

# **Systematic Review: Evidence on Home Modifications**

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# Abstract

## Background

The links between health and housing are well established and indicate that housing interventions may be an important mechanism in health maintenance and improvement. Home modifications are a specific type of housing intervention that *help people to be more independent and safe in their own home and reduce any risk of injury to their carers and care workers.*

Studies of home modifications have been published across a number of fields in the housing and health domains. Collation and synthesis of this diverse research will assist in assessing the current evidence base overall as well as supporting decision making in terms of practice and future research directions. One of the issues facing research into home modifications has been the variable definition of what a home modification constitutes. It is not uncommon in the literature for home modifications to be misconstrued as being a type of assistive technology or moving furniture or rugs in the home. This review provides a very clear definition of home modifications and filters studies carefully in alignment with this definition. Because decision makers are increasingly faced with diverse evidence of variable scope and quality, a systematic review of the evidence allows the findings of separate studies of home modifications to be compared and contrasted, providing a useful collation of the evidence.

## About this review

This review considers existing evidence regarding the relationship between provision of home modifications and benefits to recipients and the broader community. Evidence is considered internationally, across areas of health and housing.

A systematic search of literature on the effects of home modifications was conducted to determine what research had been published on the overlap of housing and health, and to understand what other studies had observed or measured home modification interventions in all contexts.

This systematic review is designed and reported according to the PRISMA statement, an internationally recognized 27-item method ensuring the highest standard in systematic reviewing.

## Objectives

To assess the evidence of health and social effects following home modifications.

## Search Methods

Academic and grey literature bibliographic databases were searched for home modification studies from 1990 to December 2014 (MEDLINE, Medline in process and non-indexed citations, PubMed, EMBASE, CINAHL, PsycINFO, Web of Science, Applied Social Sciences Index and Abstracts, Scopus and Conference proceedings citations index). Reference lists of relevant studies were also searched. Searches were restricted to English language. Searches were not restricted by publications status.

## Selection Criteria

Studies that assessed change in any effect following home modification were included. Included studies comply with an agreed definition of home modifications; any studies outside the agreed

definition were excluded. Both quantitative and qualitative grades of research methods were included. Theoretical studies or expert opinion were excluded, as were studies that looked at program uptake, prevalence or process evaluation. Studies were not limited to single factor home modification studies, and included multifactorial interventions where home modifications were involved.

### **Data collection and analysis**

Studies were independently screened and critically appraised by two review authors. Study quality and type was assessed and graded according to five categories, systematic review, RCT, Quasi-experimental Secondary Data and Qualitative. Traditional methods of data synthesis were not appropriate as the data was not amenable to meta-analysis. This was due to extreme heterogeneity of research design and data, and also because of variations in intervention (multi or single factorial) and sub-sample populations.

This review undertakes a narrative synthesis to build an understanding of the full extent of evidence on the effect of home modification intervention. Included studies are graded according to the outcomes and effects investigated and tabulated data of themes and study types is presented as a visual summary according to these outcomes.

### **Main results**

Seventy-seven studies which reported quantitative or qualitative data, or both, were included in the review. Fifty-two quantitative studies were identified. This included 6 systematic reviews, 19 random controlled trials, 23 quasi experimental studies and 14 using secondary data. The review found fifteen (15) qualitative studies.

Thematic analysis of the studies reveals that there are seven main themes of evidence in home modification research. The most research lies in the area of falls prevention, however all of the included studies are multifactorial and measure the effect of home modifications grouped in with other interventions such as hazard reduction programs. The following themes in order of decreasing prevalence within the evidence base are improved function; physical health and wellbeing; caregiving; economic effectiveness; ageing process; and social participation.

### **Author's conclusions**

Home modifications can lead to a range of health related improvements. A majority of the research across all themes was found to support the positive effects of a home modification intervention.

Further research is needed across all effect themes using single factor studies of home modifications because many of the included studies in this review are multifactorial. Also, the evidence base of home modifications will benefit from clearer definitions to differentiate research measuring home modification, assistive technology and moving furniture.

While many of the home modification interventions were targeted at older community dwelling adults, research also investigated the effects of home modifications on people living with a disability or chronic illness regardless of age.

## **Keywords**

Home modifications; systematic review; housing and health;

## **Publication History**

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## **Contribution of Authors**

This is the first edition of the Systematic Review; Evidence on Home Modifications, authored by P. Carnemolla and C.Bridge (2015) for Home Modifications Australia.

Author 1 Phillippa Carnemolla is the Primary Reviewer on this paper and generated first drafts, including all graphs and tables.

Author 2 Catherine Bridge is the Secondary Reviewer on this paper and has supervised the analysis process as well as, edited and revised all draft content.

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## Glossary

Effect	The impacts and/or outcomes measured following an intervention such as home modifications
Multi-Factorial Intervention	Refers to multiple interventions being measured as a single intervention, e.g. in some instances of falls prevention investigations home modifications have been one element within a multi-factorial intervention that also include exercise training and information program. The effect is measured as a combination of interventions and individual effects cannot be titrated.
Narrative Synthesis	An alternative to quantitative/statistical syntheses of studies included in a systematic review. Narrative synthesis is applied when included studies are highly heterogeneous in methodology, sub-sample, study type and/or measured effect.
Single Factor Intervention	Refers to a single interventions being measured for a single effect.

## Background

### Why conduct a systematic review of home modifications?

A clear overview of studies on home modification interventions has been hindered by inconsistent definitions and variable intervention parameters. A systematic approach to reviewing the literature on home modifications will give a better picture of the breadth of the effects within the evidence base, as well as an understanding of where the evidence base is most convincing and where research is lacking.

Many studies have investigated the health of populations and their housing conditions, with a body of evidence that strongly associates poorer health with poorer quality housing (Bonnefoy, 2007; Bridge, Flatau, Whelan, Wood, & Yates, 2003; Thomson, Thomas, Sellstrom, & Petticrew, 2013). In housing and health reports, housing interventions vary broadly from focusing on living conditions such as thermal or air quality, to housing poverty to levels of accessibility within the home.

In research considering home modification<sup>1</sup> effects, the lack of definitional rigour and blurring of the definitions of assistive technology and rehabilitation interventions has meant the evidence has at times been ambiguous and unclear. Studies of home modifications have been published across a number of fields in housing and health domains. Collation and synthesis of this diverse research according to clear definition of home modifications will assist in assessment of the current evidence base as well as supporting decision making in terms of practice and future research directions.

This review provides a very clear definition of home modifications and filters studies carefully in alignment with this definition. Because decision makers are increasingly faced with diverse evidence material of variable scope and quality, a systematic review of the evidence allows the findings of targeted studies of home modifications to be compared and contrasted, providing a useful collation of the evidence. Given the currency of discussion and publications about independence, housing and ageing in place, evidence of benefits of investing in home modifications could be especially potent in discussions around public health budgets, government subsidised community caregiving and housing.

### Methodological challenges

Adding to the complexity of a systematic review of home modifications is the sheer diversity of the evidence base. First the research being reviewed spans health and housing domains that result in broad focus and variable scope of research designs. Second, there are issues about comparability between sample population and research designs. Traditional systematic reviews were designed to meta-analyse homogenous

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<sup>1</sup> Home modification refers to a type of housing intervention that includes structural changes to the home environment to help people with impairments in human performance to be able to exercise greater autonomy and control (Adams, Bridge, Carnemolla, McNamara, & Quinn, 2014)

studies. In this case, it was clear that none of the 77 studies were homogenous in nature. A meta-analysis is not a necessary component of a systematic review and may present a misleading synthesis of intervention effects (Higgins & Green, 2008; O'Rourke & Detsky, 1989). In order for a heterogeneous collection of mixed-method studies to be collated and synthesised, a very specific approach to the analysis is undertaken for this review.

Very early on in the review process it became clear that there were inconsistencies in terminology when referring to home modifications, not only according to the definition of home modification, but within the definition itself. For example some of the studies were a combination of medicine review, exercise and home modification, others bundled assistive technology and home modifications together, and others still listed "moving a rug" as a home modification. This has been managed in the review by filtering studies to include only an agreed upon definition of home modification interventions, thus ensuring that the evidence base being reviewed is measuring a consistently applied intervention.

Of the seventy-seven (77) studies included in the final review, there are twenty-eight (28) different terms being used to refer to either home modifications or a multifactorial intervention that includes home modifications. See Table 1 for a complete list of terms used within the included 77 studies on home modifications.

Table 1 Terminology used to refer to home modifications within the included studies

TERMINOLOGY	Number of studies (out of a total of 77)
home modification	35
housing adaptation	4
assistive technology	3
environmental intervention	3
environmental modification	3
hazard reduction	3
home adaptation	3
assistive devices	2
home based intervention	2
accessibility feature	1
adaptation	1
bath grab bar	1
built environment	1
dwelling modifications	1
environment modification	1
environmental adaptation	1
environmental alteration	1
home adjustment	1
Home alteration	1
home based intervention	1
home environment intervention	1
home hazard management	1
Installation of safety device	1
level access shower	1
minor home safety modifications	1
modification	1
residential adaptation	1
residential modification	1

## Reviewing a diverse evidence base

The purpose of this literature review is to collate and filter the broad body of evidence around the effects of home modifications. This will enable a better understanding of the role home modifications play across health and housing and will reveal areas where the evidence base is stronger as well as areas where there is a need for further research.

Research into home modifications span across a number of disciplines within the fields of housing and health, the dynamics of which have been described as ‘complex’ in a number of studies (Johansson, Lilja, Petersson, & Borell, 2007; Lord, Menz, & Sherrington, 2006). When assessing the evidence base around a health and housing question, decision makers need to draw upon diverse and varied sources of evidence, and consider carefully how these might be synthesised (Goldsmith, Bankhead, & Austoker, 2007). The research designs that have been sourced on home modifications are broad and include Systematic reviews, Random Controlled Trials, Quasi-experimental studies, Secondary data analyses and Qualitative studies; they have been published in journals from specialised fields some of which include architecture, housing, rehabilitation and gerontology.

Traditional methods of data synthesis were inappropriate in this review as the data was not amenable to meta-analysis, meaning statistical evidence could not be collectively analysed. This was due to the extreme heterogeneity of the included studies which varied by: the type of research; the actual effect being measured; the research designs (i.e. multi or single factorial etc.) and in the population being sampled. Therefore the most systematic approach to synthesising the literature, which comprised our raw data, was to grade according to research quality and effect. The included studies were classified and graded before being synthesised into a diverging stacked bar chart in order to better understand the complexity and diversity of the data. Cluster themes were then used to describe the significance of effects, gaps and weaknesses.

