1 invested.

Table 19: The impact of Otago on costs for the total population and per person

	Total Population			Per Person		
	Otago	**Usual care**	**Difference**	**Otago**	**Usual care**	**Difference**
Intervention costs	£1,111,592	£0	£1,111,592	£441	£0	£441
Primary/secondary care costs	£2,329,764	£3,165,462	-£835,698	£925	£1,257	-£332
Social care costs	£613,007	£832,896	-£219,889	£243	£331	-£87
Total	£4,054,364	£3,998,358	£56,006	£1,610	£1,588	£22
Financial ROI - Benefits to cost ratio	**£0.95 : £1.00**					

Figure 4: Breakdown of Otago cost impact, total population

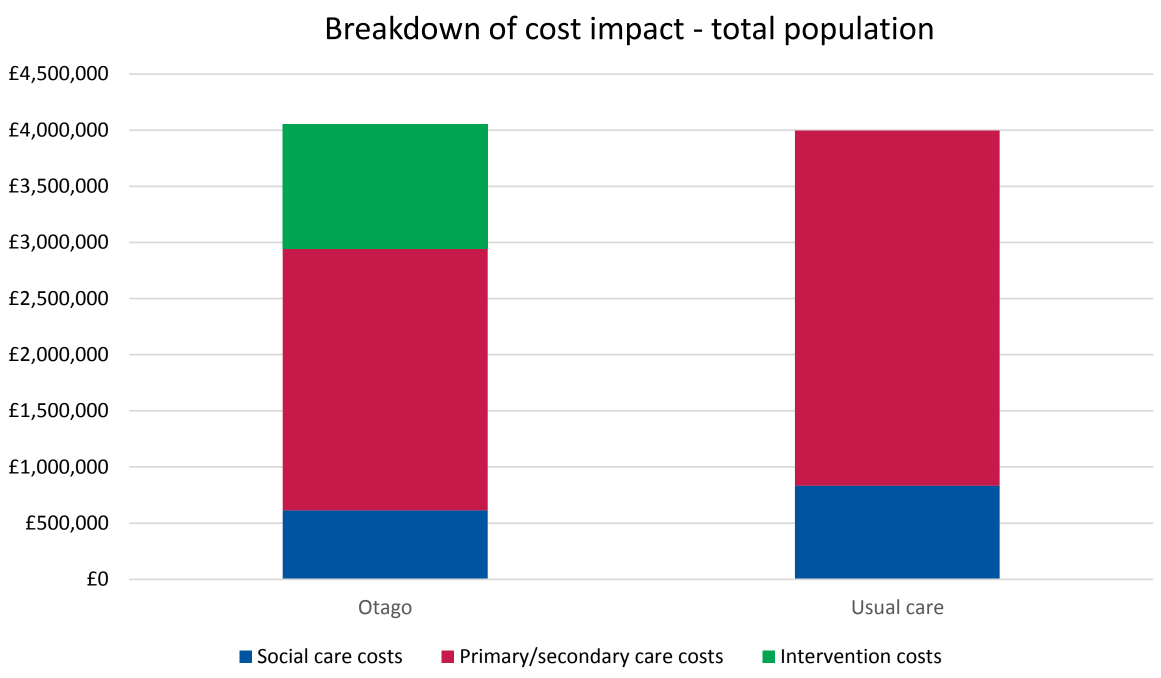


Table 20 presents the impact of Otago on quality of life, reported for the total population and per person. This table also presents the societal ROI. Including the value of the improved quality of life results in benefits exceeding costs; for every £1 invested benefits equivalent to £2.20 are generated by the intervention, indicating there is a positive return of £1.20.

Table 20: Quality of life impact of Otago for the total population and per person

	Otago	*Usual care*	Difference
Total QALYs	7,129	7,106	**23**
QALYs per person	2.8305	2.8213	**0.009**
Value of QALYs, per person	£169,832	£169,281	**£551**
Societal ROI - Benefits to cost ratio	**£2.20 : £1.00**		

Table 21 shows the cost-effectiveness of Otago using both the incremental cost-effectiveness ratio (ICER) and net monetary benefit (NMB). Under these measures the intervention is cost-effective and should be commissioned.

Table 21: Cost-effectiveness of Otago strength and balance exercise per person

	Otago	*Usual care*	Difference
Total per person costs	£1,610	£1,588	£22
Total per person QALYs	2.8305	2.8213	0.009
Incremental cost-effectiveness ratio (ICER)			**£2,422**
Net monetary benefit (NMB)			**£528.58**

3.2 FaME Group Exercise

With FaME the estimated number of falls over 2 years is 3,243 compared with 3,979 for usual care. The total number of serious falls is estimated at 649 for FaME, compared with 796 for usual care, a reduction of 147.

The impact of FaME on the overall costs are presented in Table 22, separated by the setting, and the financial ROI is also reported. Further, a breakdown of FaME on the costs in the total population is also presented in Figure 5. Overall, financial savings are £0.01 lower for every £1 invested.

