Modification of the home environment for the reduction of injuries (Review)

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[Intervention Review]

Modification of the home environment for the reduction of injuries

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ABSTRACT

Background

Injury in the home is extremely common, accounting for around a third of all injuries. The majority of injuries of children under five and people aged 75 and over, occur at home. Multifactorial injury prevention interventions have been shown to reduce injuries in the home. However, few studies have focused specifically on the impact of physical adaptations to the home environment and the effectiveness of such interventions needs to be ascertained.

Objectives

To review the evidence for the effect on injuries of modification of the home environment with a primary focus on interventions to reduce physical hazards.

Search strategy

We searched The Cochrane Library, MEDLINE, EMBASE, National Research Register and other specialised databases. We also scanned conference proceedings and reference lists. In addition, we contacted experts and trialists in the field. The searches were not restricted by language or publication status. The searches were last updated in December 2004.

Selection criteria

Randomised controlled trials.

Data collection and analysis

All abstracts were screened by two authors for relevance, outcome and design. Two authors independently assessed methodological quality and extracted data from each eligible study.

Main results

We found 18 published and one unpublished trials. Trials were not sufficiently similar to allow pooling of data by statistical analyses, so this review takes a narrative form. Studies were divided into three groups based on the primary population sample; children (five studies), older people (14 studies) and the general population/mixed age group (no studies). None of the studies focusing on children demonstrated a reduction in injuries that might have been due to environmental adaptation in the home; one study reported a reduction in injuries and in hazards but the two could not be linked. Of the 14 included studies in older people, none demonstrated a reduction in injuries due to hazard reduction, although two demonstrated a reduction in falls that could be due to hazard reduction.

Authors' conclusions

There is insufficient evidence to determine the effects of interventions to modify environmental home hazards. Further interventions to reduce hazards in the home should be evaluated by adequately designed randomised controlled trials measuring injury outcomes. Recruitment of large study samples to measure effect must be a major consideration for future trials.

PLAIN LANGUAGE SUMMARY

More evidence is needed to show whether or not altering the physical home environment by removing potential hazards reduces injuries.

Injuries in the home are very common. Most of the injuries of older people and children under five occur at home. Many people are encouraged to alter their home to try to reduce such injuries. Common alterations include the installation of locks on cupboards and covers on electrical sockets, improvement of lighting in halls and stairways, and the removal of rugs and other falls hazards. The review found that there is insufficient evidence from trials to show that such changes reduce the number of injuries in the home but does not conclude that these interventions are ineffective. Home alterations need to be evaluated by larger and better designed trials.

BACKGROUND

Injury in the home environment is an extremely common event, accounting for around a third of injuries in all age groups. The majority of injuries of children under five and people aged 75 and over, occur in the home (DTI 1997; Lilley 1995; Lyons 2002). There is evidence from certain reviews to suggest that it is possible to reduce injuries in the home by using multifaceted, injury prevention interventions (Coleman 1996; Lyons 1998; NHS CRD 1996; Towner 2001; van Haastregt 2000a). Subsequently, this evidence of effectiveness has found its way into policy documents and strategies prepared to prevent injuries in the home. In England, the National Service Framework for Older People sets as a standard the development of an integrated falls prevention service in every acute hospital (DoH 2001). In setting up such services a balance needs to be struck between the amount of resource spent on reducing intrinsic risk factors for falls (for example, excess medication, visual and balance problems) and extrinsic factors (for example, presence of environmental hazards).

Existing reviews, however, have looked at any interventions that prevent falls and injuries and have not determined the relative importance of tackling intrinsic and extrinsic factors. The aim of this review, therefore, is to determine whether modification of the home environment reduces injuries occurring in the home. It is hoped that the results of the review may inform and alert clinicians, practitioners and the public to gaps in the evidence and provide suggestions for the testing of future interventions. In addition, the conclusions will guide the research and policy development communities, and those government departments engaged in policy development. This is particularly important, given the development of cross-disciplinary collaboration in the field of injury prevention, and because government policy, strategy and implementation documents should now directly reflect the results of research evidence.

OBJECTIVES

To review the evidence for the effect on injuries of modification of the home environment that have a primary focus on interventions to reduce physical hazards. This review does not include interventions to promote smoke alarm ownership and function (which is a the focus of an existing Cochrane review (DiGuiseppi 2001)) or interventions to prevent injuries caused by items brought into the home (such as household chemicals and firearms) or home-based items unrelated to building structure (such as hip protectors for the elderly, medicines, bottles or toys).

METHODS

Criteria for considering studies for this review

Types of studies

Randomised controlled trials (RCTs).

The first published version of this review included randomised controlled trials, non-randomised controlled trials, controlled before-and after studies and interrupted time series studies due to the limited number of studies that would qualify for inclusion if it had been limited to randomised controlled trials only. However on conducting the searches for the update (December 2004) it became clear that it was now possible, and preferable in terms of the quality of the review and the evidence upon which it is based, to limit the inclusion criteria to randomised controlled trials.

Types of participants

People of all age groups who are 'at home' (that is, in the place they would normally eat and sleep), in areas where housing is normally architect-designed and always subject to housing regulations.

Types of interventions

Eligible interventions are those which focus on reducing physical hazards; including the building fabric or 'fixtures and fittings' (that is, removable items within a property that are fastened or attached to the building fabric) in the domestic environment, and where modifications such as the installation of grab rails, stair gates, fireguards, cupboard locks, hot-water tap adaptations and lighting adjustments, have been included.

Interventions which take a multi-component approach (that is, have modification plus education or action on other risk factors) are included. Studies which include the installation of smoke alarms alongside other physical interventions are included but not those where smoke alarms were the sole intervention.

Any intervention where the focus has been to change the home environment solely for non-injury benefits (for example, improved quality of life of disabled individuals) is excluded.

Types of outcome measures

- Change in injury rate or risk.
- Change in prevalence of safety features.
- Change in prevalence of hazards.

Search methods for identification of studies

Electronic searches

We searched the following electronic databases:

- The Cochrane Library
- MEDLINE
- EMBASE
- National Research Register
- PREMEDLINE
- HealthSTAR
- CINAHL
- British Nursing Index
- Dissertation Abstracts
- ISI Science (& Social Science) Citation Index
- ICONDA (International Construction Database)
- APId (Architectural Periodicals Index on disc)
- ASSIA (Applied Social Sciences Index and Abstracts)
- SIGLE (System for Information on Grey Literature)
- Urbadisk (Acompline and Urbaline)

All the database searches are updated to December 2004, with the exception of Urbadisk (Acompline and Urbaline) which was not accessible at the time of the update, however no references had been identified from this database in the original review. The search strategy can be found in Appendix 1.

Searching other resources

We also searched the Internet, relevant conference proceedings and reference lists. Lead researchers in the field were contacted for the identification of any relevant unpublished studies. Manual handsearching of relevant journals was not undertaken.

Data collection and analysis

Selection of studies

All abstracts were pre-screened by one author for relevance, duplication, outcome and design. All abstracts considered not eligible were independently reviewed by an expert assessor. Where it was not possible to determine if a study met the inclusion/exclusion criteria on the basis of the title and/or abstract alone, the full reference was retrieved and the study assessed by two authors according

to the pre-defined inclusion/exclusion criteria. The reference lists of review articles were screened for any further studies.

Data extraction and management

Eligible studies were separated into three categories for the purposes of data extraction: a) older people, b) children and c) the general population. Two expert authors independently extracted data from each study. EPOC (data collection checklists) guidelines for methodological quality were used for quality checking and inter-rater reliability was assessed by the kappa statistic. The kappa statistic percentage for the older people category was 100% in the original review and 93% in the update. It was 95% between raters for groups b), children and c) the general population in the original review and 100% in the update. Any disagreements on data extraction were resolved by consensus discussion, following review by a third assessor.

RESULTS

Description of studies

See: Characteristics of included studies; Characteristics of excluded studies; Characteristics of ongoing studies.

General findings

We identified 44,717 unduplicated citations through our electronic database searches. A stepped exclusion exercise was performed where references were excluded on the basis of title or title and abstract based on the pre-defined inclusion/exclusion criteria. Where it was not possible to confirm inclusion/exclusion criteria on review of the abstract alone, the full reference was retrieved. One hundred and twenty-eight potentially relevant references were identified at this stage. Two more studies were identified through personal contact (Elkan 2000; Thomson 2001). Thirty-seven papers were excluded from this total of 130, on the basis that they were either an inappropriate study design or considered inconsistent with the type of housing or home environment under review. Forty-two review articles were extracted from the remaining 93 citations. These included one meta-analysis, 25 systematic reviews and two guidelines. The reference lists of included studies were scanned by two independent authors for any additional citations that might have been missed by other methods. From this search, we identified a further 13 citations. This included one review article (Purdue 2003) which identified no new citations. We also found one relevant ongoing randomised controlled trial. The results of this trial were being analysed at the time of writing (Kendrick ongoing). One final randomised controlled trial (Day 2002) matching the review protocol was identified by contact with a lead researcher after the literature search had been completed.
Of the 62 studies reviewed (not including Kendrick ongoing) in full for eligibility, 44 were excluded. Eighteen completed randomised controlled trials published between 1979 and 2004 (Becker 2003; Clamp 1998; Close 1999; Cumming 1999; Day 2002; Gielen 2002; Hogan 2001; Jenson 2003; Kendrick 1999; King 2001; Nikolaus 2003; Pardessus 2002; Posner 2004; Shaw 2003; Stevens 2001; Tinetti 1994; van Haastregt 2000a; Vetter 1992) and one unpublished study (Carter unpublished) were included. Permission to quote from the unpublished paper was granted by the authors.