## Prior systematic reviews on Home modification

A literature search on home modifications revealed six relevant systematic review conducted within the fields of health, and ageing. Interestingly, none were published in the housing literature implying that for housing this is not yet of significant concern despite the fact that many households undertake home renovations relatively soon after retirement and that kitchens and bathrooms are typically replaced or updated around every fifteen years (Housing Industry Association, 2014). Further, this “accounts for the largest share of expenditure on alterations and additions each year” (p1 *ibid*).

Systematic reviews tended to be inconsistent across studies. For example, the terms ‘environmental modification’ and ‘home modification’ were sometimes interchangeable and other times ‘environmental modification’ was a very loose term used to include moving furniture, assistive equipment or other more general hazard reduction techniques.

Of the six systematic reviews, outlined in Table 2, all review research measuring the same effect - safety and fall prevention - and all investigate (to varying degrees) the home environment's relationship to injury prevalence or fall prevention. These systematic reviews include studies that are multifactorial interventions within which home modifications may or may not be a component. For example, some of the studies were a combination of medicine review, exercise and home modification, others bundled assistive technology and home modifications together, while others listed "moving a rug" as a home modification. This raises a number of concerns. Not only does it further highlight the need for a clear definition of home modifications, it also emphasises the need for research that better measures the outcomes of home modifications independently of other interventions.

Table 2 Previous systematic reviews on home modifications

<i>Reference</i>	<i>Journals published</i>	<i>Years review ed</i>	<i>No of papers reviewed</i>	<i>Factorial</i>	<i>Investigati on</i>	<i>Term used</i>
<b>SYSTEMATIC APPROACH TO REVIEW</b>						
Chang, et al.(2004)	The BMJ	1992-2002	99	Included in multifactorial interventions	Falls prevention	Environmental modification
Chase, Mann, Wasek, & Arbesman, (2012)	American Journal of Occupational Therapy	1990-2011-	33	Included in multifactorial interventions	Falls prevention	Home modification
Clemson, Mackenzie, Ballinger, Close, & Cumming, (2008)	Journal of Ageing & Health	1990-2007	6	Included in multifactorial interventions	Falls prevention	Environmental intervention
Tse (2005)	Australian Occupational Therapy Journal	1993-2004	Nov-18	Included in multifactorial interventions	Falls prevention	Environmental modification
Turner et al., (2011)	Cochrane Database of Systematic reviews	1979-2004	28	Included in multifactorial interventions	Injury reduction	Modifications to the home environment
Wahl, Fange & Oswald (2009)	The Gerontologist	1997-2006	25/29		Evidence on home modifications – falls and function	Home modifications
<b>NON-SYSTEMATIC or UNDISCLOSED APPROACH TO REVIEW</b>						
Lord, Menz & Sherrington (2006)	Age & Ageing	1988-2002	5 prospective 5 RCT	Included in multifactorial intervention	Environmental risk factors for falls	Home modifications

In the systematic review by Chang (2004), ninety-nine (99) papers were reviewed to assess the relative effectiveness of interventions to prevent falls in older adults. The interventions reviewed were a multifactorial intervention that included falls risk assessment and management programme, exercise, home modifications (referred to as environmental modifications or education. This review found the most effective intervention was a multifactorial risk assessment and management programme, with no clear evidence for a home modification program.

In another systematic review by Chase, Mann, Wasek & Arbesman (2012), 33 studies were identified as multifactorial falls interventions which included home modification

(though the term used was environmental modification). It had a focus on multifactorial interventions within occupational therapy's scope of practice, however only a part of which included home modification interventions.

This review sought to answer the research question;

*"What is the evidence for the effect of home modification and fall prevention programs on the performance of community-dwelling older adults?"*

The results of the Chase et al. (2012) review indicated that the most effective falls prevention intervention is a multifactorial falls risk assessment program which includes management, exercise, environmental modifications and education. Next most effective was a supported exercise program.

Falls prevention was also the focus in the systematic review by Clemson, Mackenzie, Ballinger, Close & Cumming (2008). This review looked broadly at what were termed "environmental interventions". All of the six (6) studies included in the review involved multifactorial hazard assessment interventions, with home modifications being an unknown proportion of the interventions components. One of the six studies did not include any home modifications in the multifactorial intervention as part of a hazard reduction or safety program. These were meta-analysed and while not measuring home modifications, the results indicated that home assessment interventions that incorporate an environmental-fit perspective could significantly reduce falls.

Tse's systematic review by (2005) included studies on environmental modification as a falls prevention strategy in both institutional settings (7 studies) and community settings (11 studies). Again, environmental modification was used as a term that addressed the broader multifactorial studies relating to hazard reduction, within which home modifications are a only a small component within some studies.

The Cochrane review by Turner et al. (2011) sought to "*determine the effect of modifications to the home environment on the reduction of injuries due to environmental hazards*". The term "Modifications of the home environment" included not only studies of home modification. It also included a number of hazard reduction programs or home safety programs that were multifactorial, many of which did not include any home modifications. Of the 28 studies included, 2 investigated environmental modifications as a single factor intervention (Cumming et al., 1999; Pardessus et al., 2002) but only one of these included an element of home modification (Cumming et al., 1999). The remaining studies were all multifactorial and included home modifications to varying degrees, or not at all. This review concluded that there is insufficient evidence to determine whether interventions focused on modifying environment reduces injuries but that multifactorial interventions were beneficial. The authors went on to recommend further random controlled trials to best measuring injury outcomes.

The systematic review by Wahl, Fänge, Oswald, Gitlin, & Iwarsson (2009) reported evidence of a relationship between home environments and disability-related outcomes for older adults but reported that this evidence was limited by cross-sectional design

and poorer research quality. In the same systematic review, evidence based on randomised controlled trials revealed that improving home environments enhanced functional ability outcomes but this relationship was less clear for falls.

Lord's (2006) systematic review investigated home environment risk factors and the efficacy of home modifications. This review concluded that the interaction between an older person's physical abilities and their exposure to environmental stressors appears to be more important than home hazards alone in determining risk factors for falls, however the failure to document the systematic search strategy makes these findings less convincing.

## Objectives

This review set out to assess the evidence of health and social effects following home modifications. The primary objective of this systematic review being to locate and synthesise all evidence about home modifications, Primary inclusion criteria were based on published research discussing a home modification effect, and where what was described as home modification met the definition as noted in Figure 1 below.

**Home modifications are defined as:**

*"...changes made to the home environment to help people to be more independent and safe in their own home and reduce any risk of injury to their carers and care workers. Modifications to the home include changes to the structure of the dwelling e.g. widening doors, adding ramps, providing better accessibility etc. and the installation of assistive devices inside or outside the dwelling e.g. grab rails, handrails, lifts etc." (P.1, Adams, Bridge, Carnemolla, McNamara, & Quinn, 2014)*

Figure 1: Definition of home modifications - one of the main criteria of inclusion or exclusion in this review.

A systematic review of the evidence base on home modification interventions enables the recognition of the interdisciplinary effects of home modifications for older people, and those living with chronic illness or disability. Existing programs of home modification are based on an understanding that home modifications support health services as well as individual health outcomes, although an overview of these effects has to date not been conducted.

For this reason, the purpose of this literature review is to collate and filter the body of evidence around the effects of home modifications. This will enable a better understanding of the role home modifications play across health and housing and will reveal areas where the evidence base is convincing as well as areas where there is a need for further research. It will also assist in the determination of strategies most likely to achieve best practice outcomes for older people, people with disabilities and their carers.



## Methods

This systematic review was designed and reported according to the PRISMA statement, an internationally recognized 27-item method ensuring the highest standard in systematic reviewing (Liberati, Altman, Tetzlaff, Mulrow & Gotzsche, 2009) .

Methodological parameters applied to this review are described within the context of (i) inclusion/exclusion criteria for considering studies, (ii) study selection, (iii) effect grading, (iv) search strategies and (v) collection and analysis of results. This review employs meta-synthesis; a non-statistical technique to integrate, evaluate and interpret the findings of multiple research studies; with the aim of transforming individual findings into new conceptualizations and interpretations (Cronin, Ryan, & Coughlan, 2008).

### Criteria for considering studies for this review

Literature searches were limited to being post-1990 as the home modification program was only established in Australia in the late eighties and research prior to this typically failed to ensure adequate representation of women and those with minority backgrounds and this is now considered critical for scientific evidence leading to a change in policy or a standard of care (National Institute of Health, 1994).

All studies (Australian and International) are considered for inclusion in the review. Both quantitative and qualitative studies were included in the review in order to build a picture of the breadth and balance of the evidence base on home modifications. Studies that were considered purely theoretical i.e. there was no experimental component and or were solely expert opinion were excluded from the review. Table 3 outlines the inclusion and exclusion criteria applied and all included literature was required to meet all five of the inclusion criteria listed in the left hand column.

Table 3 Criteria for including or excluding home modification studies.

<i>Included</i>	<i>Excluded</i>	<i>Example of exclusions where relevant</i>
<b>Dates</b> 1990-2014	Pre 1990	
<b>Research origin</b> All countries of origin	N/A	
<b>Participants</b> All participant sub samples	N/A	
<b>Study Types</b> Quantitative and qualitative study types	Theoretical and expert opinion	(Gitlin, 1998; Ling et al., 2008; Verbrugge & Jette, 1994)
<b>Intervention type</b> Within agreed definition of home modifications (described in Figure 1 on page15)	Outside agreed definition of home modifications (described in Figure 1 on page15)	(Pardessus et al., 2002)



Study setting	Institutional setting	
Community setting		
Effect measured		(Gerson, Camargo Jr, & Wilber, 2005; Johansson, Lilja, Petersson, & Borell, 2007a; Pynoos & Nishita, 2003; Unwin, Andrews, Andrews, & Hanson, 2009)
Direct measures of care, health and well being	Program/ health service usage/uptake/prevalence.	
Home modifications provided within the study design.	Advice/information on home modifications only	

The review did not set any exclusion boundaries around participants of sub-sample populations. The participants in included studies were predominantly older, community dwelling adults (71%) however other studies investigate home modifications on more specific sub-sample populations such as carers (Calkins & Namazi, 1991), dementia patients (Gitlin, Corcoran, Winter, Boyce, & Hauck, 2001), or particular diagnoses such as children with cerebral palsy or people with a multiple sclerosis diagnosis (Ostensjo, Carlberg, & Vollestad, 2005; Salminen, Kanelisto, & Karhula, 2014). Figure 6 shows the percentage spread of all sub sample populations in the included studies.