Table 22: The impact of FaME on costs for the total population and per person

	Total Population			**Per Person**		
	FaME	**Usual care**	**Difference**	**FaME**	**Usual care**	**Difference**
Intervention costs	£556,500	£0	£556,500	£221	£0	£221
Primary/secondary care costs	£1,923,125	£2,359,165	-£436,040	£764	£937	-£173
Social care costs	£506,012	£620,743	-£114,731	£201	£246	-£45
Total	£2,985,638	£2,979,908	£5,730	£1,185	£1,183	£2
Financial ROI - Benefits to cost ratio	**£0.99 : £1.00**					

Figure 5: Breakdown of FaME cost impact, total population

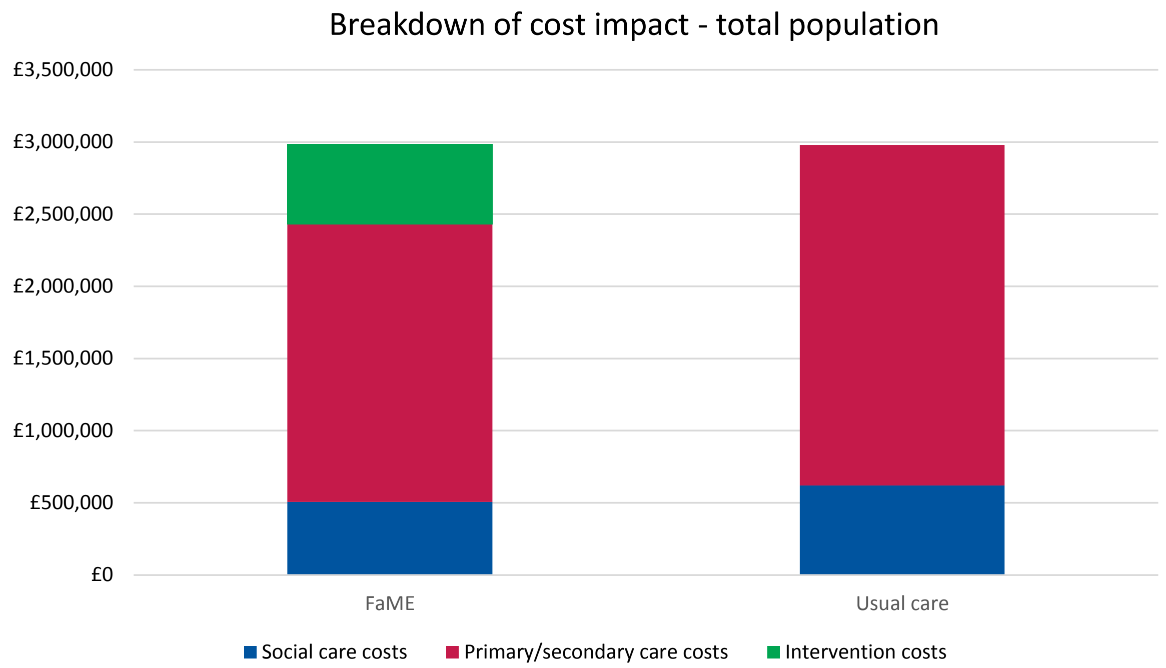


Table 23 reports the impact of FaME on quality of life, as measured by the number of QALYs. This table also includes societal ROI in which benefits are classified as the number of additional QALYs generated by the intervention plus the cost savings from the intervention. Including the value of the improved quality of life results in benefits exceeding costs; for every £1 invested benefits equivalent to £2.28 are generated by the intervention, indicating there is a positive return of £1.28.

Table 23: Quality of life impact of FaME for the total population and per person

	FaME	***Usual care***	**Difference**
Total QALYs	7,140	7,128	11.98
QALYs per person	2.8349	2.8301	0.005
Value of QALYs, per person	£170,094	£169,809	£285
Societal ROI - Benefits to cost ratio	**£2.28 : £1.00**		

Table 24 shows the costs effectiveness of FaME as measured by the ICER and NMB. Under these measures the intervention is cost-effective and should be commissioned.

Table 24: Cost-effectiveness of FaME per person

	FaME	***Usual care***	***Difference***
Total per person costs	£1,185	£1,183	£2
Total per person QALYs	2.8349	2.8301	0.005
Incremental cost-effectiveness ratio (ICER)			**Dominant**
Net monetary benefit (NMB)			**£283.07**

3.3 Tai Chi Group Exercise

With Tai Chi the estimated number of falls over 2 years is 4,019 compared with 5,087 for usual care. The total number of serious falls is estimated at 804 for Tai Chi, compared with 1,017 for usual care, a reduction of 214.

The impact of Tai Chi on the overall costs are presented in Table 25, separated by setting, and the financial ROI is also reported. Further, a breakdown of Tai Chi cost impact on the total population is presented in Figure 6. Overall, financial savings are £0.15 lower than costs for every £1 invested.