Excluded studies

There were 44 excluded studies and one ongoing study (Kendrick ongoing). One (Ozanne-Smith 2002) was an ecological study where the measures of changes to physical hazards were not reported at household level, one (Assantachai 2002) was similarly community based with no home hazard intervention, one (Duff 2002) included undefined access to home equipment with no measure of change to physical hazards, three (Haynes 2003; Huang 2003; Ramsey 2003) had no intervention to meet inclusion criteria and one (Tanner 2003) no outcome.
A further 11 were observational studies with either a cohort or case-control design, one was a German-language paper that was found not meet the inclusion criteria when it was translated, in one the environmental intervention was not taken up, four were interrupted-time series studies that did not have a sufficient number of gathering points to meet the EPOC guidelines, one was a combined before-and-after study, one a PRECEDE-PROCEED model with different subjects and methods (Durongritichai 2003) and one was a duplicate study. Eighteen (including Huang 2004; Lightbody 2002; Robson 2003; Sznajder 2003) were considered controlled clinical trials commonly because the method of randomisation was not adequately described.

Included studies

There were 18 completed randomised controlled trials published between 1979 and 2004 (Becker 2003; Clamp 1998; Close 1999; Cumming 1999; Day 2002; Gielen 2002; Hogan 2001; Jenson 2003; Kendrick 1999; King 2001; Nikolaus 2003; Pardessus 2002; Posner 2004; Shaw 2003; Stevens 2001; Tinetti 1994; van Haastregt 2000a; Vetter 1992) and one was unpublished (Carter unpublished). Fourteen were in the older age group and five in the children's.

Population

Study populations included urban and rural-based families (including families in inner-city, lower-income areas) with children

under five years, caregivers of children under five, independent community-living elderly, staff of nursing homes, nursing home residents and elderly in-patients of geriatric wards who returned home, emergency department patients, parents, and specialist physicians in training. Cluster randomised trials included units based on general practices, hospital-based clinics, elderly residential care facilities and households. Emergency department patients and parents, community census tracts, households, families, municipalities, child health clinics, nursery classes and toddler groups were also included.

Type of intervention

Two of the 19 randomised controlled trials made an environmental modification to the domestic environment as the sole intervention (Cumming 1999; Pardessus 2002). Seven trials (Carter unpublished; Clamp 1998; Close 1999; Gielen 2002; Kendrick 1999; King 2001; Stevens 2001) used a combined approach of direct or recommended modification and educational strategy. One trial (Posner 2004) used a combined approach of recommended modification with free safety devices and an educational strategy. Nine of the trials (Becker 2003; Day 2002; Hogan 2001; Jenson 2003; Nikolaus 2003; Shaw 2003; Tinetti 1994; van Haastregt 2000a; Vetter 1992) were multi-factorial. The other interventions encompassed the targeting of nutritional deficiencies, balance and resistance training, training in use of mobility aids, fitness, exercise, medication, visual problems, hip protectors, post fall problem solving conferences and reviews of medical conditions, in addition to promoting the reduction of environmental hazards.

All of the interventions, except two (Clamp 1998; Posner 2004) included a home assessment evaluation made by either a community nurse, trained researcher, project assistant, occupational therapist or health visitor. Environmental hazards were evaluated using standardised data collection forms, structured interviews, questionnaires, and checklists. Modifications to the home environment included the installation of grab bars, stair gates, handrails, fire guards, cupboard locks, table protection corners, electric outlet covers, the reduction of hot water temperatures, the repair of damaged flooring, improvement in lighting levels and the stabilisation of floor surfaces. Six of the interventions (Clamp 1998; Day 2002; Kendrick 1999; King 2001; Posner 2004; Stevens 2001) clearly provided or made available free or discounted safety equipment or devices.

Interventions were delivered in either a healthcare setting (Posner 2004), in the clinical setting as part of routine health surveillance (Clamp 1998; Kendrick 1999), the home (Becker 2003; Carter unpublished; Close 1999; Cumming 1999; Day 2002; Hogan 2001; Jenson 2003; King 2001; Nikolaus 2003; Stevens 2001; Tinetti 1994; van Haastregt 2000a) or in both a healthcare setting and the home (Day 2002; Gielen 2002; Pardessus 2002; Shaw 2003; Vetter 1992).

Outcomes

Ten of the 19 randomised controlled trials had an injury or proxy for injury (medical attendance) as an outcome variable (Becker 2003; Carter unpublished; Close 1999; Jenson 2003; Kendrick 1999; King 2001; Shaw 2003; Stevens 2001; van Haastregt 2000a; Vetter 1992). Fourteen of the trials collected data on falls (Becker 2003; Carter unpublished; Close 1999; Cumming 1999; Day 2002; Hogan 2001; Jenson 2003; Nikolaus 2003; Pardessus 2002; Shaw 2003; Stevens 2001; Tinetti 1994; van Haastregt 2000a; Vetter 1992). Nine trials collected data on hazards reduction, which may also have included the collection of data on safety knowledge, possession, use and compliance of safety equipment, as an outcome (Carter unpublished; Clamp 1998; Cumming 1999; Day 2002; Gielen 2002; King 2001; Nikolaus 2003; Shaw 2003; Stevens 2001). Posner 2004 used change in prevalence of safety features as an outcome variable.

There remained considerable heterogeneity in terms of study design, types of intervention and outcomes measured. None of the studies was sufficiently similar to allow for the combination of results data by statistical analyses and as a result of these findings the review remains a narrative one only.

Risk of bias in included studies

The adequacy of allocation concealment was evaluated for all trials using the EPOC checklist for randomised controlled trials. Where a trial reported randomisation but did not describe the method of randomisation or the method described was inadequate it was then judged to be a controlled clinical trial (CCT) and was excluded.

Allocation concealment was judged to be adequate in all 19 included studies. Nine trials (Clamp 1998; Close 1999; Cumming 1999; Gielen 2002; Kendrick 1999; Pardessus 2002; Stevens 2001; Tinetti 1994; Vetter 1992) used a table of random numbers and five (Carter unpublished; Day 2002; Hogan 2001; Shaw 2003; van Haastregt 2000a) computer generation. Four trials (Becker 2003; Jenson 2003; Nikolaus 2003; Posner 2004) used sealed envelopes and one (King 2001) used sealed envelopes mixed in an opaque container, sequentially numbered when withdrawn and then distributed in aliquots to each study site.

Three studies had sufficient statistical power to detect important effects as statistically significant and recorded power (Nikolaus 2003; Posner 2004; Shaw 2003). In one (Day 2002) the power calculation was stated requiring a sample size of 1143 and achieved a sample size of 1107. In two it was reported that the study was underpowered. Jenson 2003 stated that a lack of previous studies into cognitively impaired older people had led to an over-estimation of the rate of falling and planned intervention effect and hence an under-powering of the lower cognition subgroup. Similarly another study (Becker 2003) was underpowered to detect a significant difference due to a lower than expected number of hip fractures. Pardessus 2002 did not report a power calculation but

concluded that the number of participants in their study (n = 60) was perhaps too small to detect a significant difference between the intervention and control in terms of rate of falls.
Blinding of outcome assessment was stated in only two trials (King 2001; Posner 2004) . Although allocation concealment was judged to be adequate in Jenson 2003, a cluster randomised trial, it was non-blinded within each home. Self-reporting of outcomes occurred in all but one of the trials (Becker 2003). Loss to follow-up ranged from 0 to 65.2% .