The included study designs were graded according to five design typologies shown in Table 4. Further, all home modifications were required to be provided in a community setting, and all studies in an institutional setting were excluded. Studies investigating both multi and single factor intervention were included as long as there was evidence that the intervention included an aspect of home modifications as defined in Figure 1.

## Types of effect measures

Effect measures included any measure that could be interpreted as a direct result of home modification intervention. Effects were considered to be a direct measure of care, health or mental and physical illness as well as general measures of well-being and quality of life. Effects such as home modification program service use or prevalence were excluded as this is not considered a direct measure of health or well-being effect. Similarly any process evaluations or research measuring “advice about modifications” was also excluded on the basis that it does not measure a direct effect of home modifications.

The coding undertaken enabled multiple effects to be recorded for each study. As a result, it became apparent during the full text review process that a majority of included studies were reporting on multiple effects following home modifications. Therefore effects were graded as primary and secondary depending on the main line of investigation. For example, (Sheffield, Smith, & Becker, 2013) reported on the measured effects of both improved safety (primary effect) and also reduced fear of falling (secondary effect).

## Assessment of methodological quality

An assessment strategy was developed based on the approaches documented in prior, related systematic reviews such as Bridge, Flatau, Whelan, Wood, & Yates (2003). The review methodology employed is an inclusive one, because the main objective is to detect all evidence of a specific intervention across the broadest research base. Therefore it was decided that both quantitative and qualitative interventions be built in to the inclusion criteria.

Evidence hierarchies reflect the relative authority of various types of [research](#) where there is broad agreement on the relative strength of the principal types of research, or epidemiological studies. [Randomized controlled trials](#) (RCTs) rank above [observational studies](#), while expert opinion and anecdotal experience are ranked at the bottom. A tabulated matrix of potentially appropriate studies and reviews of existing literature was checked by both reviewers. The final results were graded in terms of five methodologies outlined in Table 4.

Table 4: Grading of the evidence

Level	Research Design	Explanation	Examples
0	Systematic Review <sup>2</sup>		
1	Random Control Trial <sup>3</sup>		
2	Quasi Experimental <sup>4</sup>	Non-random still has control?  No random assigning of control therefore non-random.  Non-random  No control non-random	Observational  Cohort studies  Pre/post test  Cross sectional  Longitudinal  Case-control
3	Secondary Data analyses <sup>5</sup>	Uses secondary data	

<sup>2</sup> *Systematic Review* is a critical evaluation, where the researchers use an organised method of locating, assembling, and evaluating published research on a particular topic using a set of specific inclusion and exclusion criteria.

<sup>3</sup> *Randomised Controlled Trial (RCT)* assigns participants into an experimental group or a control group, thus the only expected difference between the control and experimental groups is the effect being studied.

<sup>4</sup> *Quasi-experimental* studies take on many forms, but may best be defined as lacking key components of a true RCT experiment.

<sup>5</sup> *Secondary data*, is raw data that is collected by someone other than the researcher and may include censuses, organisational records etc..

4	Qualitative <sup>6</sup>	Exploratory	in-depth qualitative interviews; participant and non-participant observation; focus groups; document analyses; case studies
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## Search Methods

A comprehensive literature search was conducted for all original research articles about home modifications published between 1990 and 2014 using a selection of electronic databases (see Table 5 Electronic Databases searched (1990 – 2014)). The initial search was conducted in July 2014 with subsequent searches in September, October and December 2014.

Table 5 Electronic Databases searched (1990 – 2014)

<i>Electronic Database</i>
The Cochrane Central Register of Controlled Trials
PubMed
MEDLINE
Medline in process and non –indexed citations
EMBASE
CINAHL
PsycINFO
Web of Science
Applied Social Sciences Index and Abstracts
Scopus
Conference proceedings citations index

## Searching other resources

In addition to the electronic databases shown in Table 5 Electronic Databases searched (1990 – 2014), reference lists of relevant studies were reviewed for further studies relevant to the review as illustrated in Figure 2 Study flow diagram based on the ‘PRISMA Statement for reporting Systematic Reviews’, illustrating the selection, inclusion and exclusion process of original articles.

Searches used the term “home modification” and its associated synonyms where possible. However, applying additional search terms such as “environmental adaptation” or “residential modifications” resulted in many unrelated studies in unrelated research areas, see Table 6 Literature search terminology following.

<sup>6</sup> *Qualitative* refers to research designed to gain an understanding of underlying reasons, opinions, and motivations.

Table 6 Literature search terminology

<i>Search Term</i>	<i>Used</i>	<i>Reason</i>
"home modification"	Yes for all searches	Home modification as a subject (exact) was effective in the library and electronic catalogues and resulted in relevant articles which also used alternative terms for home modifications.
"environmental adaptation"	For Google and grey literature search only	Was more about the environment and animals adapting to their environment.
"residential modifications"	For Google and grey literature search only	Came up with a lot about drug rehabilitation programs

## Data collection and Analysis

Two authors to ensure that each study met all the inclusion criteria screened the results of the searches independently. The initial screening was based on the study title and its associated abstract. Where there was any ambiguity about inclusion the full reference was obtained to allow more detailed scrutiny of the full text paper. Both review authors met regularly to discuss studies where there was disagreement over the inclusion or exclusion of a particular study.

All search citations were stored in EndNote © (bibliographic software). The reported findings from each study were then extracted and entered into an Excel database matrix. The data extraction fields included country, sub sample participant description, study size, study type, primary and secondary effects of the intervention etc...

Quantitative studies within the review comprised 81% of final included studies. The quantitative study designs included were broad in methodological design and ranged from systematic review, random controlled trial, quasi-experimental, and secondary data analysis. However it is important to note that quantitative data was not synthesised independently of qualitative data because a number of studies were mixed methods in nature, meaning that they had both quantitative and qualitative elements. The objective of this review was to isolate and better understand the full breadth of home modification research and its associated effects.

While the debate about the values and comparative potential of qualitative and quantitative study remains unresolved, qualitative studies were included in this review and independently valued as contributing to the evidence base. Qualitative research is a means of understanding phenomena (such as home modification effects) in terms of the meanings people bring to them (Denzin, 1994) and has an equally important role to play in exploring and answering questions not easily evaluated in quantitative study designs. Qualitative data can provide support or reasoning for quantitative outcomes and can identify peoples' priorities or concerns. Qualitative research can also address research questions directly and stand alone, informing evidence-based practice independently of quantitative method outcomes. Cochrane identifies four ways that

qualitative research can contribute to health policy and practice (Higgins & Green, 2008):

1. **Informing** reviews by using evidence from qualitative research to help define and refine the question.
2. **Enhancing** reviews by synthesizing evidence from qualitative research identified whilst looking for evidence of effectiveness.
3. **Extending** reviews by undertaking a search and synthesis specifically of evidence from qualitative studies to address questions directly related to the effectiveness review.
4. **Supplementing** reviews by synthesizing qualitative evidence to address questions on aspects other than effectiveness.

## Data synthesis

As anticipated there were extreme levels of heterogeneity within the identified studies and conventional methods of meta-analysis were not considered an appropriate synthesis approach in this instance. For this review a narrative synthesis of the studies is undertaken to describe the overall evidence base on home modifications. In the first full text filtering of the studies, a natural clustering of effects within the included studies emerged. This meant that the 77 studies could be clustered in the themes and coded according to study design type, and whether the study found evidence of a positive relationship with the effect, or found no relations with the effect being investigated.

The narrative synthesis was conducted in line with the guide published by Popay et al. (2006). According to Popay, the process of a narrative synthesis involves four steps;

1. Development of a theoretical model of how the intervention works, why and for whom.
2. Develop a preliminary synthesis
3. Explore relationships in the data
4. Assess the robustness of the synthesis product.

Each of these steps was undertaken. To illustrate the synthesis, the final data from each study was tabulated and graphed to provide a visual summary of the data using a column graph included in Figure 9 on page 32.

The qualitative research we included encompassed a range of philosophies, research designs and specific techniques including in-depth qualitative interviews; participant and non-participant observation; focus groups; document analyses; and a number of other methods of data collection (Pope, Ziebland, & Mays, 2006).

## Results

Following the searches, 397 citations were identified. Duplicates were found and removed across databases and a first review of titles and abstract led to 299 studies being excluded. Following this first filtering phase, a second filtering phase involving

reference list checks and web search which, revealed a further 57 potentially relevant studies which were then also filtered using the same criteria. After this process a total of 131 studies were put through a full text screening process. This resulted in 55 studies being excluded based on the exclusion criteria explained in Table 3 on page16.

A flow chart reports the numbers of citations excluded on the basis of title and abstract, and those citations screened for full text (Figure 2 Study flow diagram based on the 'PRISMA Statement for reporting Systematic Reviews', illustrating the selection, inclusion and exclusion process of original articles.