Table 25: The impact of Tai Chi on costs for the total population and per person

	Total Population			**Per Person**		
	Tai Chi	**Usual care**	**Difference**	**Tai Chi**	**Usual care**	**Difference**
Intervention costs	£944,310	£0	£944,310	£375	£0	£375
Primary/secondary care costs	£2,379,125	£3,016,148	-£637,022	£945	£1,198	-£253
Social care costs	£625,995	£793,608	-£167,613	£249	£315	-£67
Total	£3,949,430	£3,809,756	£139,675	£1,568	£1,513	£55
Financial ROI - Benefits to cost ratio	**£0.85 : £1.00**					

Figure 6: Breakdown of Tai Chi cost impact, total population

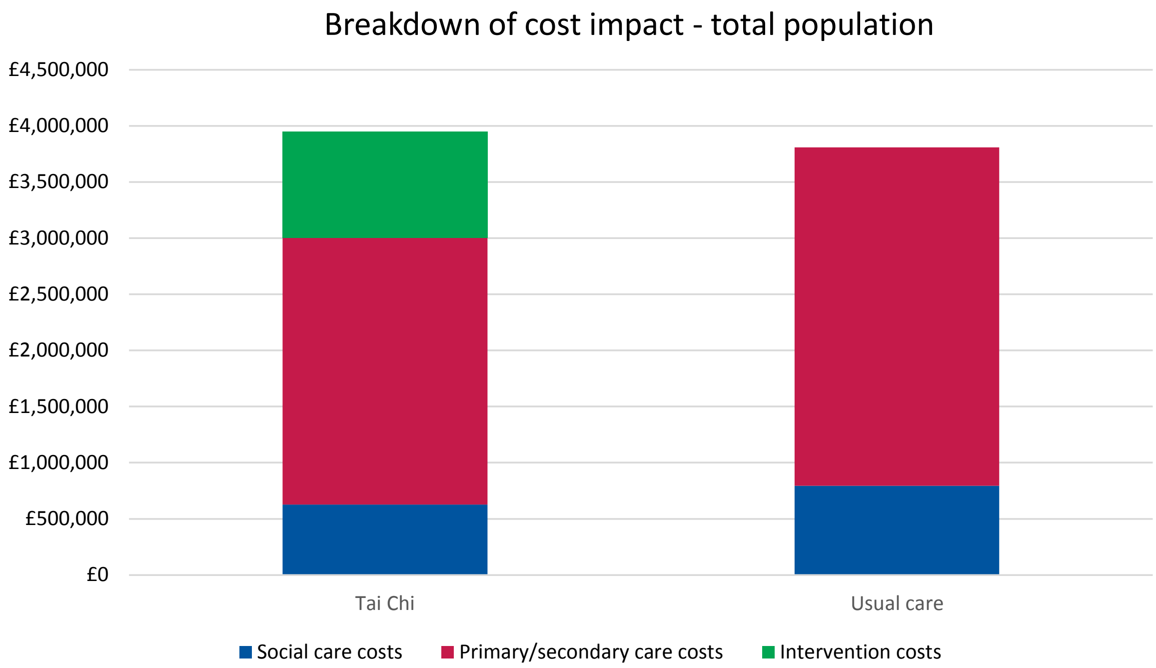


Table 26 reports Tai Chi impact on people's quality of life reported for the total population and per person. This table also includes societal ROI in which benefits are classified as the number of additional QALYs generated by the intervention plus the cost savings from the intervention. Including the value of the improved quality of life results in benefits exceeding costs; for every £1 invested benefits equivalent to £1.97 are generated by the intervention, indicating there is a positive net return of £0.97.

Table 26: Quality of life impact of Tai Chi for the total population and per person

	Tai Chi	***Usual care***	**Difference**
Total QALYs	7,127	7,110	17.62
QALYs per person	2.8300	2.8230	0.007
Value of QALYs, per person	£169,798	£169,379	£420
Societal ROI - Benefits to cost ratio	**£1.97 : £1.00**		

Table 27 shows the cost-effectiveness of Tai Chi. This table also presents the ICER and NMB. Under these measures this physical activity is cost-effective and should be commissioned.

Table 27: Cost-effectiveness of Tai Chi per person

	Tai Chi	***Usual care***	***Difference***
Total per person costs	£1,568	£1,513	£55
Total per person QALYs	2.8300	2.8230	0.007
Incremental cost-effectiveness ratio (ICER)			**£7,925**
Net monetary benefit (NMB)			**£364.41**

3.4 Home Assessment and Modification

With HAM the estimated number of falls which require a hospital admission over 2 years is 485 compared with 632 for usual care. The total number of serious falls is estimated at 97for HAM, compared with 126 for usual care, a reduction of 147.

The impact of HAM on the overall costs are presented in Table 28, separated by setting, and the financial ROI is also reported. Further, a breakdown of the cost impact of HAM on the total population is presented in Figure 7. Overall, the financial savings exceed costs by £2.17 for every £1 invested.

Table 28: The impact of HAM on costs, by the total population and per person

	Total Population			**Per Person**		
	HAM	**Usual care**	**Difference**	**HAM**	**Usual care**	**Difference**
Intervention costs	£34,921	£0	£34,921	£247	£0	£247
Primary/secondary care costs	£287,223	£374,883	-£87,660	£2,035	£2,656	-£621
Social care costs	£75,574	£98,639	-£23,065	£535	£699	-£164
Total	£397,719	£473,523	-£75,804	£2,818	£3,355	-£537
Financial ROI - Benefits to cost ratio	**£3.17 : £1.00**					