Effects of interventions

Falls

a) Older people

There were 14 trials in the older people category (Becker 2003; Carter unpublished; Clamp 1998; Close 1999; Cumming 1999; Day 2002; Hogan 2001; Jenson 2003; Nikolaus 2003; Pardessus 2002; Stevens 2001; Tinetti 1994; van Haastregt 2000a; Vetter 1992) reporting falls data.
Many of the studies involved multi-factorial interventions. In five studies (Day 2002; Hogan 2001; Pardessus 2002; Shaw 2003; Stevens 2001) no significant effect of the home modification intervention on falls outcomes was found. In Day 2002 the percentage estimated reduction in annual fall rate attributed to home hazard management was not significant (3.1, 95% CI -2.0 to 9.7). However there was a significant effect when combined with exercise (9.9, 95% CI 2.4 to 17.9). The strongest effect was observed when all three interventions (exercise, home hazard management, vision correction) were combined together (14.0, 95% CI 3.7 to 22.6); rate ratio 0.67 (95% CI 0.51 to 0.88). The study authors argue that the modifications of home hazards may not have been large enough or may have been of the wrong type to affect falls outcome.
Hogan 2001, which combined a home visit to record hazards and falls prevention classes, found no significant differences between the control or intervention groups in the cumulative number of falls (311 versus 241, P = 0.34), having one or more falls (79.2% versus 72.0%, P = 0.30) or in the mean number of falls (4.0 versus 3.2, P = 0.43).
In Pardessus 2002 a home visit was performed post hospitalization for a fall. The main intervention was the identification of environmental hazards and modifications recommended. However social supports were also addressed. There was no significant difference in fall recurrence between the IG (intervention group) and CG (control group): number of fall recurrences IG 0.68 ± 0.16; CG 0.82 ± 0.16. However the study was underpowered to detect such a difference. Shaw 2003 was a multi-factorial intervention where intention to treat analysis showed no significant difference between intervention and control groups in proportion of patients who fell during one years follow up (relative risk ratio 0.92, 95% CI 0.81 to 1.05). Stevens 2001, which combined a home visit to assess hazards, free devices and an educational strategy, found that there was no significant reduction in the intervention group in the incidence rates of falls involving environmental hazards inside the home (adjusted rate ratio 1.11, 95% CI 0.82 to 1.50) or the rate of falls inside the home (adjusted rate ratio 1.17, 95% CI 0.85 to 1.60).
In other multi-factorial studies (Becker 2003; Jenson 2003; Nikolaus 2003) the effect of modifications on the outcome was impossible to separate from other interventions on falls outcomes. Although Becker 2003 reported the incident density rate of falls per 1000 resident years was 2558 for the control group and 1399 for the intervention group, relative risk 0.55 (95% CI 0.41 to 0.73), this was a multi-factorial intervention on falls in nursing homes. There had been agreement on a list of environmental hazard removal and prosthetic supports but the study authors admit that a lack of a validated scoring system for environmental factors and time differences for corrections made the reporting of adherence to environmental corrections unfeasible and hence any contribution of home modification to the intervention effect impossible to quantify. Additionally, it was argued that to see the effects of environmental adaptations such as installing new floor surfaces would take more time than allowed in the study.
Jenson 2003 was a multi-factorial fall prevention programme including staff education, environmental adjustment, exercise, drug review, aids, hip protectors, and post fall problem-solving conferences. A significant intervention effect on falls appeared in the higher cognitive group but the study was under powered to detect such a difference in the lower cognitive group. The study authors conclude that the particular interventions which reduce falls need to be further investigated. In Nikolaus 2003, the interventions were modification to the home environment and training in the use of mobility and technical aids. The intervention group had 31% fewer falls than the control group (incidence rate ratio = 0.69, 95% CI 0.51 to 0.97). The intervention was most effective in a subgroup of participants who reported having had two or more falls during the year before recruitment into the study.
One study (Close 1999) also reported hospitals admission rates. This study found that the risk of falling in the intervention group was significantly reduced: OR 0.39 (95% CI 0.23 to 0.66). Odds of admission to hospital were, however, not improved: OR 0.61 (95% CI 0.35 to 1.05).
In one trial (Cumming 1999) a reduction in falls was observed in an intervention subgroup only. For those participants with a history of falls, the relative risk (RR) was equal to 0.64 (95% CI 0.50 to 0.83). In Tinetti 1994 the adjusted incidence ratio for falling in the intervention group compared with the control group was 0.69 (95% CI 0.52 to 0.90). van Haastregt 2000a reported that the odds ratios for at least one fall was 1.3 (95% CI 0.7 to 2.1) for the intervention group, while Vetter 1992 found that more falls without fracture occurred in the intervention group (23% versus

16%).
Falls data was not collected for either of the other two age group categories.

Injuries

a) Older people

Seven included studies in the older people category (Becker 2003; Jenson 2003; Nikolaus 2003; Shaw 2003; Stevens 2001; van Haastregt 2000a; Vetter 1992) reported injuries data, six of which found no significant reduction in the intervention group. In Becker 2003 no significant difference was seen for hip fractures between intervention and control group (relative risk [RR] 1.11, 95% CI 0.49 to 2.51). The incidence density rate of other fractures was also similar in both groups (RR 0.78, 95% CI 0.57 to 1.07). Similarly in Shaw 2003 relative risk ratio between the intervention and control group was not significant for major injuries (RRR 1.32, 95% CI 0.87 to 2.00) and fractured necks of femurs (RRR 0.55, 95% CI 0.21 to 1.72). However in all these studies the numbers of injuries were small. Nikolaus 2003 was not designed to examine fall related injuries but listed the figures stating numbers were too small for statistical comparisons.
Three further studies (Stevens 2001; van Haastregt 2000a; Vetter 1992) found no significant reduction in the number of injurious falls or fracture rates. Stevens 2001 found no significant reduction in the rate of injurious falls in the intervention group (adjusted relative risk 0.92, 95% CI 0.73 to 1.14). Vetter 1992 reported a similar proportion of fractures in both the intervention and control groups (5% versus 4%) and van Haastregt 2000a found an odds ratio for injurious falls in the intervention group 1.4 (95% CI 0.8 to 2.6).
The picture is only a little different in Jenson 2003. Fifty-nine minor, moderate or serious injuries occurred in the higher cognitive group giving a non-significant crude incident rate ratio (IRR) compared with the control group (CG) of 0.9 (95% CI 0.5 to 1.5) and similarly in the lower cognitive group crude IRR 0.9 (95% CI 0.5 to 1.3). However in the lower cognitive group the 171 participants sustained 10 femoral fractures, all of which were in the control group (result expressed as P = 0.006).

b) Children

Two studies (Kendrick 1999; King 2001) reported data on injuries. One of these trials found no significant difference in injury occurrence between intervention and control groups: Kendrick 1999 reported no significant change in the frequency of at least one medically attended injury OR 0.97 (95% CI 0.72 to 1.30), at least one attendance at an accident and emergency department for injury OR 1.02 (95% CI 0.76 to 1.37), at least one primary care attendance for injury OR 0.75 (95% CI 0.48 to 1.17) or at least one hospital admission for injury OR 0.69 (95% CI 0.42 to 1.12). In King 2001 at eight months follow-up, the rate of injury visits per patient year was 0.23 (95% CI 0.19 to 0.29) in the intervention group and 0.31 (95% CI 0.58 to 0.96) in the control group.

c) General population (mixed age groups)

There were no included studies carried out in the general population.

Hazards reduction (including safety knowledge, possession, use and compliance of safety equipment)

a) Older people

Six included studies (Carter unpublished; Cumming 1999; Day 2002; Nikolaus 2003; Shaw 2003; Stevens 2001) reported data on hazards reduction in the older people category. All found a significant reduction in hazards between intervention and control groups making changes to improve home safety. Only two (Cumming 1999; Nikolaus 2003) had an associated reduction in falls, in one other study (Day 2002) the reduction in falls could not be directly associated with the reduction in hazards.
In Nikolaus 2003 222 home modifications were recommended. There were at least 137 homes with a minimum of one recommended change (75.7%). The most commonly recommended changes were elevation of the toilet seat (43), use of a rollator (37) and fixing grab rails in the bathroom (270). Compliance with recommendations ranged from 33.3% to 82.6% at 12 months follow-up. Participants who made at least one of the recommendations at 12 months follow up experienced a significant reduction in the rate of falls (IRR 0.64, 95% CI 0.37 to 0.99, P = 0.047). The number of falls in those subjects in the IG with no home modifications was not significantly different from those in the control group (IRR 1.05, 95% CI 0.82 to 1.41).Therefore an intention-to-treat analysis would be likely to report no difference between the groups. Cumming 1999 found a significant reduction in hazards in the intervention group and falls were reduced in the intervention sub-group with a history of falls.
Carter unpublished found a significant association between intervention and control groups making changes to improve home safety with the brief (35%) and the intensive intervention (49%) compared to the control group (28%) over a 12 month follow-up. In Shaw 2003 there was no significant change in environmental risk factors score at three months in either the intervention or the control group, but there was a significant change in score between the two groups, P < 0.001. However there was no change in primary outcome measures. Stevens 2001 found that intervention homes had significantly reduced mean numbers of hazardous steps, unsafe rugs and training cords by 16 to 26%.