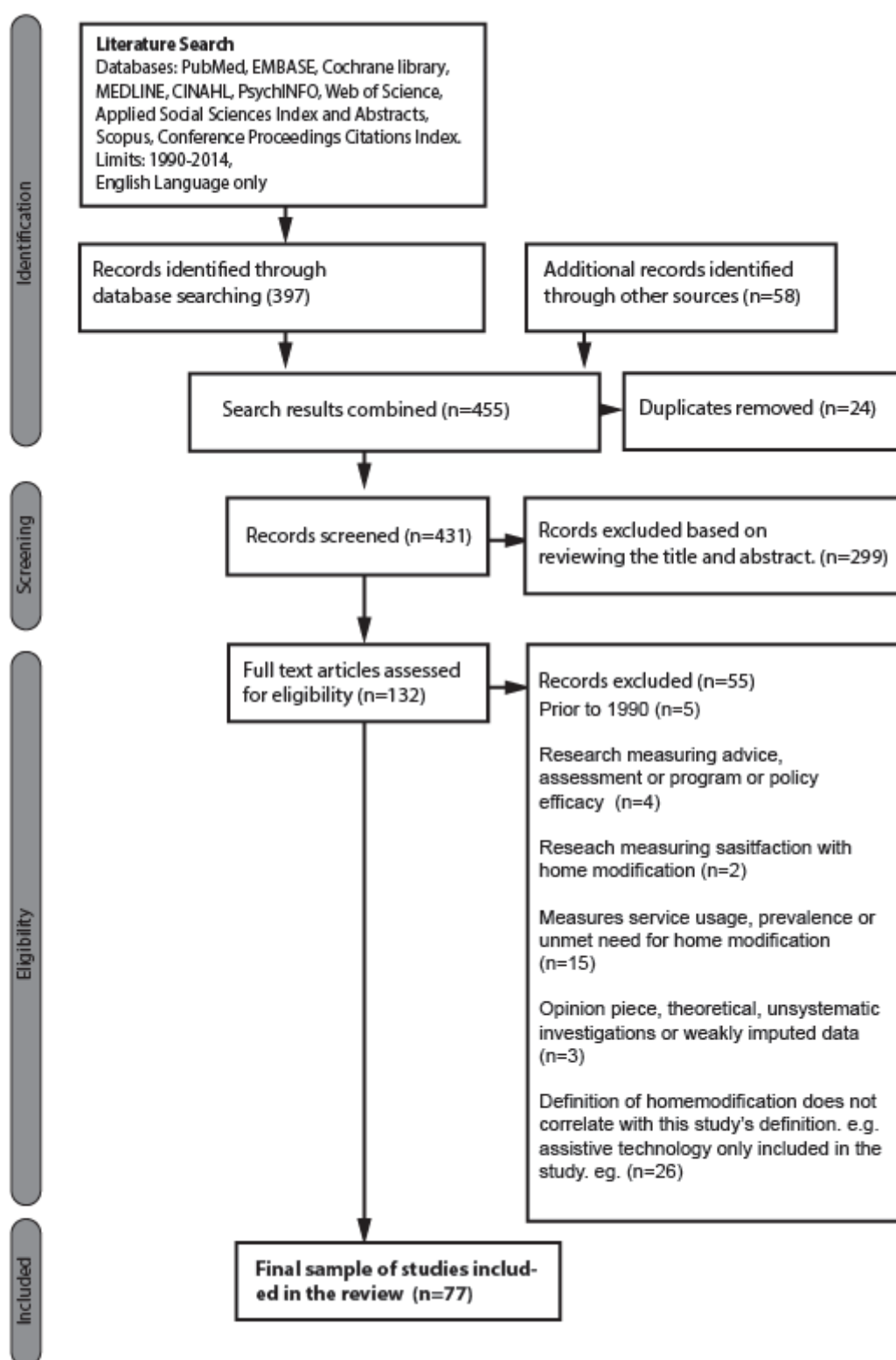


Figure 2 Study flow diagram based on the 'PRISMA Statement for reporting Systematic Reviews', illustrating the selection, inclusion and exclusion process of original articles.

## Included studies

Seventy seven (77) studies in total identified as meeting the inclusion criteria were systematically reviewed in order to determine the evidence base of the effects of home modification interventions. The tabulated summary of main findings is provided in Appendix 2. The meta-analysis following examines the results in terms of publication year, nationality, sub-sample population and study methodologies.

## Nationality

Inclusion criteria restricted the review to only English language papers. Despite this many studies were included from countries where English is not the primary spoken language. Figure 3 below illustrates the breakdown of studies mapped by global location.



Figure 3 Included studies mapped by global location. Total studies (n=77)

The majority of the literature originates from the United States (US) followed by the United Kingdom (UK) which is unsurprising given that both countries share similar social policies and structures and the social care context has been shaped by post-colonial and post-world war shared thinking and values. Indeed, both the US and the UK have a well-established history of government supported or provided housing and health care interventions (Bridge et al., (2003). Hence, studies from the UK and US are also most likely to be of greater transferability in terms of social, cultural and economic similarities and assumptions. Further, larger population numbers and earlier onset population ageing dynamics relative to Australia may account for more research activity



in this domain (acknowledging that other countries may have great populations but may not publish in English).

Figure 4 below shows the included studies country of origin by percentage. Australian studies accounts for 11% of those included. The combined European Union accounts for 33% of the total included studies. The US and Canada combined account for nearly half (45%) of the included studies.

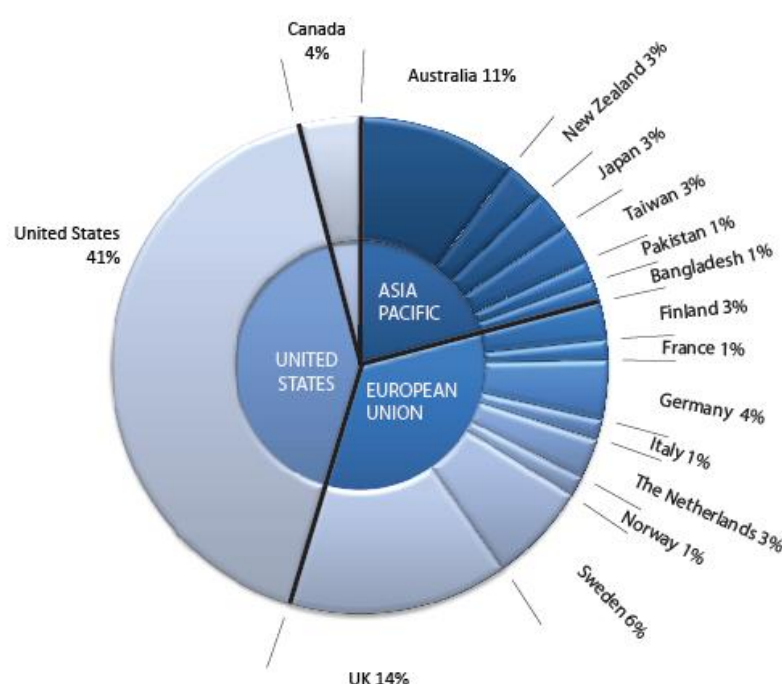
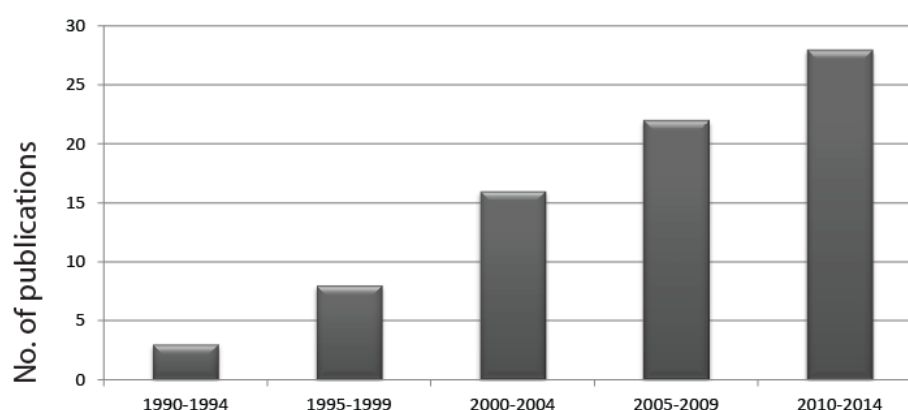


Figure 4 Included studies by country of origin

## Publication year

Analyses of the included studies by year of publication reveal a steady (almost linear) increase in studies into home modification effects since 1990 (Figure 5). This reflects changes in the way housing is perceived and an increasing acknowledgement of the role housing plays in health maintenance, plus an increasing awareness of the need for alternative interventions to support Australia's ageing populations (Carnemolla & Bridge, 2011).



Publication in 5 year intervals.

Figure 5 Included studies mapped by publication year intervals of five years from 1990 – 2014.

## Sub-population sample

Of the 77 studies reviewed, 71% investigate home modifications in regard to a sample of older, community dwelling adults (Figure 6). This makes sense, as home modifications are by their nature provided in a community setting, and when it is considered that 34% of the included studies are falls prevention focused, older people living at home is one of the sub-groups of the population most vulnerable to falls and fall injuries (Lord, Sherrington, Menz, & Close, 2007).

Nevertheless, there is a lack of consistency among studies as to exactly what demographic group constitutes older people, with variations in included literature as wide-ranging as 60+ years (Stark, Landsbaum, Palmer, Somerville, & Morris, 2009), 65+ years (Close et al., 1999), 70+ years (Palvanen et al., 2014; Tinetti et al., 1994) and 73+ years (Naik & Gill, 2005). Given that there are no established age cut-offs in age-related research and no consensus on a guiding theoretical paradigm, this is not an unusual finding (Hedge & Borman, 2012).

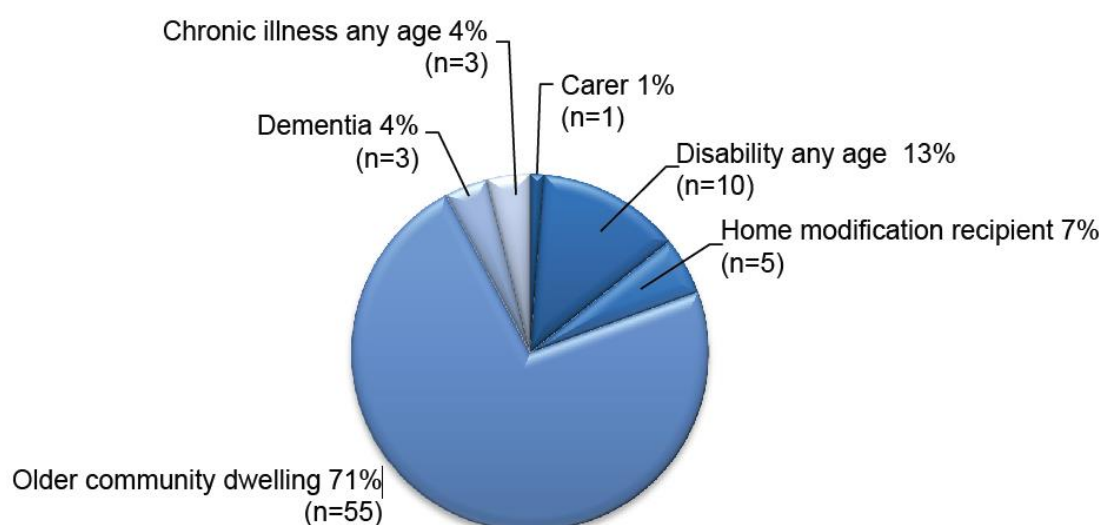


Figure 6: Percentage spread of sub-sample populations of included studies

## Home modifications and multifactorial interventions.

Of the 77 studies included, 13 studies were categorised as a single factor intervention of home modifications. The remaining 64 were all multi-factorial interventions. A Table 7 below lists the thirteen (13) single-factor home modification studies included in this review along with date of publication.