Figure 7: Breakdown of HAM cost impact

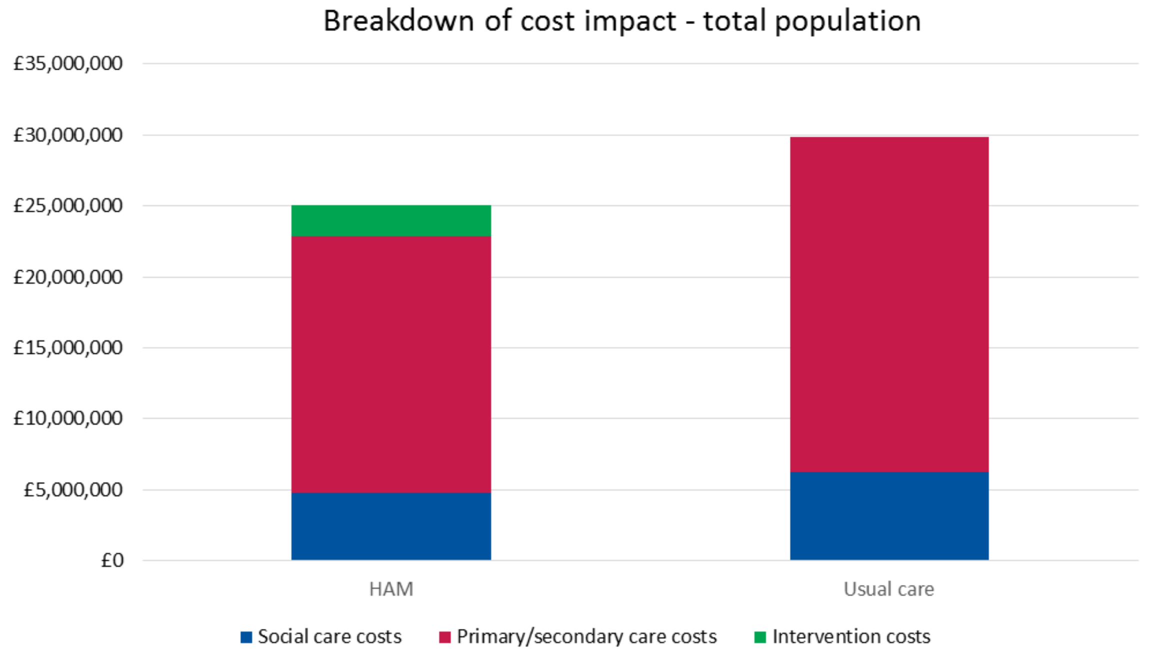


Table 29 presents the impact of HAM on quality of life reported for the total population and per person. This table also includes societal ROI in which benefits are classified as the number of additional QALYs generated by the intervention plus the cost savings from the intervention. Including the value of the improved quality of life results in benefits exceeding costs; for every £1 invested benefits equivalent to £7.34 are generated by the intervention, indicating there is a positive return of £6.34.

Table 29: Quality of life impact with HAM for the total population and per person

	HAM	**Usual care**	**Difference**
Total QALYs	395	393	**2.43**
QALYs per person	2.8001	2.7829	**0.017**
Value of QALYs, per person	£168,003	£166,973	**£1,031**
Societal ROI - Benefits to cost ratio	**£7.34: £1.00**		

Table 30 shows the cost-effectiveness analysis results for HAM versus usual care via the ICER and NMB. Under these measures the intervention is cost-effective and should be commissioned.

Table 30: Cost-effectiveness of HAM per person

	HAM	*Usual care*	Difference
Total per person costs	£2,818	£3,355	-£537
Total per person QALYs	2.8001	2.7829	0.017
Incremental cost-effectiveness ratio (ICER)			**Dominant**
Net monetary benefit (NMB)			**£1,568**

3.5 Summary of sensitivity analysis

The deterministic sensitivity analysis that was undertaken indicates that changes in the value of 3 parameters cause substantial changes in the results (ie cause each intervention not to be cost-effective thereby indicating they no longer produce a viable return on investment). These are: the rate of falls for usual care, the incident rate ratio and, the proportion of falls that are serious. The IRR is a particularly important driver of the results. For example, if the IRR for Otago increases from 0.65 (used in the analysis) to approximately 0.84 then the intervention is no longer cost-effective and all estimated returns would cease. The value that must be inputted for each intervention to no longer be cost-effective, along with the percentage change from the initial value, for each of these 3 parameters are summarised in Table 31, Table 32 and Table 33

For all other parameters that were assessed (destination at discharge, number of events following a fall, unit cost of fall events and utility) the changes only had a minor impact on the results indicating these parameters are not key drivers of the results. It should also be noted that the results of the analysis are not sensitive to the population size. Therefore, the results of the analysis should be valid no matter how many people are included in the defined population.

Table 31: Results of the sensitivity analysis, rate of falls for usual care

Intervention	Value adopted in the analysis	Value for substantial change	Percentage change
Otago	1.06	0.47	-56%
FaME	0.79	0.35	-56%
Tai Chi	1.01	0.51	-50%
HAM	2.24	0.30	-87%

Table 32: Results of the sensitivity analysis, incidence rate ratio

Intervention	Value adopted in the analysis	Value for substantial change	Percentage change
Otago	0.65	0.84	29%
FaME	0.825	1.03	25%
Tai Chi	0.72	0.86	19%
HAM	0.69	0.96	39%

Table 33: Results of the sensitivity analysis, proportion of falls that are serious

Intervention	Value adopted in the analysis	Value for substantial change	Percentage change
Otago	20%	9.10%	-55%
FaME	20%	8.85%	-56%
Tai Chi	20%	10.15%	-49%
HAM	20%	2.70%	-87%

4. Discussion

4.1 Findings in context

The findings from this analysis indicate that all 4 interventions can be considered cost-effective when compared with usual care in an English setting. In terms of return on investment, one out of 4 interventions (HAM) produced a positive financial return with the remaining 3 interventions (Otago, FaME and Tai Chi) falling just short of generating positive financial returns (£0.95, £0.99 and £0.85 per £1 for Otago, FaME and Tai Chi respectively). It should be noted that it is expected that only a small proportion of these financial returns will be due to cash releasing savings. For example, if the number of nursing home admissions following a fall are reduced then NHS commissioners could save an estimated £113 per week per person for nursing costs.