Day 2002 reported that of the 543 participants receiving the home hazard management intervention 478 were advised to have modifications to their homes. Three hundred and sixty-three received help to do these modifications which included 275 hand rails fitted, 72 modifications to floor coverings and 72 homes receiving contrast edging to steps. Modification of environmental hazards on its own did not reduce injuries but the strongest effect was found when all three interventions (exercise, medical review and home modification) were combined (relative risk 0.67, 95% CI 0.51 to 0.88).

b) Children

Four studies reported data on hazards reduction. Three of the four (Clamp 1998; King 2001; Posner 2004) showed some reduction in hazards. Clamp 1998 found that significantly more families in the intervention group used fireguards (relative risk 1.89, 95% CI 1.18 to 2.94), socket covers (1.27, 95% CI 1.10 to 1.48), locks on cupboards for storing cleaning materials (1.38, 95% CI 1.02 to 1.88), and door slam devices (3.60, 95% CI 2.17 to 5.97) compared to the control group. In addition, significantly more families in the intervention group showed safe practice for windows (1.30, 95% CI 1.06 to 1.58), fireplaces (1.84, 95% CI 1.34 to 2.54) and door-slam safety (7.00, 95% CI 3.15 to 15.6). Significant reductions were observed in one study (King 2001) where the primary intervention targeted the prevalence of excessive hot water temperatures. They found a significant reduction in the observed prevalence of homes without hot water (>54%; OR 1.31, 95% CI 1.14 to 1.50) and the presence of a fire extinguisher (OR 0.81, 95% CI 0.67 to 0.97). In one trial (Posner 2004) the intervention group received a comprehensive home safety education and free safety devices and the control group received a focused injury specific emergency department discharge set of instructions. The intervention group demonstrated significantly higher average overall safety scores than the control group (73.3% ± 8.4% versus 66.8% ± 11.1%), and significant improvements in poison, cut/piercing, and burn category scores. Caregivers in the intervention group also demonstrated greater improvement in reported use of the distributed safety devices.

However Gielen 2002 found no significant differences in safety practices between study groups. Odds ratios for families who visited the safety centre versus those who did not for observed safety practices were: hot water temperature <48.9 degrees centigrade (1.36, 95% CI 0.57 to 3.27); had at least one safety gate (2.64, 95% CI 0.77 to 9.14).

c) General population (mixed age groups)

There were no included studies in this group.

Authors of included studies were not contacted for further information or data.

Supplementary results data are included in the Additional tables (Table 1; Table 2).

Table 1. Children

Study ID	Study Type	Intervention	Results	Reduction
Clamp 1998	RCT	GP safety advice	Post intervention, intervention group families used fireguards (relative risk 1.89, 95% Confidence Interval: 1.18 to 2.94), smoke alarms (1.14: 1.04 to 1.25), socket covers (1.27: 1.10 to 1.48), locks on cupboards for storing cleaning materials (1.38: 1.02 to 1.88), and door slam devices (3.60: 2.17 to 5.97). Intervention group families showed safe practice for: window (1.30: 1.06 to 1.58), fireplace (1.84: 1.34 to 2.54), socket (1.77: 1.37 to 2.28), smoke alarm (1.11: 1.01 to 1.22) and door slam safety (7.00: 3.15 to 15.6).	Injury NA Falls NA Hazards Y

Table 1. Children (*Continued*)

Gielen 2002	RCT	Safety counseling by paediatric residents, referral to Children's safety Centre, plus home visit	No significant differences in safety practices were found between study groups. Odds ratio for families who visited the safety centre versus those who did not for observed safety practices were:hot water temperature <48.9oC (95% CI: 1.36, 0.57 to 3.27);working smoke alarm (0.98: 0.33 to 2.96);all stairs protected by gate/door (1.82: 0.56 to 5.86);had at least 1 safety gate (2.64: 0.77 to 9.14).	Injury NA Falls NA Hazards N
Kendrick 1999	RCT	Safety advice, low-cost safety equipment and home visit	No significant difference was found in frequency of at least one medically attended injury (OR 0.97, 95% CI: 0.72 to 1.30), at least one attendance at an accident and emergency department for injury (1.02: 0.76 to 1.37), at least one primary care attendance for injury (0.75: 0.48 to 1.17) or at least one hospital admission for injury (0.69: 0.42 to 1.12).	Injury N Falls NA Hazards NA
King 2001	RCT	Home hazards assessment, discount coupons for safety devices and information package	At 8 months the rate of injury visits per patient year was 0.23, (95% CI: 0.19 to 0.29) in the intervention group and 0.31, (95% CI: 0.58 to 0.96) in the control group. There was significant reductions in the observed prevalence of homes without hot water >54%, OR 1.31, (95% CI: 1.14 to 1.50), and the presence of a fire extinguisher, OR 0.81, (95% CI: 0.67 to 0.97). Other changes were small and non-significant. Self reported home safety modifications were reported in 62% of intervention and 23% of control homes (P <0.05).	Injury Y Falls NA Hazards Y

Table 1. Children (*Continued*)

Posner 2004	RCT	Home visit with structured home safety questionnaire caregivers of those < 5 years given comprehensive home safety education and free safety devices	At 2 months follow-up intervention group higher average overall safety score than control (73.3% +/- 8.4% vs 66.8% +/- 11.1%) and significant improvements in poison, cut, and burn category scores. Also intervention group reported higher used of safety devices.	Injury NA Falls NA Hazard reduction Y

Table 2. Older people

Study ID	Study Type	Intervention	Results	Reduction
Becker 2003	RCT	Staff and resident education on fall prevention, advice on environmental adaptations, progressive balance and resistance training and hip protectors.	Incidence density rate of falls was reduced (RR = 0.55; 95% CI 0.41 to 0.73). No significant difference was seen for hip fractures. Lack of validated scoring meant no hazard reduction was recorded.	Injury N Falls Y Hazards NA
Carter (unpublished)	RCT	Home visit to assess hazards followed by action plan.	Significant association between intervention and control groups making changes to improve home safety over 12 months: Control 28%, brief intervention 35%, intensive intervention 49%. The proportion of older people falling in and around their homes was not significantly different between the control group and either of the intervention groups.	Injury N Falls N Hazards Y
Close 1999	RCT	Home visit to identify hazards.	Risk of falling was significantly reduced in the intervention group: OR 0.39; 95% CI 0.23 to 0.66 as was risk of recurrent falls, OR 0.33; 95% CI 0.16 to 0.68. Odds of admission to hospital were non significantly lower in the intervention group (0.61; 95% CI 0.35 to 1.05). Changes in hazards were not	Injury N Falls Y Hazards NA

Table 2. Older people (*Continued*)

			reported.	
Cumming 1999	RCT	Home visit to record hazards and facilitate modifications.	Hazard Percentage of homes with modifications recommended. Compliance at 12 months Remove mats/rugs 48% 49% Change footwear 24% 54% Non-slip mats 21% 75% Change behaviour 15% 60% Night light 13% 58% Stair rails 12% 19% Remove electrical cords 12% 67% Falls were reduced in the intervention subgroup with a history of falls. Relative risk = 0.64; 95% CI 0.50 to 0.83.	Injury NA Falls Y Hazards Y
Day 2002	RCT	Multifactorial intervention including home hazards management.	Home hazards management did not show a significant effect. Strongest effect was observed for all three interventions combined (rate ratio 0.67; 95% CI 0.51 to 0.88).	Injury NA Falls Y Hazards Y
Hogan 2001	RCT	Home visit to assess environmental risk factors followed by treatment plan.	No significant differences between the control and intervention groups in the cumulative number of falls (311 versus 241, P = 0.34), having one or more falls (79.2% versus 72.0%, P = 0.30) or in the mean number of falls (4.0 versus 3.2, P = 0.43).	Injury NA Falls N Hazards NA
Jensen 2003	RCT	Multi-factorial fall prevention programme comparing staff education, environmental adjustment, exercise, drug reviews, aids, hip protectors and post fall problem solving conferences.	Significant reduction in falls in higher Mini Mental State examination group than lower (adjusted hazard ration P = 0.001 and P = 0.0420. In the lower MMSE group 10 femoral fractures occurred, all in control group (P = 0.006).	Injury Y Falls Y Hazard NA
Nikolaus 2003	RCT	Home visit with advice about environmental hazards, offer of facilities to change them and training in the use of mo-	Intervention group had 31% fewer falls than control group (incidence rate ratio IRR = 0.69; 95% CI 0.51 to 0.97)	Injury NA Falls Y Hazards Y

Table 2. Older people (*Continued*)

		bility and technical aids.	Study not designed to examine fall related injuries. Compliance rate of 75.7% with at least one recommended hazard change. Participants who made at least one recommendation experienced a significant reduction in the rate of falls (IRR = 0.64; 95% CI 0.37 to 0.99). The number of falls in those in the intervention group with no modifications was not significantly different from those in the control group.	
Pardessus 2002	RCT	Home visit that assessed environmental hazards and recommended modifications.	Rate of falls, hospitalisation for falls were not significantly different between the two groups.	Injury N Falls N Hazards N
Shaw 2003	RCT	Multi-factorial intervention including medication review, vision, blood pressure, mobility, footwear and an assessment of home environmental fall hazards and modification using standard checklists.	No significant differences between two groups in proportion who fell after 1 year or in injuries sustained. Compliance with hazard advice was 41/105 in intervention group and 8/111 in control.	Injury N Falls N Hazards Y
Stevens 2001	RCT	Home visit to assess hazards, installation of free safety devices and educational strategy.	No significant reduction in the intervention group in the incidence rate of falls involving environmental hazards inside the home (adjusted rate ratio 1.11; 95% CI 0.82 to 1.50), or the rate of falls inside the home (adjusted rate ratio 1.17; 95% CI 0.85 to 1.60). There was no significant reduction in the rate of injurious falls in intervention subjects (adjusted rate ratio 0.92; 95% CI 0.73 to 1.14). Two thirds of falls that occurred inside the home involved an environmental hazard - most frequently implicated falls were caused by fur-	Injury N Falls N Hazards Y