Table 7: Included studies with single factor home modification as an intervention (13 out of 77)

<i>References: Single factor home modification study</i>	<i>Year Published</i>	<i>Methodological grade</i>
Ahn & Hegde,	2011	2
Berg, Hines, & Allen,	2002	2
Heywood	2001	4
Heywood	2004	4
Hwang, Cummings, Sixsmith, & Sixsmith,	2011	3
Corea, Lutzky, & Alexih,	2000	3
Keall et al.	2014	1
Liu & Lapane	2009	3
Mitoku & Shimanouchi	2014	2
Petersson, Lilja, & Borell,	2012	4
Petersson, Lilja, Hammel, & Kottorp,	2008	2
Tanner, Tilse, & De Jonge,	2008	4
Mitoku & Shimanouchi,	2014	2

## Evidence gathering outcomes

In the review of the five methods employed that met the study inclusion criteria, the most experimental (systematic review and RCT) accounted for a third of the findings (25 of the 77 studies equalled 33%). Of this one-third, six studies were systematic

reviews (Chang et al., 2004; Chase et al., 2012; Clemson et al., 2008; Tse, 2005; Turner et al., 2011; Wahl et al., 2009).

Figure 7 illustrates how the remaining study categories quasi-experimental accounted for just under a third (30%). with secondary data analysis 15% and qualitative data 19% represented the remainder.

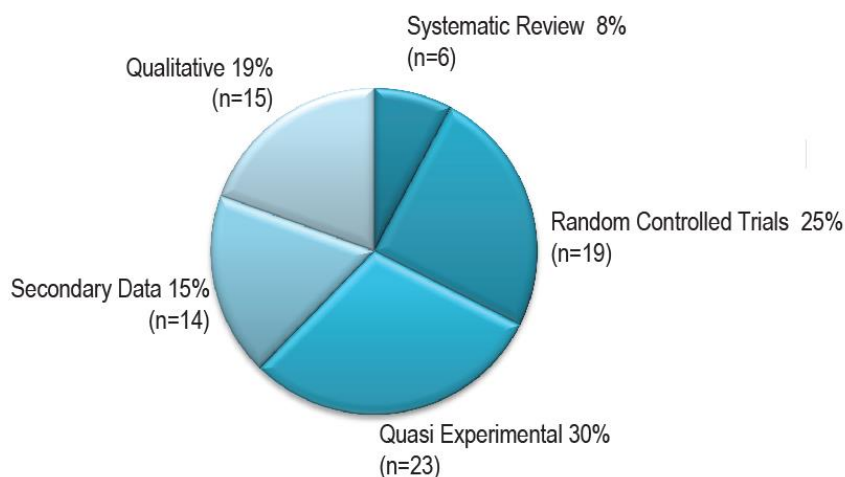


Figure 7 Spread of methodological category by percentage

The following paragraphs examine the included studies in terms of the effects as a result of their methodological category.

## RCT Studies

Of the 19 RCT studies, 9 investigate the effects of home modifications on falls, while 5 are clustered around the theme of functional effects or effect on Activities of Daily Living performance improvements. This is unsurprising as toilet modification, provision of grab rails and or automatic wash functions in a toilet may make it possible for an individual to regain autonomy and independence in toileting with concurrent changes in perceived and expressed safety and comfort and this has been well documented in the wellness, restorative and wellbeing literature. For instance, two of the included RCT studies found positive evidence of the effects of home modification on physical health and wellbeing

However, a minority of the RCT trials, two (2), cited a null or negative relationship for home modification effect in fall interventions for older persons. One RCT found no relationship in terms of an effect on functional improvement whilst the other cited no evidence of economic effectiveness. Given that both studies were examining multifactorial interventions and that definitions and assumptions were to some extent unclear this apparent disagreement within the body of the literature may be the result of physical, social or cultural confounders or other limitations and biases.

The sub sample population investigated with the majority of RCT's was mainly older, community dwelling adults (14). However there were four (4) studies, which

investigated people living with a disability of any age, and one (1) study which investigated home modification for people with dementia.

## Quasi Experimental

Of the 23 quasi experimental studies in the review, the majority supported the effect of functional improvement following home modifications (Gitlin, Miller, & Boyce, 1999; Gitlin, Winter, et al., 2006; Hammel, Lai, & Heller, 2002; Petersson, Kottorp, Bergstrom, & Lilja, 2009; Stark, 2008; Stark et al., 2009). Of the quasi experimental studies that found negative or no evidence of effect relationships, two investigated falls reduction (Korp, Taylor, & Nelson, 2012; Peel, Steinberg, & Williams, 2000) and one ageing in place. Two quasi-experimental studies support home modifications ability to increase longevity (Gitlin et al., 2009; Jutkowitz, Gitlin, Pizzi, Lee, & Dennis, 2011).

## Secondary Data analysis

Of the 14 studies using secondary data, 11 were multifactorial in nature; in the remainder the home modification definition was often unclear. Appendix 1 outlines the range of instrumentation sourced in the 14 studies of this type.

## Qualitative

The qualitative data on home modifications is overwhelmingly positive, with only two studies reporting little or no evidence of a positive relationship with home modifications. Qualitative evidence was found to support all themes including; falls related research (Adams & Grisbrooke, 1998), function (Pettersson, Löfqvist, & Malmgren Fänge, 2012), health and wellbeing (Andrich, Ferrario, & Moi, 1998), ageing (Tanner, Tilse, & De Jonge, 2008), economic (Heywood & Turner, 2007), caregiving (Calkins & Namazi, 1991) and social participation (Randström, Asplund, & Svedlund, 2012).

Of the studies finding no relationship, Petersson, Lilja, & Borell (2012) reported no evidence of a relationship between home modifications and improved safety, and Anderson & Wiener (2013) reported little evidence of home modifications' ability to substitute for formal caregiving.

## Where is the research being published

The 77 studies included have been published broadly, more predominantly across the health sector with only six (6) published in housing specific journals. The two housing journals that published the home modification articles are *The Journal of Housing for the Elderly* and *Housing Studies*.

Publications in health sector journals and books span diverse specialty areas including medical, occupational therapy, nursing rehabilitation, public health, gerontology, geriatrics and rehabilitation. The graph following, shows where the included home modification research was published (Figure 8).

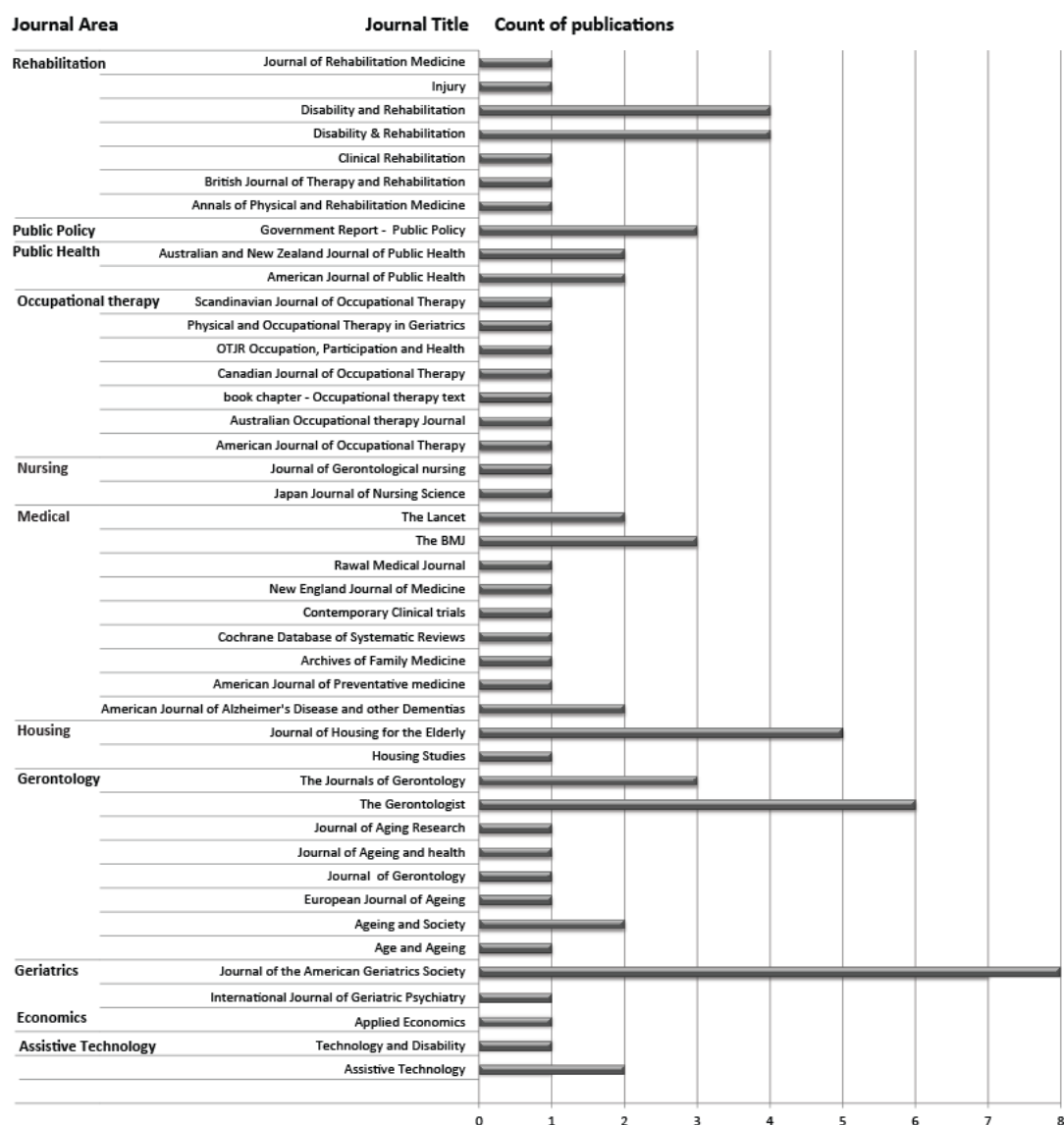


Figure 8: Where home modification research is being published.

## Thematic analysis of the evidence

The effects reported in the 77 studies were coded and grouped into thematic clusters. Twenty (20) different individual effects were identified in the studies, and these were clustered into 7 effects themes. The following table shows the breadth of effects researched following home modification intervention, how each effect was clustered into a theme and the prevalence (count) of each effect being measured across the included studies. A stacked-column chart of the included studies graphically displays attributes of research type, effect theme, and whether evidence of a relationship was found (Figure 9).