However, the majority of the financial returns are due to opportunity cost savings, such as the freeing up of hospital beds due to fewer inpatient admissions. Whilst these benefits will not produce cash that can be spent elsewhere it will relieve certain pressures on the NHS and LAs, such as reducing the burden on accident & emergency departments. There may also be other benefits to NHS and LAs that are not captured in the analysis as they could not be quantified, in particular those relating to non-serious falls (ie a reduction in anxiety and loneliness).

When a wider societal perspective is adopted and the impact of each intervention on a participant's quality of life is formally quantified then returns with each intervention increase. Moreover, the 3 interventions that fell short of producing a positive financial return do produce a positive societal return on the initial investment.

Of the 4 interventions included in the analysis, the home assessment and modification intervention provided large returns on investment, both financial and societal, and provided the greatest return overall. However, it is important to note that, as discussed previously, the overall risk of falls in the people recruited into the HAM clinical study was much higher than for the other interventions. This is because people were recruited into the HAM study because they had been admitted to hospital due to a fall. Therefore, the high returns for HAM are specific to this intervention in this population.

If the intervention was to be introduced into lower risk population, such as those included in the clinical trials that inform the effectiveness of the 3 exercise programmes, then the return on investment is expected to be lower. This also indicates that the return on investment for each of the other interventions may increase if the intervention is targeted at sub-groups of people with a higher risk of falls.

4.2 Strengths and limitations of the analysis

To accurately estimate the impact of each intervention it is important to ensure their effectiveness is captured appropriately. Within the analysis, the effectiveness data have been sourced from randomised controlled trials or systematic reviews and meta-analyses. Therefore, these sources should provide robust and accurate estimates with a limited potential for biases. These inputs together with the assumptions on the falls pathway, resource use and costs have also been validated by members of the Steering Group and User Group, who are experts in the field.

A range of different resources associated with the treatment of, and ongoing care for, falls events have been incorporated within the analysis. This is to ensure the cost of falls is estimated as accurately as possible given it is a key driver of the analysis outputs. Based on the data applied the mean cost per serious fall is estimated to be £4,174. This cost was deemed to be acceptable by members of the Steering Group.

As discussed previously, each intervention has been compared against usual care with a different baseline rate of fall applied for each comparison. This is due to differences in the characteristics of the participants recruited into the clinical studies that inform how effective each intervention is at reducing the rate of falls. As there is not a consistent baseline rate of falls across all interventions it is not possible to compare precisely the included interventions to one another (eg Otago versus FaME) for a population with identical characteristics. Such comparisons are expected to be informative, if possible, as it would allow commissioners to choose between interventions when multiple options are available to them.

The distinction between the characteristics of study participants also limits the generalisability of the results of this analysis. The results will remain valid if the intervention is targeted at populations that are similar to the study cohorts (eg in terms of age, number of previous falls and mobility). It should also be noted that in a number of studies informing the analysis there was a significantly higher number of females. This is likely to reflect the target population for the interventions.

Whilst the main data sources for the analysis are robust there is relatively limited follow-up data on the effectiveness of each intervention. Consequently, the timeframe of the analysis has been limited to 2 years with the assumption made that all benefits from the intervention will cease by the end of this 2 year period. In reality, certain interventions may produce benefits over a greater period, in which case the analysis may underestimate the cost savings and/or improvement in quality of life, and subsequently the overall return on investment, that can be obtained from the interventions.

The tool assumes each intervention is delivered using protocols consistent with the approaches used in the RCTs (eg the same number of contact hours between staff and participants), by trained people and with sufficient equipment. If in practice the delivery is to a lower standard than in the RCT then the benefits may also be commensurately lower and hence the return poorer. The importance of this is illustrated by the sensitivity analysis, which found that effectiveness of each intervention (ie the IRR) is a key driver of the overall results of the analysis. It is also illustrated by the evaluation of the Otago programme that was undertaken in the Iliffe (2014) study (used for data on FaME). Iliffe and colleagues found that Otago was not clinically effective compared with usual care, which contradicts previous conclusions relating to the effectiveness of the programme [13, 19].

Therefore, if data from Iliffe (2014) was used to support the Otago analysis undertaken here then the estimated return on investment is expected to be lower. However, the delivery of Otago in that study was to a lower fidelity (eg shorter total duration) and to a lower risk population group, which is likely to explain the reduction in efficacy. Measuring the outcome of the intervention through on-going evaluation is thus essential to ensure each intervention is clinically effective.

Only one of the RCTs was conducted in England [13]. Hence there may be issues about generalising from non-UK setting to practice in England. Practitioners should ensure they are familiar with the intervention as originally conducted in order to minimise the potential of delivering poorer efficacy outcomes in their own setting. More information on the included interventions, and the specific approach adopted in the underlining clinical trials, can be found in the Compendium of Effective Fall Interventions compiled by the Centre for Disease Control and Prevention.