Table 2. Older people (*Continued*)

			niture (25%), steps (19%), wet and slippery floors (13%), objects on the floor (9%) and mats and rugs (7%). Intervention homes had significantly reduced mean numbers of hazardous steps, unsafe rugs, and trailing cords, by 16 to 26%.	
Tinetti 1994	RCT	Home visit assessment and changes made to environmental hazards.	The adjusted incidence ratio for falling in the intervention group as compared with the control group was 0.69; 95% CI 0.52 to 0.90. Changes in physical hazards were not reported.	Injury NA Falls Y Hazards NA
van Haastregt 2000	RCT	Home visit screening for environmental & behavioural factors.	Odds Ratios for the intervention group for at least one fall was 1.3; 95% CI 0.7 to 2.1 and for an injurious fall 1.4; 95% CI 0.8 to 2.6. Changes in physical hazards were not reported.	Injury N Falls N Hazards NA
Vetter 1992	RCT	Home visit to provide environmental hazards check.	Similar proportions of fractures were observed in both groups (5% [I] versus 4% [C]). More falls without fracture occurred in the intervention group (23% [I] versus 16% [C]). Stratifying by disability there were more falls for all disability levels in the intervention group participants. No results reported related to changes in environmental hazards and no indication of uptake/self reported falls and injurious falls implementation.	Injury N Falls N Hazards NA

DISCUSSION

It is logical to consider that the presence of environmental factors must play some part in the causation of injuries in the home. However, despite the inclusion of 19 randomised trials, the findings of this review suggest that there is little high-level scientific evidence for modification of the built home environment as a method of reducing the risk of injury.

Three of the included studies were demonstrably underpowered (Becker 2003; Jenson 2003; Pardessus 2002). Seven studies in older people (Becker 2003; Jenson 2003; Nikolaus 2003; Shaw 2003; Stevens 2001; van Haastregt 2000a; Vetter 1992) had injury reduction as a primary or specified outcome. Many of these were based on very small samples and could never be expected to detect a plausible effect size. The Vetter 1992 study was a randomised controlled trial of 674 people with the intervention group receiving an assessment and advice on nutritional deficiencies, referral for medical conditions, exercise classes and correction of environmental hazards. The outcome was a non-significant change in fracture rate; fracture rates were 5% in the intervention group and 4% in the control group. Environmental adaptations included adjustments to trailing wires, loose rugs, lighting levels and modification of dangerous slippery slopes. However, the penetrations of these interventions were not reported and the study would have suffered from very low power to detect an effect.

Seven trials (Carter unpublished; Clamp 1998; Close 1999; Gielen 2002; Kendrick 1999; King 2001; Stevens 2001) used a combined approach of direct or recommended modification and educational strategy. The study by King 2001 is interesting in that the intervention group had a 25% reduction (95% CI -4% to -42%) in injury visits to the doctor. However, the prevalence of environmental hazards was only significantly reduced for two of sixteen safety modifications: lowering of hot water temperature and presence of smoke alarms, but not for functioning smoke alarms. The actual observation of hazard changes was at variance with the self-reported adoption of safety precautions. The authors conclude that it is unlikely that the intervention had an impact on the adoption of home safety measures and that other effects of the intervention, such as behavioural changes, might explain the reduction in injuries. Similarly the study by Close 1999 found the risk of falling in the intervention group was significantly reduced but here they did not have hazard reduction as an outcome. Conversely two studies (Clamp 1998; Stevens 2001) reported a significant reduction in home hazards but either did not have injuries or falls as an outcome (Clamp 1998) or demonstrated no significant reduction in falls or injuries (Stevens 2001). Gielen 2002 and Carter unpublished demonstrated no significant reductions in falls or injuries or hazards. One trial (Posner 2004) used a combined approach of recommended modification with free safety devices and an educational strategy but did not include injuries as an outcome measure.

Nine of the trials (Becker 2003; Day 2002; Hogan 2001; Jenson 2003; Nikolaus 2003; Shaw 2003; Tinetti 1994; van Haastregt 2000a; Vetter 1992) were multi-factorial and all in the older people group. Five trials did not report hazard reduction outcomes (Becker 2003; Jenson 2003; Tinetti 1994; van Haastregt 2000a; Vetter 1992). Six trials in the older people category (Becker 2003; Day 2002; Jenson 2003; Nikolaus 2003; Pardessus 2002; Shaw 2003) reported falls data. Not all focused on falls requiring medical attention but included self-reported falls or those observed by residential care home staff. Shaw 2003 found a significant reduction in hazards between intervention and control groups making changes to improve home safety but no significant reduction in falls in IG and CG. In Nikolaus 2003 participants who made at least one of the home modification recommendations at 12 months follow-up experienced a significant reduction in the rate of falls (IRR 0.64, 95% CI 0.37 to 0.99, P = 0.047). Among the studies of older people, four (Becker 2003; Jenson 2003; Nikolaus 2003; Shaw 2003) included injury as an outcome measure. Three of the four reported non-significant differences between the intervention and control group (Becker 2003; Shaw 2003) with one having very small numbers (Nikolaus 2003). The picture was only a little different in Jenson 2003 where in the lower cognitive group the 171 participants sustained 10 femoral fractures, all of which were in the control group (result expressed as P = 0.006). However this study was seriously underpowered to detect such a difference a priori.

For the vast majority of these multi-factorial trials the effect of home modification on falls and/or injuries was either inseparable from other interventions or non-significant. While Nikolaus 2003 found 31% fewer falls in the intervention than in the control group, with the effect strongest in people who had fallen twice or more before the study, the intervention also included training in the use of technical and mobility aids. Day 2002 used a rigorous factorial design where the separate and additive effects of exercise training, vision improvement and house hazards management on falls could be assessed. The trial reported non-significant reductions in falls following home hazard management as a sole intervention but additive effects when combined with both of the other interventions. The actual hazards remediated were not described in the publication but the number of hazards following remediation was reduced by 17%, compared with changes in the control homes. Despite the incorporation of a rigorous design, the penetration of the intervention was low. Interventions which largely do not happen cannot be expected to substantially change outcomes. Many of the studies reported low uptakes of hazard interventions.

Two studies had home modification as the primary intervention (Cumming 1999; Pardessus 2002). Only one of these demonstrated a positive effect (Cumming 1999) with both a reduction in falls and a reduction in the prevalence of home hazards. As the

only intervention revolved around home hazard reduction it seems reasonable to conclude that the reduction in falls relates to the reduction in hazards. It is worth noting that this reduction only occurred in an intervention subgroup with a previous history of falls. Pardessus 2002 found no significant effect of the home modification intervention on falls outcomes but was underpowered to detect such an effect.

Overall there were five included studies involving children (Clamp 1998; Gielen 2002; Kendrick 1999; King 2001; Posner 2004). Posner 2004 reported significant changes in prevalence of safety features only following the intervention, there was no associated data on injury reduction. Only two of the studies considering children had sample sizes large enough to demonstrate anything but moderate to large reductions in injury. As previously discussed in the study by King 2001 the actual observation of hazard changes was at variance with the self-reported adoption of safety precautions so other effects of the intervention, such as behavioural changes, might explain the reduction in injuries. The Kendrick 1999 study included 2152 children in a cluster randomised trial of the provision of safety advice, low-cost safety equipment, home safety checks and first aid training over a period of two years. Injury occurrence (rate ratio 0.97, 95% CI 0.72 to 1.30) was not affected by the intervention. However, only 9.7% of the intervention group received low-cost safety equipment (stair gates, fireguards, cupboard locks and smoke alarms) and so the likelihood of demonstrating an effect related to this level of intervention was very low.

It is worth noting that there are currently no randomised controlled trials included in the mixed age group. A controlled clinical trial by Petridou 1997 included only 172 households and 636 people in the intervention group. Significant improvement in the provision of automatic electricity cut off services, and better lighting in corridors as well as first aid kits were reported post intervention but there was no changes in structural or expensive interventions for example, modification to stairs or balconies. A non-significant 21% reduction in home injuries was reported (95% CI -40% to +6%).

A limitation of many of the studies is the short timescale used in measuring the uptake of interventions. Most studies have a single measure of uptake, usually within three to 12 months of starting, and cannot comment on whether the intervention persisted in the long term. This will be a particular problem where the intervention is dependant on individual behaviour for example, whether rugs are replaced by the householder.