Table 8 Individual effect, thematic clustering and count of effects indicating prevalence in the body of reviewed evidence

<i>Theme cluster</i>	<i>Effects included in theme cluster</i>	<i>Number of times this effect was reported and investigated in the reviewed studies</i>
Falls related evidence	Fall or injury accident reduction	21
	Reduced fear of falling/increased confidence	9
	Improved safety	4
Improved function/self-care and independence	Improved function outcome/reduced ADL difficulty	17
	Improved self-care / self-efficacy	5
	Independence autonomy	3
	Supports mobility	1
Physical health and well being	Quality of life well being	7
	Reduced pain	3
	Longevity/ reduced mortality	2
	Decreased breathlessness	1
	Supports rehabilitation	1
Caregiving	Supports/ supplements caregiving in general	7
	Substitutes for informal care	2
	Offsets institutional care	1
	Substitutes for formal care	1
Economic effectiveness	Economic effectiveness	7
Ageing process	Supports ageing in place	6
	Reduces progression of frailty	1
Social Participation	Improves social participation	5

The table above gives an indication of the more dense areas in the evidence base, which are overwhelmingly the study of the effect of home modification on falls reduction and functional performance. Figure 9 on page 32 grades the clusters and counts not only for the effects theme, but methodological quality and type.

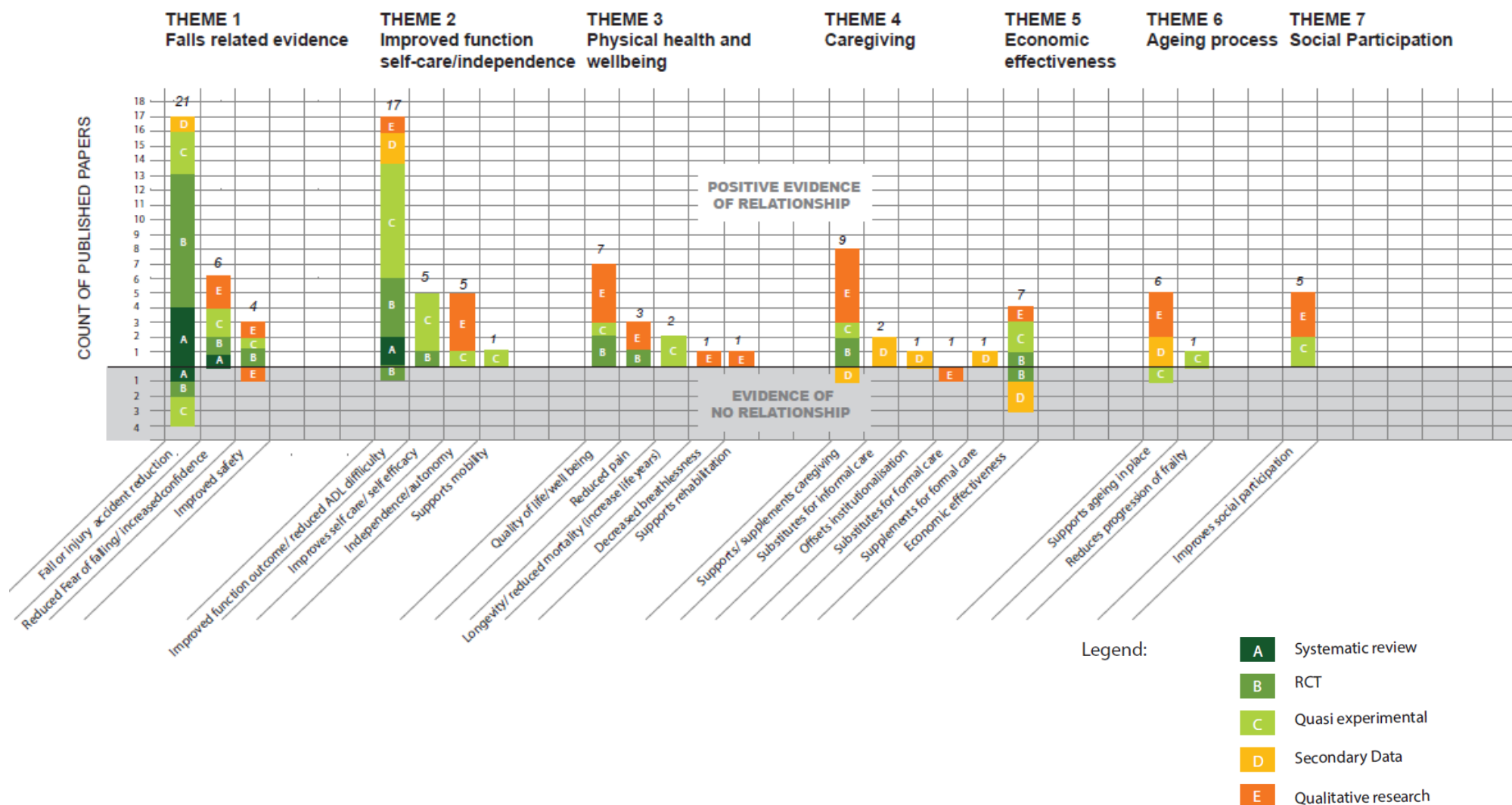


Figure 9: Mapped effects of home modification research. Graded according to methodology type, effect theme and positive or no evidence of relationship.



It should be noted that any one study might report more than one effect; therefore it is possible for a single study to be included in more than one effect theme. The diagram enables a visual summary of the broad body of evidence according to study category, effect type, and effect direction. Evidence found to positively report the effect following home modification are located above the horizon line in the graph; whereas studies that reported negative or no evidence of the relationship between the effect and home modification were placed below the horizon line in the graph.

## Theme 1: Falls related evidence

Effect evidence in the theme of falls prevention is the most prevalent in the included data. All of the six systematic reviews included in the study investigate falls prevention in some way. Five of the systematic reviews found positive evidence that a home modification intervention can reduce likelihood of a fall or injury occurring (Chang et al., 2004; Clemson et al., 2008; Tse, 2005; Turner et al., 2011). However the review by Wahl et al. (2009) found no evidence of effect on fall prevention following home modification intervention. One of the reviews found that home modifications have a positive effect by improving confidence and reducing fear of falling (Chase et al., 2012).

All of these Systematic reviews assess multifactorial interventions, so what can be inferred from these results is that the evidence is strong that multifactorial interventions which include home modifications can reduce the likelihood of falls and injury, reduce fear of falling and improve confidence of those at risk of falls. Improvements in confidence and reduction of fear are also related to the well-being effects of home modifications and are discussed in a subsequent section.

Of the 19 RCTs in the review, over half (53%) investigate and report effects in the area of fall or injury prevention (Campbell et al., 2005; Close et al., 1999; Cumming et al., 1999; Day et al., 2002; Johnson, 2012; Kamei et al., 2014; Keall et al., 2014; Nikolaus & Bach, 2003; Palvanen et al., 2014; Pighills, Torgerson, Sheldon, Drummond, & Bland, 2011) with only one RCT reporting a negative effect (Stevens, Holman, Bennett, & De Klerk, 2001).

The prevalence of the highest quality systematic evidence (Systematic reviews and RCT) in the area of falls prevention is unsurprising. Research in medical health services continues to report on the cost burden that falls at home are on public health systems (Carroll, Slattum, & Cox, 2005; Heinrich, Rapp, Rissmann, Becker, & König, 2010; Johnson, 2012) .

The quasi-experimental studies in the falls cluster report predominantly positive results. Of the positive reports of effects, the populations being studied vary significantly. For instance, Guo, Tsai, Liao, Tu, & Huang (2013), report on a subsample of cognitively impaired recipients. Berg, Hines, & Allen (2002) examine falls by people in wheelchairs and Plautz, Beck, Selmar, & Radetsky (1995) look more generally into older people living at home. Of the two quasi experimental studies that found little or no link between home modifications and falls reduction, Peel et al. (2000) investigated older people,

self-reported falls and multifactorial intervention. Korp et al.(2012) also did not find evidence of an effect relationship and investigated a combination of assistive technology and home modifications as they related to self-reported falls and bathing activities.

There was only one study that analysed secondary data in the falls cluster (Braubach & Power, 2011). This study examined results from a European housing and health survey (LARES) and found that home modifications reduced the likelihood of falls.

The qualitative research reveals how home modifications are valued by recipients including broader studies of general home modifications (Heywood, 2004) and more specific investigations into particular home modifications such as level access showers (Adams & Grisbrooke, 1998). For instance, Salminen et al. (2014) reported that 56% of their sub-sample (people with diagnosis of Multiple Sclerosis) felt home modifications were helpful in increasing safety as part of their rehabilitation process. Nevertheless, there one study cited no direct relationship between feeling safer and home modifications (Petersson et al., 2012).

## **Theme 2: Improved function/ self-care and independence**

There were two systematic reviews conducted that reported on this effect (Chase et al., 2012; Wahl et al., 2009) and both found positive evidence of a relationship between home modifications and increase in function (reduced ADL difficulty).

Of the five RCTs that investigated functional effects, four report positive results (Gitlin et al., 2001; Mann, Ottenbacher, Fraas, Tomita, & Granger, 1999; Szanton et al., 2014; Wilson, Mitchell, Kemp, Adkins, & Mann, 2009). Sheffield (2013) found no link between functional status and home modifications but did find evidence of improvements in fear of falling and safety. Szanton et al. (2014) also found evidence of improvements to self-care ability following home modifications.

All of the fifteen (15) quasi-experimental studies that reported within the theme improved function found a positive relationship. It was more common for studies to focus on functional improvement itself, (Gitlin, Hauck, Winter, Dennis, & Schulz, 2006; Gitlin et al., 1999; Hammel et al., 2002; Petersson, Kottorp, Bergström, & Lilja, 2009; Stark, 2008; Stark et al., 2009). However four (4) quasi experimental studies reported on related effects of self-care and self-efficacy improvements (Gitlin, Hauck, et al., 2006; Gitlin et al., 1999; Ostensjo et al., 2005; Petersson, Lilja, Hammel, & Kottorp, 2008)., and one on improvements in independence (Gignac, Cott, & Badley, 2000). Ostensjo et al. (2005) also reported on the effect of increased mobility following home modifications and was the only included study to do so, indicating a need of more research in this particular effect area.

The secondary data analyses included in this theme are all related to measurement of function (Liu & Lapane, 2009) and (Stineman, Ross, Maislin, & Gray, 2007). However most of the qualitative work in this theme relates to independence and autonomy (Andrich et al., 1998; Heywood, Oldman, & Means, 2001; Pettersson et al., 2012; Tanner et al., 2008).

### **Theme 3: Physical health and wellbeing**

There are no systematic reviews represented in this theme and all represented research reports a positive relationship of the effect to home modifications. There are no negative instances of studies in this theme. In the effect of quality of life and wellbeing, two RCTs directly measure quality of life and report positive relationship with home modifications (Ahmad, Shakil-ur-Rehman, & Sibtain, 2013; Lin, Wolf, Hwang, Gong, & Chen, 2007).