The tool has been developed to assess the return on investment for each intervention when implemented in an average cohort of people based on relevant data in the literature and feedback from experts. However, there is expected to be a degree of variation in local practice and this will impact on the results of the analysis. In particular, the location is expected to impact on the cost of intervention implementation (eg exercise classes may be more expensive to implement in rural locations due to a need for staff to travel greater distances) and the costs of the falls-related events may differ across Trusts.

The Market Forces Factor (MFF) can sometimes be used to adjust prices for geographical variation in the UK but only when National tariff payments are being applied. Such payments were not considered in the analysis making the MFF irrelevant. Further, a number of assumptions were required when costing each intervention. Whilst these inputs were validated by members of the Steering and User Groups, the robustness of the analysis is expected to increase if accurate local data can be identified. Therefore, users should update the tool to use local resources and costs to facilitate accurate evaluations for their local area, where possible.

4.3 Recommendations for future research

As the tool that supports this analysis is interactive it can be updated to reflect ongoing changes in falls prevention practice. For example, Otago is no longer just a home-based programme and it is increasingly being delivered during group sessions in the community. Therefore, if data on the efficacy of Otago in a group setting become available the analysis can be updated.

The analysis can also be updated to include new data sources and possibly even new interventions if they have the potential to be clinically and cost effective in older people. Of note there is an ongoing, large-scale RCT that is investigating the efficacy of Otago and a multifactorial falls prevention programme in a UK setting. The PreFIT study, aimed to recruit over 9,000 people aged 70 years and over, living in a community setting, to assess the clinical and cost-effectiveness of these programmes [54]. This study is now complete and results are expected in Summer 2018. There are also ongoing studies on Otago delivered in groups (in Australia and America).

Multifactorial risk assessment and management (MFRAM) was identified as a cost effective intervention at the literature review stage. This intervention was not ultimately included in the ROI tool as there was insufficient data to inform the cost of the intervention. Following the publication of this PreFIT study results we will assess the feasibility of using the findings to inform the return on investment of MFRAM and may be able to update the ROI tool to include this intervention.

5. Conclusions

The conclusions of the assessment are informed by a tool that has been developed to assess the ROI for 4 falls prevention programmes targeted at older people living in the community. These interventions have evidence that indicates they were cost-effective in their original settings. The results of the analysis undertaken using the tool indicates that all 4 interventions are cost-effective when compared with usual care (ie no falls prevention service) in the English setting. Moreover, one of the 4 (HAM) should produce a positive financial return on the investment whilst 2 of the other 3 virtually achieve financial break-even.

The positive financial return is due to a reduction in the number of serious falls, with the associated cost savings outweighing the cost of implementation. Consequently, by commissioning these interventions health and social care providers have the potential to generate savings and reduce the number of serious falls. For the 3 interventions without a positive financial ROI (Otago, FaME and Tai Chi) there is a positive return when the impact of each intervention on the quality of life of participants is considered (ie the societal ROI).

The estimated returns are only expected if each intervention is implemented in clinical practice with fidelity, and delivered to a consistent quality, such that the effectiveness of each intervention at reducing the number of falls is similar to the reduction measured in the clinical studies that underpin the analysis. Further, the interventions should be targeted at population groups that are similar to those enrolled in the clinical studies just discussed. This is to ensure that the effectiveness data are applied in a valid manner.

For example, if in practice an intervention is implemented in a population group with a lower risk of falls, due to them being younger or more mobile than the population enrolled in the associated clinical study, then the results of this analysis will not translate given the key differences in characteristics. Evaluations should be commissioned as part of the intervention to ensure they are delivering the anticipated benefits. Preventing falls in older community dwellers by commissioning these programmes has the potential to deliver material benefits to a wide range of stakeholders but particularly to the participants and their families.

6. References

1. Tian Y TJ, Buck D, Sonola L. Exploring the system-wide costs of falls in older people in Torbay. London, UK: 2013. Available from: https://www.kingsfund.org.uk/publications/exploring-system-wide-costs-falls-older-people-torbay.
2. Church J, Goodall S, Norman R, Haas M. The cost-effectiveness of falls prevention interventions for older community-dwelling Australians. Aust N Z J Public Health. 2012;36(3):241-8.
3. 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.
4. Skelton D, Todd, C,. What are the main risk factors for falls amongst older people and what are the most effective interventions to prevent these falls?,. Copenhagen: WHO Regional Office for Europe 2004. Available from: http://www.euro.who.int/__data/assets/pdf_file/0018/74700/E82552.pdf.
5. Yang T, et al. Exploring the system-wide costs of falls in older people in Torbay. London: King's Fund; 2013.
6. Treml J, Husk J, Lowe D, Vasilakis N. Falling standards, broken promises: Report of the national audit of falls and bone health in older people 2010. London: 2011. Available from: file://userfs/ds1270/w2k/Desktop/FINAL%20National%20Report_0.pdf.
7. NICE. Falls – Assessment and prevention of falls in older people. London: 2013. Available from: https://www.nice.org.uk/guidance/cg161/evidence
8. Leal J, Gray AM, Prieto-Alhambra D, Arden NK, Cooper C, Javaid MK*, et al.* Impact of hip fracture on hospital care costs: a population-based study. Osteoporos Int. 2016;27(2):549-58.
9. Office for National Statistics. Subnational population projections for England: 2014-based projections. Office for National Statistics; 2016. Available from: https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationprojections/bulletins/subnationalpopulationprojectionsforengland/2014basedprojections.
10. Barnett D, Davis M. The correlates of 3-year change in accelerometer-assessed physical activity for a diverse sample of older urban UK adults. Journal of Science and Medicine in Sport. 2012;15:S240-S41.
11. 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 Syst Rev. 2012;9:CD007146.
12. McLean K, Day L, Dalton A. Economic evaluation of a group-based exercise program for falls prevention among the older community-dwelling population. BMC geriatr. 2015;15:33.
13. Iliffe S, Kendrick D, Morris R, Masud T, Gage H, Skelton D*, et al.* Multicentre cluster randomised trial comparing a community group exercise programme and