The low penetration of many of the interventions was noted in the original review. Most of the studies included consenting participants and none appeared to involve local people in the design, planning and implementation of the studies. The low penetration of the interventions was taken as an indication that most participants were ambivalent or not really convinced about the benefits of the interventions. Active participation of local people in the design of future studies was suggested as a means of increasing relevance and uptake. There is now evidence emerging from the update that this advice was followed in more recent studies.

The focus of this systematic review is on the prevention of injuries by the modification of the home environment. Most of the studies of older people used the incidence of falls rather than that of injuries as their main outcome measure. The majority of fractures in older people follow a fall, but only around one in 20 falls leads to a fracture. A reduction in the proportion of people in an intervention group suffering a fall should lead to a similar reduction in the proportion suffering a fracture, but the absolute number of fractures prevented will be much smaller. The effectiveness of such strategies as means of injury prevention will be correspondingly smaller, as will be the cost-effectiveness.

Studies using fracture incidence as their endpoint would need to be very much larger in scale, and this explains the literature's focus on fall prevention. Of the studies that included injuries as an outcome, two were underpowered (Becker 2003; Jenson 2003), one had small numbers of injuries (Nikolaus 2003) and one reported no significant difference between the intervention and control group rates (Shaw 2003). There is no doubt that falls and the fear of falling are significant public health problems in themselves, but one cannot automatically assume that success in a falls prevention strategy will necessarily be reflected in reduced rates of injuries or fractures.

An additional problem is posed by the fact that falls, injuries or fractures in a older people are commonly multi-factorial in origin. A child may suffer a fracture that reflects the severity of the trauma, but over 95% of fractures in older people occur after only minor or moderate trauma (Johansen 1999). Factors underlying the causation of falls or the reduced ability to react and cushion the impact, and those affecting bone fragility are all relevant to the occurrence of injuries in older people. Environmental modification cannot address all of these factors, and injury prevention studies in older people therefore tend to be multi-factorial in nature. This makes it more difficult to distinguish the contribution of environmental modification to the effectiveness of any strategy. Factorial designs, such as that used by Day 2002 are required to determine the contribution and cost-effectiveness of environmental modification for injury prevention.

A clear problem with many of the studies is the low power resulting from inadequate sample sizes in relation to plausible changes in baseline risks. Statistics are available that show that the likelihood of home injury varies with the age of the property. For example, the annual likelihood of a fall on the stairs is one in 320 in all dwellings, dropping from one in 180 in homes built before 1919 to one in 560 in post-1980 homes; the risk of a fall due to inadequate lighting is one in 560 for all homes, one in 320 for pre-1919

and one in 1000 for post-1980 properties (DTI 1997). Although such data do not take account of intrinsic risk factors in residents, and it is plausible that such intrinsic factors could confound the relationship between age of property and injury occurrence, it is unlikely that this is the full explanation. Consider the above example relating to stairs. Assuming a modification of the stairs (such as change from crazy pattern to plain carpets, or a change in the steepness of steps) was possible to implement and might have a modest impact on falls on the stairs, say a 35% reduction. Then, given the baseline frequency of injurious falls of one in 320 in older properties, a sample of nearly 109,000 is required to have an 80% power to detect such a difference at a 5% significance level. Assuming it was possible to find a subgroup with a ten-fold higher risk, then a sample of some 13,000 would still be required. Such studies would require an enormous change in the level of funding available to injury prevention researchers.

The conclusion of this systematic review is that there is very little high-grade evidence that interventions to modify the home physical environment affect the likelihood of sustaining an injury in the home. The first version of this review included 28 studies (13 randomised controlled trials, 14 controlled clinical trials and one before-and-after study). This update identified six additional randomised controlled trials which has allowed for the inclusion criteria of the updated review to now be limited to higher quality randomised controlled studies. However this review still does not provide a clear unequivocable evidence base that modification of the home environment reduces injuries. Only one study (Nikolaus 2003) demonstrated that a programme of home modification based on home visits to assess environmental hazards, provide information on possible changes and facilitate any necessary home modifications was effective in reducing repeated falls (not necessarily injuries) in a small sub-group of frail older individuals (360 participants in the study). This is not the same as saying that such interventions are ineffective. Multi-factorial interventions can be effective as demonstrated by Day 2002. However, it is important to know the cost-effectiveness of specific components of multi-factorial interventions, so that scarce resources can be targeted to the most effective interventions. In order to answer these questions, future studies should adopt a factorial design and have sufficient power to detect modest, but important, changes in injury occurrence.

Limitations of the review

Publication bias can threaten the validity of systematic reviews if research which does not reach statistical significance or produces a counter intuitive result is not published. We searched a large number of electronic databases covering health, social science and architectural domains. We did not contact lead researchers in this update to ask about unpublished material, although this was done in the original review, since it had had a very low yield and was resource intensive. We did not carry out manual handsearching of recent journals, as this task was beyond the resources available. We cannot rule out the possibility, therefore, of missing studies published in journals not indexed in the electronic databases and which have not been referenced in any of the included studies. This review is limited to interventions with primary outcomes of reductions in injuries, falls and the prevalence of home hazards. It does not comment on the effectiveness of physical modification of the home environment with the intention of influencing other outcome measures, for example, morbidity, satisfaction, independence or quality of life.

AUTHORS' CONCLUSIONS

Implications for practice

Injuries occur as a result of complex interactions between individuals and the environment and can always be considered multi-factorial in nature. The results of this systematic review of modifying the physical environment in the home to reduce injuries (with the exception of the provision and promotion of smoke alarm ownership, which was excluded from the review) demonstrate a paucity of evidence on which to base current practice. Whilst it is logical to deduce that physical hazards and poor design and layout contribute to a sequence of events culminating in an injury, it is not possible to conclude that the amelioration of such hazards will definitely reduce the number of injuries. Nor is it possible to determine which aspects of multi-factorial interventions are most cost effective. In the absence of good quality evidence, it is human nature for individuals to use interventions in the hope that they might be effective. This review has not shown that such interventions do not work. The quality and size of the studies were not sufficiently good or large to reach definitive conclusions in most cases.

Implications for research

Randomised controlled trials provide the gold standard for the assessment of the effectiveness of interventions. This review shows the paucity of appropriately designed and sized studies to test the effectiveness of interventions to remove or reduce physical hazards in the home environment in reducing injury occurrence.

Studies were generally too small to have sufficient power to detect anything but a very large effect and rarely employed a factorial design that would allow an assessment of specific interventions as part of a multi-factorial intervention. Most studies had very low uptake rates for interventions. The active involvement of participants in the design of studies might improve this. The challenge to the global injury research community is to collaborate to design and implement studies of a sufficient size, rigorous design and acceptability to participants to answer these important questions.

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* *Indicates the major publication for the study*

CHARACTERISTICS OF STUDIES

Characteristics of included studies *[ordered by study ID]*

Becker 2003

Methods	RCT
Participants	Long-stay residents>60 from 6 community nursing homes.
Interventions	Staff and resident education on fall prevention, advice on environmental adaptations, balance and resistance training,hip protectors.
Outcomes	Falls, injury (fractures).
Notes	

Risk of bias

Item	Authors' judgement	Description
Allocation concealment?	Yes	A - Adequate

Carter unpublished

Methods	RCT
Participants	Patients >70 years of age identified from patient lists of 37 family physicians. n=163(I1) n=133(I2) n=161(C)
Interventions	Brief intervention - Home visit assessment of house/garden for hazards. Post-home visit - summary of hazards found and given pamphlet on home safety and use of medications. Intensive intervention-Home assessment as above. Post-assessment participant joint development of action plan including actions to be taken to modify hazards found. Phone prompts for action plan were provided after 3 and 6 months. 6-month follow-up advised to see family physician for medication review. Home hazards not specifically reported. Control group received no intervention.
Outcomes	Falls and falls resulting in medical attention, hazard reduction.
Notes	

Risk of bias

Item	Authors' judgement	Description
Allocation concealment?	Yes	A - Adequate

Clamp 1998

Methods	RCT
Participants	Families with children <5 years registered with a single-handed general practice. n=83(I) n=82(C)
Interventions	Intervention group families received GP safety advice and leaflets to promote the use of smoke alarms, stair gates, fireguards, cupboard locks, covers for electric sockets and door slam devices. Access to low-cost safety equipment was made available for families receiving means tested state benefits. Control group families received usual care.
Outcomes	Prevalence of safety devices and practices.
Notes	

Risk of bias

Item	Authors' judgement	Description
Allocation concealment?	Yes	A - Adequate

Close 1999

Methods	RCT
Participants	All patients >65 years living in the local community who attended A & E department with a primary diagnosis of a fall between Dec 1995 and June 1996. n=184(I) n=213(C)
Interventions	Intervention group participants received a single home visit by occupational therapist after medical assessment. Environmental hazards were identified using a checklist. Control group patients received usual care.
Outcomes	Primary diagnosis of a fall, hospital admissions.
Notes	