In terms of physical health there are a number of effects reported in less systematic, lower quality studies, which require further research to develop the evidence base. These include the ability for home modifications to decrease breathlessness, reduce mortality and reduce pain.

There is considerable qualitative research included in this cluster with four studies exploring quality of life, two exploring reduction of pain effect and a further two exploring breathlessness and rehabilitation support.

### **Theme 4: Caregiving**

Most of the research studies in this theme investigate support for caregiving in general (7 studies) however the remaining studies investigate specific care types such as informal (Agree, Freedman, Cornman, Wolf, & Marcotte, 2005; Anderson & Wiener, 2013), formal (Anderson & Wiener, 2013) and the offsetting of institutional care (Newman, Struyk, Wright, & Rice, 1990).

There appears to be a lack of high quality evidence in the study of care effects of home modifications, with only two RCTs (Gitlin et al., 2001; Mann et al., 1999) and one quasi experimental study (Naik & Gill, 2005) included in the entire theme.

Evidence in the specific types of care and how they supplement and substitute for one another is particularly weak. There is only qualitative evidence for the substitution of formal care (and this reports a negative effect) and the remaining data is secondary analysis. This lack of experimental data is surprising given the potential for interventions such as home modifications to substitute for caregiving.

### **Theme 5: Economic effectiveness**

The studies in economic effectiveness are important because they value home modifications in terms of other interventions and inform on a variety of effects including how home modifications substitute for care, reduce falls or improve well-being.

There are seven (7) included studies that investigate the economic effectiveness of home modifications with three (3) studies reporting negative cost effectiveness of home modifications (Corea, Lutzky, & Alecxih, 2000; Salkeld et al., 2000; Stearns et al., 2000). The studies that report on a positive relationship between cost effectiveness and home modifications include Jutkowitz et al. (2011) Lansley, McCreddie, & Tinker (2004), Mann et al. (1999) and Heywood (2007). To date, there have been no cost

utility studies or cost effectiveness studies conducted on single factor home modifications.

## Theme 6: Ageing process

There is also a lack of strong experimental data in this cluster (no RCT or systematic review) with only one quasi-experimental study, and two secondary studies reporting on home modification's effect on ageing in place in general. The quasi-experimental study by Ahn & Hegde (2011) did not find a strong relationship between having home modifications and improved satisfaction with their home environment. The other quasi-experimental study by Mitoku & Shimanouchi (2014) reports positively on a relationship between home modifications and slower progression of frailty.

Two (2) secondary analysis studies report positively on ageing in place effects of home modifications (Hwang, Cummings, Sixsmith, & Sixsmith, 2011; Safran-Norton, 2010). There are a three (3) of qualitative studies included in this cluster; all report positive relationships with Tanner et al., (2008) reporting that modifications enhance the meaning of home. Renaut, Ogg, Petite, & Chamahian (2014) found more neutral results reporting that a person's individual experience, not home modifications will determine how people adapt to home. Pettersson et al. (2012) results were positive regarding the effect of ageing in place for home modification clients in general and Van Hoof, Kort, Van Waarde, & Blom (2010) reported positively for people with Alzheimer's.

## Theme 7: Social Participation

This cluster includes a single effect, social participation. All the evidence is positive with two quasi-experimental studies (Ostensjo et al., 2005; Vik, Nygard, & Lilja, 2007) and three qualitative studies (Heywood et al., 2001; Pettersson et al., 2012; Randström et al., 2012). Given the value placed on social models of housing and the value of participation by the WHO in Active Ageing, there is a need for further exploration of this effect (World Health Organisation AgeingLife Course Unit, 2008; Cannuscio, Block, & Kawachi, 2003; Noreau et al., 2004).

# Conclusions

## Implications for practice

Knowing who will benefit from a home modification intervention as well as how and why is a critical reasoning process for best practice decisions in home modification installations. Therefore although this review is an important step in understanding the full spectrum of home modification effects, there is a considerable way to go before the evidence base establishes and measures the full range of effects following home modifications. For example, the review reveals that there is a need for further research into the *social participation effect* of home modification.

Of significance to community care practitioners is the potential for home modifications to substitute and support community caregiving, both formal and informal. The cluster

of research effects in the caregiving theme suggest that the home modifications/care relationship is positive and the lower number of studies covering this mean that further research is needed.

## Implications for research

The increasing quantity of available research evidence since 1990 (Figure 5 on page 26) is an encouraging trend towards improving the understanding of how home modifications effect caregiving, safety, health, wellbeing and social participation. However one of the main gaps to overcome in the evidence base is the lack of studies measuring home modifications as a single factor intervention. The prevalence of multifactorial interventions has meant that in many studies the true effect of home modifications simply cannot be determined.

Equally confounding for the continued development of a stronger evidence base is a blurred or absent definition of what home modifications are and what they are not. Home modifications are not assistive technology, and they are not the act of moving a rug across a room. Home modifications are integral changes to the house structure itself, they are fixed to the house frame or skin in some way. This ensures their relevance as a housing intervention and they should be measured and discussed as such.

For the available evidence in this review it is clear that there are considerable gaps in knowledge in relation to home modification. The prevalence of multifactorial studies coupled with the widely differing definitions of home modifications, mean that it is unavoidable for this review to be synthesising some data that lies outside the agreed definition of home modifications (stated on page 15 in Figure 1). It is therefore important that any calls for further research on home modifications emphasize the importance of a clear definition of home modifications and a single factor intervention for measurement.

This review allows for the identification of thematic gaps in the evidence base. Falls reduction research and Activities of Daily Living (ADL) or function related effects are strongly supported by high quality studies. Alternately, effects on physical health and wellbeing, caregiving, economic effectiveness, ageing process and social participation are less well evidenced at this point in time.

## Implications for policy

As the evidence base continues to build, this review reaffirms the importance of continued exploration of how home modification impacts non-shelter or health related effects. Understanding the strength of effects in multiple themes helps policy makers assess the true value of a home modification intervention, value to both the recipient and value to health support providers.

As policy makers in health, aged care and housing tackle the complex problems associated with ageing populations and limited health budgets, understanding the metrics of how home modifications substitute or support for caregiving and improve

well-being are critical to informing policy decision making. The multi-disciplinary nature of the home modification and health relationship reaffirms the importance of broader focus in policy making beyond the immediate policy domain.

The reviewed research suggests an overall positive body of evidence supporting home modifications as an intervention to benefit community dwelling older people and those living with a disability.

## Appendix 1: Secondary Instruments

<i>Instrument Name</i>	<i>Acronym</i>	<i>N</i>	<i>Sample</i>	<i>Country</i>
<b>National Health and Ageing Trends Study</b>	NHATS	6578	Community dwelling Americans over 65+	US
<b>National Alliance for Caregiving and the American Association of Retired Persons caregiver survey dataset.</b>	NAC/AARP	737	This study is based on a national survey of 6,139 adults in the U.S., from which 1,247 caregivers were identified. <sup>3</sup> Caregivers are defined as 18 years of age or older living in the U.S., and providing one or more ADLs or IADLs for someone 18 years of age or older. The 1,247 caregiver interviews include a total of approximately 200 African-American, 200 Hispanic, and 200 Asian-American caregivers obtained through over-sampling. Interviewing was conducted from September 5 through December 22, 2003.	US
<b>National Long Term Care Survey (America)</b>	NLTCS	2004	The National Long-Term Care Survey (NLTCS) has completed six waves, nominally at five-year intervals, 1982, 1984, 1989, 1994, 1999, and 2004. The NLTCS is a nationally-representative sample both of the community and of institutionalized populations and is longitudinal in that sample persons join the survey once they reach 65 years of age and stay in the survey until they either die or are lost to follow-up. At each wave, a screener questionnaire is administered to the sample which divides the sample into three parts: the non-disabled (frequently called screen-outs), the disabled but living in the community, and the disabled living in an institution. About 5,000 people die between waves and are replaced by a sample of about that size of people who have become age 65 since the prior wave.	US
<b>ENABLE-AGE</b>	ENABLE AGE	376	Home interviews with a sample of 1,918 very old people aged 75 to 89 years living alone in their own homes in Swedish, German, British, Hungarian and Latvian urban areas.	Europe
<b>Health and Retirement Survey (HRS)</b>	HRS	6585	Longitudinal panel study that surveys a representative sample of more than 26,000 Americans over the age of 50 every two years.	US
<b>Regional Office for Europe (the Large Analysis and Review of European housing and health Status [LARES] project)</b>	(sub group of ) LARES (WHO 2007) Cross sectional	8519	The LARES project was based on (a) an evidence review and (b) a pan-European survey on housing and health carried out in eight cities (Angers, Bonn, Bratislava, Budapest, Ferreira do Alentejo, Forli, Geneva, Vilnius). Results show that across Europe, a range of housing-related risks affect the health of large population parts – with some risk factors being relevant for 20-25% of the population.	WHO Europe
<b>Second Longitudinal Study on Ageing</b>	LSOA II	9447	The LSOA II is a prospective study with a nationally representative sample comprised of 9,447 civilian noninstitutionalized persons 70 years of age and over at the time of their SOA II interview. The LSOA II followed this cohort of older persons through two follow up interviews, conducted in 1997-98 and 1999-2000.	US
<b>National Survey of Self-Care and Aging (NSSCA), 1990-1994</b>	NSSCA	3485	A population-based, national longitudinal survey of noninstitutionalized Medicare beneficiaries.	US



<b>Asset and Health Dynamics Among the Oldest Old</b>	AHEAD	7447	Is an HRS auxiliary study, also known as Aging and Health in America. It centres on "data to address a broad range of scientific questions focused on the interplay of resources and late life health transitions." The initial sample consisted of 7,447 respondents aged 70+, including 2,548 aged 80 and over, plus 775 younger spouses. There are follow-ups every two years. Data, including errata, is available on-line.	US
<b>1997 National Hospital Ambulatory Medical Care Survey</b>	NHAMCS	94.9mil (?)	NHAMCS is part of the ambulatory care component of the National Health Care Survey that measures health care utilization across various types of providers. NHAMCS is a national probability survey of visits to hospital emergency and outpatient departments of non-Federal, short-stay, and general hospitals in the United States. Sample data were weighted to produce annual estimates.	US
<b>National Health Interview Survey- Disability Supplement</b>	NHIS -D	32788	The National Health Interview Survey (NHIS) has monitored the health of the nation since 1957. NHIS data on a broad range of health topics are collected through personal household interviews. For over 50 years, the U.S. Census Bureau has been the data collection agent for the National Health Interview Survey. Survey results have been instrumental in providing data to track health status, health care access, and progress toward achieving national health objectives.	US
<b>Canadian Health and Disability Survey (1983-4)</b>	CHDS	8895	<p>The Canadian Health and Disability Survey (CHDS) were conducted as a supplement to the Labour Force Survey in October 1983 and in June 1984. The project was sponsored by the Health Division of Statistics Canada in response to the recommendation by the Special Parliamentary Committee on the Disabled and the Handicapped, in 1981, to initiate a long-term programme to generate comprehensive data on disabled persons in Canada.</p> <p>Adult file variable categories include: screening &amp; follow-up, nature of disability, employment, education, transportation, accommodation, economic characteristics (income), derived variables, Sample weights, Geographic variables, Demographic variables, Socio-economic variables</p> <p>Child file variable categories include: screening, nature of disability, education, transportation, economic characteristics, Derived variables, Geographic variables, Demographic variables, Socio-economic variables, Sample weight, Health problems</p>	Canada



## Appendix 2: Tabulated overview of results

Table A: tabulated overview of results.