home-based exercise with usual care for people aged 65 years and over in primary care. Health Technology Assessment. 2014;18(8):1-106.
14. Li F, Harmer P, Fitzgerald K. Implementing an Evidence-Based Fall Prevention Intervention in Community Senior Centers. Am J Public Health. 2016;106(11):2026-31.
15. Tse T. The environment and falls prevention: Do environmental modifications make a difference? Australian Occupational Therapy Journal. 2005;52(4):271-81.
16. Skelton D, Dinan S, Campbell M, Rutherford O. Tailored group exercise (Falls Management Exercise -- FaME) reduces falls in community-dwelling older frequent fallers (an RCT). Age Ageing. 2005;34(6):636-9.
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. Sach TH, Logan PA, Coupland CAC, Gladman JRF, Sahota O, Stoner-Hobbs V*, et al.* Community falls prevention for people who call an emergency ambulance after a fall: an economic evaluation alongside a randomised controlled trial. Age Ageing. 2012;41(5):635-41.
22. Statistics OfN. MYE2: Population estimates by single year of age and sex for local authorities in the UK, mid-2015. In: Statistics OfN, editor.; 2016.
23. Statistics OfN. Clinical Commissioning Group Mid-Year Population Estimates. In: Statistics OfN, editor.; 2016.
24. Health Do. Impact Assessment of fracture prevention interventions. London, UK: 2009. Available from: http://webarchive.nationalarchives.gov.uk/+/http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/DH_103146.
25. Nyman SR, Victor CR. Older people's participation in and engagement with falls prevention interventions in community settings: an augment to the Cochrane systematic review. Age Ageing. 2012;41(1):16-23.
26. Craig J, Murray A, Mitchell S, Clark S, Saunders L, Burleigh L. The high cost to health and social care of managing falls in older adults living in the community in Scotland. Scott Med J. 2013;58(4):198-203.
27. Digital N. Hospital Episode Statistics. In: Digital N, editor.NHS Digital; 2016.
28. Curtis L BA. Unit Costs of Health & Social care 2016. Canterbury, UK: 2016. Available from: http://www.pssru.ac.uk/project-pages/unit-costs/2016/index.php.
29. Scotland ISD. Care Home Census - data. Edinburgh, Scotland: Information Services Division Scotland; 2016. Available from: http://www.isdscotland.org/Health-Topics/Health-and-Social-Community-Care/Publications/data-tables.asp?id=1769#1769.
30. Economy N. Unit Cost Database. In: Economy N, editor. Manchester, UK; 2016.
31. Department of Health. NHS Reference Costs 2015-16 [webpage]. London: 2016. Last updated 15 December 2016. [cited 30th June 2017]. Available from: https://www.gov.uk/government/publications/nhs-reference-costs-2015-to-2016.

32. Scotland ISD. R040LSX - speciality costs and activity - inpatients in long stay specialties, by speciality. In: Scotland ISD, editor. Edinburgh, UK; 2016.
33. Poole CD, Smith J, Davies JS. Cost-effectiveness and budget impact of Empirical vitamin D therapy on unintentional falls in older adults in the UK. BMJ Open. 2015;5(9):e007910.
34. Kind P HG, Macran S. UK Population Norms for EQ-5D. York, UK: 1999.
35. Brazier JE, Green C, Kanis JA, Committee Of Scientific Advisors International Osteoporosis F. A systematic review of health state utility values for osteoporosis-related conditions. Osteoporos Int. 2002;13(10):768-76.
36. Church J, Goodall S, Norman R, Haas M. The cost-effectiveness of falls prevention interventions for older community-dwelling Australians. Aust N Z J Public Health. 2012;36(3):241-8.
37. 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.
38. Austrian Development Agency EU. Guidelines for Project and Programme Evaluations. Vienna, Austria: 2009. Available from: https://www.oecd.org/development/evaluation/dcdndep/47069197.pdf.
39. Riglin J LD, Buttery A, Vasilakis N. Older people's experiences of therapeutic exercise as part of a falls prevention service. London, UK: 2012.
40. 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.
41. Laterlifetraining.co.uk. About OTAGO Exercise Programme Leader - Costs. Available from: http://www.laterlifetraining.co.uk/courses/otago-exercise-programme-leader/about-otago-exercise-programme-leader/#1461597926950-5373640f-0300.
42. Laterlifetraining.co.uk. About Postural Stability Instructor - Costs. Available from: http://www.laterlifetraining.co.uk/courses/postural-stability-instructor/about-postural-stability-instructor/#1461597926950-5373640f-0300.
43. Logghe IH, Zeeuwe PE, Verhagen AP, Wijnen-Sponselee RM, Willemsen SP, Bierma-Zeinstra SM*, et al.* Lack of effect of Tai Chi Chuan in preventing falls in elderly people living at home: a randomized clinical trial. J Am Geriatr Soc. 2009;57(1):70-5.
44. Voukelatos A, Cumming RG, Lord SR, Rissel C. A randomized, controlled trial of tai chi for the prevention of falls: the Central Sydney tai chi trial. J Am Geriatr Soc. 2007;55(8):1185-91.
45. Wolf SL, Sattin RW, Kutner M, O'Grady M, Greenspan AI, Gregor RJ. Intense tai chi exercise training and fall occurrences in older, transitionally frail adults: a randomized, controlled trial. J Am Geriatr Soc. 2003;51(12):1693-701.
46. Wolf SL, Barnhart HX, Ellison GL, Coogler CE. The effect of Tai Chi Quan and computerized balance training on postural stability in older subjects. Atlanta FICSIT Group. Frailty and Injuries: Cooperative Studies on Intervention Techniques. Phys Ther. 1997;77(4):371-81; discussion 82-4.
47. Li F, Harmer P, Fisher KJ, McAuley E, Chaumeton N, Eckstrom E*, et al.* Tai Chi and Fall Reductions in Older Adults: A Randomized Controlled Trial. The