Risk of bias

Item	Authors' judgement	Description
Allocation concealment?	Yes	A - Adequate

Cumming 1999

Methods	RCT
Participants	Inpatients, >65 years of age, in 2 hospitals. Also recruitment from outpatient clinics at study hospitals and local day care centres for older people. n=264(I) n=266(C)
Interventions	Intervention group participants received home visit by an occupational therapist who conducted a 1-hour home assessment using a standardised form to record hazards and facilitated necessary home modifications. Modifications included:removal of mats and electrical cords, installation of non-slip mats, night-lights and stair rails and advice on footwear and activities. Control group participants received usual care.
Outcomes	Falls, and modifications to the home.
Notes	

Risk of bias

Item	Authors' judgement	Description
Allocation concealment?	Yes	A - Adequate

Day 2002

Methods	RCT
Participants	Independent community-dwelling elderly >70 years of age registered on the Australian electoral roll for the area. n=395(I) n=47(C)
Interventions	Factorial intervention trial of group-based exercise including a balance component, home hazard management and vision improvement delivered separately or combined. Control participants received no intervention until after study end. Home hazards intervention consisted of a walk-through checklist for rooms used in a normal week to review steps/stairs, floor surfaces, lighting, bathroom fittings and furniture and the removal/modification of home hazards either by participants or via the City's home maintenance staff. The control group received a home visit by a research nurse for baseline questionnaire and risk factor measurements before randomisation took place (as did intervention group), a falls calender for monthly falls recording and other variables (as did intervention group), phone call if their calendar was more than 7-10 days late in being returned each month (as did intervention group), a phone call if fall reported and a telephone interview regarding circumstances of the fall (as did intervention group), promise of being given most effective intervention at study end. About 50% of control group were been re-visited at study end for risk factor measurements & questionnaire (as did intervention group). There was however no placebo intervention for the control group, so they did not for example receive visits by a social worker etc.
Outcomes	Falls and hazard reduction

Day 2002 (*Continued*)

Notes		
Risk of bias		
Item	**Authors' judgement**	**Description**
Allocation concealment?	Yes	A - Adequate

Gielen 2002

Methods	RCT
Participants	Paediatric residents in a large, urban teaching hospital in Maryland. Parents/guardians of infants 6 months/of age. n=19(I1) n=94(I2) n=20(C1) n=93(C2)
Interventions	Intervention group parents received safety counseling and referral to Children's Safety Centre (providing safety products such as, safety gates, smoke alarms, and hot water thermometers)from paediatric residents plus a home safety visit by community health worker between patient's 6- and 9-month well-infant clinic visit. Paediatric residents received 2-part training program. (Physical hazards assessed during home visit unspecified). Control group families received the same as above without the home visit.
Outcomes	Prevalence of safety practices.
Notes	

Risk of bias

Item	Authors' judgement	Description
Allocation concealment?	Yes	A - Adequate

Hogan 2001

Methods	RCT
Participants	Ambulatory, community-dwelling residents, >65 years of age, of Calgary, Alberta. n = 79(I) n = 84(C)
Interventions	Intervention subjects received in-home assessments to identify both host and environmental risk factors in conjunction with the development of an individualised treatment plan, including an exercise program for those deemed likely to benefit. Environmental risk factors identified by example only. Examples include:no grab bars on bath/shower and

Hogan 2001 (*Continued*)

	the removal of floor rugs. Control group participants received a home visit from a recreational therapist who performed a leisure assessment following which a letter was sent to each participants GP.
Outcomes	Falls.
Notes	

Risk of bias

Item	Authors' judgement	Description
Allocation concealment?	Yes	A - Adequate

Jenson 2003

Methods	RCT
Participants	Living in residential care facilities, >65 years, could be assessed by Mini Mental Status Examination.
Interventions	Staff education, environmental adjustment, exercise, drug review, aids, hip protectors, post-fall problem-solving conferences.
Outcomes	Falls and injuries.
Notes	

Risk of bias

Item	Authors' judgement	Description
Allocation concealment?	Yes	A - Adequate

Kendrick 1999

Methods	RCT
Participants	All children aged 3-12 months registered with 36 participating general practices in Nottingham. All health visitors in Nottingham. n=1,100(I) n=1,019(C)
Interventions	Intervention group participants received:age-specific safety advice at child health surveillance consultations at 6-9, 12-15 and 18-24 months, provision of low cost safety equipment (stair gates, fireguards, cupboard locks and smoke alarms) to families on means tested state benefits and home safety checks by a health visitor. Physical hazards checked during home visit unspecified. Control group participants received usual care.

Kendrick 1999 (*Continued*)

Outcomes	Frequency and severity of medically attended injuries.	
Notes		
Risk of bias		
Item	**Authors' judgement**	**Description**
Allocation concealment?	Yes	A - Adequate

King 2001

Methods	RCT	
Participants	Participants <8 years old presenting to the Emergency Departments at 5 hospitals in 4 urban centres. n=601(I) n=571(C)	
Interventions	Study research assistant conducted home visits to observe home safety hazards for both control and intervention groups. Intervention group participants received an information package on injury prevention, discount coupons for safety devices, specific instruction regarding home safety measures and a letter from site project directors on need to maintain preventive behaviours. Hazards measured were:access to small and dangerous objects, absence of child resistant medicine containers, tap water greater than 54oC, functioning smoke detectors, fire extinguishers, stair gates, infant walkers, ease of opening basement door, absence of bicycle helmets and car restraints. Control group participants received a general pamphlet on safety and notification if a non-functioning smoke detector was found. All participants were contacted at 4 and 8 months.	
Outcomes	Injuries, hazard reduction.	
Notes		
Risk of bias		
Item	**Authors' judgement**	**Description**
Allocation concealment?	Yes	A - Adequate

Nikolaus 2003

Methods	RCT
Participants	Patients admitted from home to geriatric hospital with functional decline especially mobility.
Interventions	Geriatric assessment, home visit, advice regarding environmental hazards, facilities to address environmental hazards, training in use mobility aids.

Nikolaus 2003 (*Continued*)

Outcomes	Falls, hazard reduction.	
Notes		
Risk of bias		
Item	**Authors' judgement**	**Description**
Allocation concealment?	Yes	A - Adequate

Pardessus 2002

Methods	RCT	
Participants	Patients admitted following a fall to a geriatric hospital. Mean age 83.5 years.	
Interventions	Home visit to assess environmental hazards and recommend modifications.	
Outcomes	Falls.	
Notes		
Risk of bias		
Item	**Authors' judgement**	**Description**
Allocation concealment?	Yes	A - Adequate

Posner 2004

Methods	RCT	
Participants	Caregivers of <5 year olds who presented to casualty with acute unintentional injury sustained at home.	
Interventions	Comprehensive home safety education and free safety devices.	
Outcomes	Degree of improvement in safety practices assessed by improvement in safety scores.	
Notes		
Risk of bias		
Item	**Authors' judgement**	**Description**
Allocation concealment?	Yes	A - Adequate

Shaw 2003

Methods	RCT
Participants	>65 years, cognitively impaired, presenting to casualty following a fall.
Interventions	Home hazard modification using standard protocol, also medical and physiotherapy assessment and intervention.
Outcomes	Falls, injury rates, objective effect on environmental risk factors.
Notes	

Risk of bias

Item	Authors' judgement	Description
Allocation concealment?	Yes	A - Adequate

Stevens 2001

Methods	RCT
Participants	Residents, aged >70 years of age, living independently in the Perth metropolitan area and listed on the State Electoral Roll and the White Pages telephone directory. n=570(I) n=1167(C) individual households
Interventions	All members of both the intervention and the control groups received a home visit from a nurse. Intervention consisted of 3 strategies:a home hazard assessment, the installation of free safety devices and an educational strategy to empower seniors to remove or modify home hazards. Modifications included:installation of grab bars, removal of obstacles, removal/stabilization of rugs and mats, repair of damaged flooring, improving the height of chairs and improving poor lighting. Control subjects received no safety devices or information on home hazard reduction.
Outcomes	Falls, injurious falls, hazard reduction.
Notes	

Risk of bias

Item	Authors' judgement	Description
Allocation concealment?	Yes	A - Adequate

Tinetti 1994

Methods	RCT
Participants	>70 years of age, members of a Health Maintenance Organisation (HMO) with one of the following risk factors for falling: postural hypotension; use of sedatives; use at least four prescription medications; and impairment in arm or leg strength or range of motion, balance, ability to move safely from bed to chair or to the bathtub or toilet, or gait. n=153 (I) n=148 (C)
Interventions	Multifactorial intervention. Intervention group received home assessment visit by a nurse followed 1-week later by physical therapist. Nurse assessment included:postural hypotension, medication review and use, transfer and gait training skills, balance exercises and exercises with resistive tools. Appropriate changes to environmental hazards for falls or tripping were made such as removal of hazards, safer furniture (correct height, more stable), installation of structures such as grab bars or handrails on stairs determined by room-by-room assessment. Control group received home visits from social-work students where structured interviews were conducted.
Outcomes	Falls.
Notes	