Author	Year	Country	Methodology code see page 18	Sub-sample/population	Primary Effect	Secondary Effect	Tertiary Effect
Adams & Grisbrooke	1998	UK	0	recipients of level access showers	decreased breathlessness	pain relief	feelings of safety
Agree Freedman Cornman Wolf & Marcotte	2005	US	0	older (65+)	substitution of informal care	supplement formal care	
Ahmad, Shakil-ur-Rehman, & Sibtain	2013	Pakistan	0	community dwelling adult wheelchair users 18+	quality of life		
Ahn & Hegde	2011	US	0	Older community Dwelling adult	perception of home and home modification - no link		
Allen	2005	UK	0	Cross-cultural community dwelling adult with chronic heart condition.	improved mental health well being		
Anderson & Wiener	2013	US	0	Older community Dwelling adult	substitution of informal care	substitution of formal care	
Andrich Ferrario Moi	1998	Italy	1	varied pathologies impairment	improved independence/reduce need for care/increase utility		
Berg, Hines, & Allen	2002	US	1	community dwelling adult wheelchair users 18+	fall reduction		
Braubach & Power	2011	Germany	1	older community Dwelling adult	reduces likelihood of accidents		
Calkins & Namazi	1991	US	1	Caregiver	Support Care giving		
Campbell et al	2005	New Zealand	1	older community dwelling adult with vision impairment	Falls reduced by home hazard management.		
Chang et al	2004	US	1	the performance of community-dwelling older adults	risk reduced most by multifactorial interventions that include environmental interventions		
Chase, Mann, Wasek, & Arbesman	2012	US	1	community dwelling older adult	decreased functional decline	decrease fear of falling	
Clarke	2014	Canada	1	older community dwelling adult	presence of stairs negatively impacts those who use a walker. Presence of ramps is positive for wheeled mobility. But those with no mobility device are more likely to report difficulties getting out the house despite having a ramp.		
Clemson, Mackenzie, Ballinger, Close, & Cumming	2008	Australia	1	n/a	significant fall reduction effects		
Close et al.	1999	UK	1	Older Emergency Department patient	Effectively reduces falls.		
Corea et al	2000	US	1	older community dwelling adult	Economic effectiveness due to falls reduction		
Cumming et al.	1999	Australia	1	Older Emergency Department patient	Injury/reduce falls		

Day et al	2002	Australia	1	older community dwelling adult	Falls reduced by home hazard management.		
Gignac, Cott, & Badley.)	2000	Canada	1	older community dwelling with OA or OP	home mods are an adaptation tool utilised to manage chronic illness and changes to independence		
Gitlin, Corcoran, Winter, Boyce, & Hauck,	2001	US	1	Dementia Patient	Support Care giving		
Gitlin, Hauck, Dennis, Winter, Hodgson, & Schinfeld	2009	US	1	older community dwelling adult	mortality/survivorship (survival)		
Gitlin, Winter, Dennis, Corcoran, & Hauck	2006	US	1	older community dwelling adult	Functional ADL Performance/transfers	self-efficacy	home hazards
Gitlin, Miller, & Boyce,	1999	US	1	older community dwelling adult	Functional ADL Performance/transfers	Self-care	Importance of OT involvement
Guitard, Sveistrup, Edwards, & Lockett	2011	Canada	1	active adults up to 60	vertical bath rail makes bath transfers safer		
Guo, Tsai, Liao, Tu, & Huang	2013	Taiwan	2	cognitive impairment	fall reduction		
Hakim & Bahheit	1998	UK	2	stroke patient	lack of home mods is a predictor of long stay in hospital		
Hammel, Lai, & Heller	2002	US	2	transitioning to community developmental disabilities 35+	Functional ADL Performance/transfers		
Heywood & Turner	2007	UK	2	disability and older	projected health and care savings	quality of life	care substitution
Heywood (a)	2001	UK	2	home modification recipients	improved independence	carer support	social connection
Heywood (b)	2004	UK	2	home modification recipients	reduced pain, reduced fear of falling, ending depression, carer supported		
Hossain & Hoque	2014	Bangladesh	2	paraplegic spinal cord injured	independence, correlates with financial stability,		
Hwang, Cummings, Sixsmith, & Sixsmith	2011	UK	2	older community dwelling adult	increases length of stay in home and supports ageing in place		
Jutkowitz, Gitlin, Pizzi, Lee, & Dennis	2011	US	2	older community dwelling adult	mortality/survivorship (survival)	cost effectiveness	
Kamei et al.	2014	Japan	2	older community Dwelling adult	fall reduction		
Keall et al.,	2014	New Zealand	2	Older housing (pre 1980) with at least one person receiving benefits. Or subsidies	reduction of injuries		
Korp, Taylor, & Nelson,	2012	US	2	older community dwelling adult	fall reduction		
Kutty,	2000	US	2	older community dwelling adult	Autonomy/non-determination		
Lansley, McCreddie, & Tinker	2004	UK	2	older community dwelling adult	Economic effectiveness		
Leland, Porell, & Murphy	2010	US	2	older community dwelling adult	link between fall history and RA (home mod a part of this)		
Lin Wolf et al	2007	Taiwan	2	older person recent fall	Home assessment and home modifications resulted in improvements in the quality of life measure - more than education but less than exercise.		

Liu & Lapane,	2009	US	2	older community dwelling adult	Functional ADL Performance/transfers		
Mann, Ottenbacher, Fraas, Tomita, & Granger	1999	US	2	older community dwelling adult	Functional ADL Performance/transfers	Economic effectiveness	Support Care giving
Mitoku & Shimanouchi,	2014	Jap an	2	older community dwelling adult requiring care	prevents progression of frailty		
Naik & Gill,	2005	US	2	older community dwelling adult	Support Care giving		
Newman Struyk Rice	1990	US	2	older frail adult	increased risk of institutionalisation		
Nikolaus Bach	2003	Ger man y	2	post discharge from geriatric hospital	falls reduction for subsample (those who had falls in past)		
Ostensjo, Carlberg, & Vollestad,	2005	Nor way	2	children with cerebral palsy	mobility	self-care	social function
Palvanen et al.,	2014	Finl and	3	older community dwelling adult	fall reduction		
Peel Steinberg and Williams	2000	Aust ralia	3	older community dwelling adult	reduces falls	improves confidence	
Petersson, Kottorp, Bergstrom, & Lilja	2009	Swe den	3	Community dwelling with physical disability	Functional ADL Performance/transfers		
Petersson, Lilja, & Borell,	2012	Swe den	3	older, home modification clients with reported lack of safety	feelings of safety		
Petersson, Lilja, Hammel, & Kottorp	2008	US	3	home modification clients	Functional ADL Performance/transfers	Self-care	confidence/sense of safety
Petersson, Löfqvist, & Malmgren Fänge	2012	Swe den	3	home modification clients	Independence	Participation	Ageing in place
Pighills et al	2011	UK	3	older community dwelling adult	Falls reduced by OT with home hazard reduction and mods.		
Plautz, Beck, Selmar, & Radetsky	1995	US	3	older community dwelling adult	reduced reported falls by 60%, reduced burns and scalds		
Randstrom, Asplund & Svedlund	2012	Swe den	3	older community dwelling adult	impacts activity and participation		
Renaut, Ogg, Petite, & Chamahian	2014	Fran ce	3	older community dwelling adult and carers	Supports multidimensional experience of ageing in place. Not all people want home mods and others offset.		
Safran-Norton	2010	US	3	older community dwelling adult	more substantial home mods support ageing in place		
Salkeld et al	2000	Aust ralia	3	Older Emergency Department patient	Economic effectiveness		Socio economic link
Salminen, Kanelisto, & Karhula	2014	Finl and	3	multiple sclerosis diagnosis	increased safety		
Sheffield Smith & Becker	2013	US	3	older community dwelling adult	improved safety	fear of falling	functional status
Stark	2008	US	4	older community dwelling adult	Functional ADL Performance/transfers		
Stark, Landsbaum, Palmer, Somerville, & Morris	2009	US	4	older community dwelling adult	Functional ADL Performance/transfers		

Stearns et al.	2000	US	4	community dwelling Medicare beneficiaries	increased cost for home mods		
Stevens, Holman, Bennett, & De Kler	2001	Australia	4	older community dwelling adult	Injury/reduce falls		
Stineman	2007	US	4	older (65+)	higher risk of ADL limitation		
Szanton et al.,	2014	US	4	low income older adult with self-care disability	self-care	ADL independence	
Tanner, Tilse, & De Jonge	2008	Australia	4	older, home modification clients	ageing in place		independence
Thomé & van Groenou	2006	The Netherlands	4	older community dwelling adult	home adjustments effect on depressive symptoms		
Tinetti et al	1994	US	4	older community dwelling adult	falls reduction		
Tse	2005	Australia	4	Older community dwelling adult	reduces falls when implemented with other fall prevention interventions		
Turner et al.	2011	UK	4	older community dwelling adult	Injury/reduce falls		
Van Hoof, Kort, Van Waarde, & Blom	2010	The Netherlands	4	Alzheimer's/dementia patients	ageing in place		
Vik, Nygard & Lijla	2007	Sweden	4	older community Dwelling adult receiving rehabilitation	Home modifications facilitate participation.		
Wahl, Fange & Oswald	2009	Germany	4	Older community dwelling adult	falls	function related outcomes	
Wilson, Mitchell, Kemp, Adkins, & Mann	2009	US	4	Community dwelling with physical disability (any age)	Reduced decline in functionality		

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