Journals of Gerontology Series A: Biological Sciences and Medical Sciences. 2005;60(2):187-94.
48. Cumming RG, Thomas M, Szonyi G, Salkeld G, O'Neill E, Westbury C*, et al.* Home visits by an occupational therapist for assessment and modification of environmental hazards: a randomized trial of falls prevention. J Am Geriatr Soc. 1999;47(12):1397-402.
49. Amazon.co.uk. 2017. Available from: www.amazon.co.uk.
50. Council W. Handyperson service. In: Wiltshire Council. Sailsbury, UK.
51. Nikolaus T, Bach M. Preventing falls in community-dwelling frail older people using a home intervention team (HIT): results from the randomized Falls-HIT trial. J Am Geriatr Soc. 2003;51(3):300-5.
52. Home I. Wet rooms - the essential guide. Available from: http://www.idealhome.co.uk/bathroom/bathroom-advice/wet-rooms-the-essential-guide-shower-room-ideas-85882.
53. Glover D HJ. Quantifying health impacts of government policies: A how-to guide to quantifying the health impacts of government policies. London, UK: 2010. Available from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/216003/dh_120108.pdf.
54. Bruce J, Lall R, Withers EJ, Finnegan S, Underwood M, Hulme C*, et al.* A cluster randomised controlled trial of advice, exercise or multifactorial assessment to prevent falls and fractures in community-dwelling older adults: protocol for the prevention of falls injury trial (PreFIT). BMJ Open. 2016;6(1):e009362.
55. Craig Health Economics Consultancy Ltd. Resources, costs and benefits associated with implementing care bundles to prevent falls in the community. 2012. Unpublished.

Appendix A: Members of the Steering Group and User Group

Steering Group Members

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- Daniel MacIntyre, Population Health Service Manager, Public Health England
- Rebecca Worboys, Health Economist, Public Health England
- Panos Zerdevas, Senior Economic Advisor, Public Health England (now of the Department of Health)
- Jake Gommon, Senior Economic Advisor, Public Health England
- Leoni Belsman, Economic Advisor, Public Health England
- Matt Hennessey, Knowledge and Intelligence Team, Public Health England
- Sharon Hughes, Project Manager (Falls), Public Health, Leeds City Council
- Lucy Jackson Consultant in Public Health Leeds City Council/Leeds CCGs
- Kay Nolan, Associate Director for Surveillance and Methods, NICE
- Susan Hamilton, Strategic Development Director, National Osteoporosis Society
- Sue Hayward-Giles, Assistant Director or Director, Chartered Society of Physiotherapy
- Katie Walkin, NHS Project Delivery Manager, NHS England
- Victoria Goodwin, NIHR CLAHRC South West Peninsula, University of Exeter Medical School
- Tim Jones, Commissioning Advisor, National Osteoporosis Society
- Dawn Skelton, Professor in Ageing and Health, School of Health and Life Sciences, Glasgow Caledonian University
- Finbarr Martin, Consultant Physician and Geriatrician, Guy’s and St Thomas’ NHS Foundation Trust
- Rachel Clark, National Osteoporosis Society
- Shelagh Morris, Deputy Chief Allied Health Professions Officer , NHS England
- Sarah Marsh, Programme Manager, NHS England
- Alice O’Connell, NHS England

User Group

- Jane Reddaway, Falls Prevention Lead, Community Services, Torbay and South Devon NHS Foundation Trust
- Jackie Riglin, Team Manager, Brookfields Hospital, Cambridge
- Cordelle Mbeledogu, Consultant in Public Health Medicine, Manchester City Council/North Manchester CCG
- Julian Cox, Deputy Director, New Economy Manchester
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- Julie Owen, Public Health Principal, Wakefield City Council
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- Cameron Russell, Advanced Public Health Practitioner, Worcestershire County Council
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