Risk of bias

Item	Authors' judgement	Description
Allocation concealment?	Yes	A - Adequate

van Haastregt 2000b

Methods	RCT
Participants	Participants, >70 years of age, from 6 general practices in Hoensbroek, who had reported two or more falls in the previous six months or had scored three or more on the mobility control scale of the short version of the sickness impact profile. n=159(I) (n=138 received standard intervention programme n=21 did not receive standard intervention programme) n=157(C)
Interventions	Multifactorial intervention. Intervention group received 5 home visits by community nurse over a period of 1 year. During home visits participants were screened for medical, environmental and behavioural factors potentially influencing falls and mobility and followed by advice, referrals and other actions aimed at dealing with observed hazards. The control group did not receive any special attention or intervention on prevention of falls and impairments in mobility. No details of any home modification given.
Outcomes	Falls, injurious falls.
Notes	

Risk of bias

van Haastregt 2000b (*Continued*)

Item	Authors' judgement	Description
Allocation concealment?	Yes	A - Adequate

Vetter 1992

Methods	RCT
Participants	70 years of age patients registered at a group practice of 5 General Practitioners in a Welsh market town. n=350(I) n=324(C)
Interventions	Intervention participants received intensive health visiting, over 4 years, to provide nutrition advice and make medical and environmental checks environmental hazards included:trailing wires, loose carpets, outside toilets, lighting levels and slippery slopes. Muscle tone and fitness levels were addressed at physiotherapist-led classes. Health visitor visited as often as believed to be necessary, carrying out referrals. Details concerning the control group are not available.
Outcomes	Change in fracture rates, falls.
Notes	

Risk of bias

Item	Authors' judgement	Description
Allocation concealment?	Yes	A - Adequate

Characteristics of excluded studies *[ordered by study ID]*

Assantachai 2002	Community based with no home hazard intervention.
Clemson 1996	Case-control study.
Colver 1982	Controlled clinical trial. Allocation concealment unclear.
Dershewitz 1979	Controlled clinical trial. Allocation concealment unclear.
Duff 2002	Undefined access to home equipment with no measure of change to physical hazards.
Durongritichai 2003	PRECEDE-PROCEED methodology with randomisation not described.
Haynes 2003	No intervention that met inclusion criteria.
Hermann 1999	German-language paper translated does not meet inclusion/exclusion criteria.
Hornbrook 1994	Controlled clinical trial. Allocation concealment unclear.
Huang 2003	No intervention to meet inclusion criteria.
Huang 2004	Controlled clinical trial. Allocation concealment unclear.
Katcher 1989	Controlled clinical trial. Allocation concealment unclear.
Kelly 1987	Controlled clinical trial. Allocation concealment unclear.
Laffoy 1997	Case-control.
Lightbody 2002	Controlled clinical trial. Allocation concealment unclear.
McLean 1996	Case-control.
McMurdo 2000	Environmental intervention was not undertaken.
Morgenstern 2000	Stage 1: cohort. Stage 2: case-control.
Northridge 1995	Cohort.
Ozanne-Smith 2002	Ecological study. Changes to hazards not reported at a household level.
Paul 1994	Controlled clinical trial. Allocation concealment unclear.
Petridou 1996	Case-control.
Petridou 1997	Controlled clinical trial. Allocation concealment not used.
Plautz 1996	Interrupted time-series. Insufficient data gathering points.

(*Continued*)

Poulstrop 2000	Controlled before and after study.
Ramsey 2003	No intervention that meets inclusion criteria.
Robson 2003	Controlled clinical trial. Allocation concealment unclear.
Runyan 1992	Case-control.
Sattin 1998	Case-control study.
Schwarz 1993	Controlled clinical trial. Allocation concealment not used.
Spiegel 1977	Interrupted time-series. Insufficient data gathering points.
Steinberg 2000	Controlled clinical trial. Allocation concealment unclear.
Studenski 1994	Cohort study.
Sznajder 2003	Controlled clinical trial. Allocation concealment unclear.
Tanner 2003	No outcome that met inclusion criteria.
Thomas 1984	Controlled clinical trial. Allocation concealment unclear.
Thompson 1996	Interrupted time series. Insufficient data gathering points.
Tideiksaar 1990	Interrupted time-series. No control group.
van Rijn 1991	Case-control.
Wagner 1994	Controlled clinical trial. Allocation concealment not used.
Waller 1993	Controlled clinical trial. Allocation concealment unclear.
Yates 2001	Controlled clinical trial. Allocation concealment not used.
Ytterstad 1996	Controlled before and after study. Allocation concealment not used.

Characteristics of ongoing studies *[ordered by study ID]*

Kendrick ongoing

Trial name or title	A randomised controlled trial of health visitor safety advice plus low-cost safety equipment for families living in deprived areas.
Methods	
Participants	All families with children under 5 years on the caseloads of participating health visitors. All health visitors working in deprived areas, defined by practice Townsend score.
Interventions	The Intervention involves: families completing a checklist of safety practices/safety equipment prior to health visitor consultation; a consultation with the health visitor to assess safety practices and needs for safety equipment; safety equipment offered free to low income families or at cost price to non low income families; safety equipment fitted in homes of low income families; a home safety checklist to be completed one week after health visitor consultation.
Outcomes	The primary outcome measure will be the proportion of families in which at least one child experiences a medically attended unintentional injury in the two year follow up period. Secondary outcome measures: these include safety equipment possession and use and other safety practices.
Starting date	01/11/1999
Contact information	Dr Denise Kendrick Division of General Practice University of Nottingham Queen's Medical Centre Nottingham NG7 2UH Telephone: 0115 970 9387 Fax: 0115 970 9389
Notes	This trial is currently (July 2003) being analysed.

DATA AND ANALYSES

This review has no analyses.

APPENDICES

Appendix 1. Search strategy

The searches were based on the following strategy adapted as appropriate to the specifications of each database. The strategy was deliberately designed to capture a broad range of references and the 'explode' feature was used wherever this was applicable to the database.

Set 1
#1 housing or house*
#2 home* or abode*
#3 accommodation*
#4 residence* or residential
#5 apartment* or flat*
#6 maisonette*
#7 condo or condominium*
#8 dwelling or domocil*
#9 menage or bedsit*
#10 domestic or living quarter*
#11 stair* or modificat*
#12 building* or estate*
#13 neighbourhood* or neighborhood*
#14 urban environment*
#15 buil* environment
#16 environment* design*
#17 ergonomic*
#18 local authorit*
#19 or/#1-#18
Set 2
#20 injury or injuries
#21 accident* or wound*
#22 fall* or scald* or burn*
#23 suffocat* or poison*
#24 fire* or fracture*
#25 or/#20-#24
#26 = Set #1 and Set #2
*=wildcard that was used as a substitute for one or more missing characters. For each database that used a structured thesaurus (Medical Subject Headings, MeSH for example) appropriate indexing words are chosen. In addition, each of the words above were searched as a text word. Results, as indicated, for each individual set were combined using the Boolean 'OR' term and the two sets were then combined using the Boolean 'AND' term for each database.

WHAT'S NEW

Last assessed as up-to-date: 31 July 2006.

11 July 2008	Amended	Converted to new review format.

HISTORY

Protocol first published: Issue 3, 2002

Review first published: Issue 4, 2003

16 August 2006	New search has been performed	August 2006 This update of the original review includes studies identified in literature searches performed to December 2004. Since the original study a further six randomised controlled trials have been indentified and the review is now limited to high quality randomised controlled trials, providing the best evidence available. There are 18 completed published randomised controlled trials and one unpublished study investigating the effect on injuries of modification of the home environment. There are no randomised controlled trials that met the inclusion criteria in the mixed age group. There is still insufficient evidence to determine the effects of interventions to modify environmental home hazards.

CONTRIBUTIONS OF AUTHORS

RL helped to write and edit the protocol, critically appraise included studies, write the results, discussion and authors' conclusions of the review, complete tables and make review amendments as recommended by the peer referees.

AJ ran searches of for the update, screened abstracts, critically appraised studies, wrote updated sections.

SB sreened abstracts for the update, critically appraised included studies.

LS helped to design the protocol, run electronic database searches, screen records, critically appraise included studies, write all review sections except the results, discussion and authors' conclusions, complete tables and references and make review amendments as recommended by peer reviewers.

AW helped to design the protocol, develop the search strategy, run electronic database searches, screen records, critically appraise included studies and commented on the review.

JW helped to develop the search strategy, run electronic database searches, screen records, critically appraise included studies and edit included studies table.

AJ was a member of the critical appraisal team.

SJ was a member of the critical appraisal team.

SL was a member of the critical appraisal team.

AK was a member of the critical appraisal team.

BR was a member of the critical appraisal team.

DECLARATIONS OF INTEREST

None known.

INDEX TERMS

Medical Subject Headings (MeSH)

*Housing; Accidents, Home [*prevention & control]; Controlled Clinical Trials as Topic; Interior Design and Furnishings; Randomized Controlled Trials as Topic; Wounds and Injuries [*prevention & control]

MeSH check words

Aged; Child; Humans