Shock-absorbing flooring for fall-related injury prevention in older adults and staff in hospitals and care homes: the SAFEST systematic review

Amy Drahota,[1*] Lambert M Felix,[1] James Raftery,[2] Bethany E Keenan,[3] Chantelle C Lachance,[1] Dawn C Mackey,[4] Chris Markham,[1] Andrew C Laing,[5] Kirsten Farrell-Savage[1] and Olanrewaju Okunribido[6]

[1]School of Health and Care Professions, University of Portsmouth, Portsmouth, UK
[2]Wessex Institute, University of Southampton, Southampton, UK
[3]School of Engineering, Cardiff University, Cardiff, UK
[4]Department of Biomedical Physiology and Kinesiology, Simon Fraser University, Burnaby, BC, Canada
[5]Department of Kinesiology, University of Waterloo, Waterloo, ON, Canada
[6]Health and Safety Executive Science and Research Centre, Buxton, UK

*Corresponding author amy.drahota@port.ac.uk

Declared competing interests of authors: Amy Drahota and Bethany E Keenan collaborated with the Health and Safety Laboratory (2018–20) on some unfunded academic research using a new testing procedure to assess the shock absorbency of various floor coverings. Five flooring manufacturers delivered free samples for use in the project; Amy Drahota and Bethany E Keenan have no stake in any of these companies. In 2015, Amy Drahota was involved in a collaborative funding application with Polyflor Ltd (Manchester, UK) for some SBRI Healthcare innovation funding. The application was shortlisted, but was unsuccessful. Amy Drahota has no stake in Polyflor Ltd. Andrew C Laing reports grants from SofSURFACES Inc. (Petrolia, ON, Canada), and grants and personal fees from SorbaShock LLC (Fort Wayne, IN, USA) and Viconic Sporting (Dearborn, MI, USA) outside the submitted work. Andrew C Laing was a member of an ASTM International Work Group (WK38804), whose technical contact is the president of Seamless Attenuating Technologies (SATECH), Inc. (Chehalis, WA, USA). SATECH, Viconic Sporting and Mannington Mills (Salem, NJ, USA) have donated flooring materials to Andrew C Laing's laboratory that have formed the basis of several studies examining the biomechanical effectiveness of compliant flooring (i.e. safety flooring). Andrew C Laing has never had (nor does he currently have) any financial links to these companies. Chantelle C Lachance is employed at the Canadian Agency for Drugs and Technologies in Health (CADTH) outside the submitted work. Amy Drahota, Dawn C Mackey, Chantelle C Lachance and Andrew C Laing authored original research papers that were included in this review. James Raftery is a member of the National Institute for Health Research Health (NIHR) Technology Assessment and Efficacy and Mechanism Evaluation Editorial Board (2012–present). He was also director of the Wessex Institute, University of Southampton (2005–12), and was concurrently director of the NIHR Evaluation, Trials and Studies Coordinating Centre, part of the Wessex Institute, which was funded by NIHR.

Published January 2022
DOI: 10.3310/ZOWL2323

Scientific summary

SAFEST systematic review

Health Technology Assessment 2022; Vol. 26: No. 5
DOI: 10.3310/ZOWL2323

NIHR Journals Library www.journalslibrary.nihr.ac.uk

Scientific summary

Background

Falls have significant morbidity, mortality and economic impacts, particularly for older adults, and are the most common safety incident in hospitals and care homes. Falls and injuries have numerous risk factors and potential interventions. In this review, the focus is on shock-absorbing flooring, which aims to prevent fall-related injuries by reducing the impact forces experienced when individuals come into contact with the ground. Shock-absorbing floors vary in design, cost and suitability for use in different areas of care settings. They include novel, compliant floors designed to prevent injuries in older adults, sports floors that have been repurposed for use in health and social care, and more common flooring types (carpet and wooden subfloors) that may offer more shock absorbency than alternatives (standard vinyl and concrete subfloors). To date, and to our knowledge, there has been no systematic review on shock-absorbing flooring to help inform practice.

Objectives

We aimed to review the evidence on shock-absorbing flooring use in hospitals and care homes for fall-related injury prevention among older adults. The objectives were to:

- assess the potential benefits (fall-related injury prevention) and risks (falls, staff injuries) of different flooring systems in care settings
- assess the extent to which these potential benefits and risks may be modified by different study/setting, intervention and participant characteristics
- critically appraise and summarise current evidence on the resource use, costs and cost-effectiveness of shock-absorbing flooring in care settings for older adults, compared with standard flooring
- summarise findings on the implementation of flooring interventions in the included studies
- summarise the views and experiences of shock-absorbing flooring use from staff's, patients', residents' and visitors' perspectives
- identify gaps in existing evidence.

Methods

This review incorporated evidence from quantitative, qualitative and economic studies. Studies needed to evaluate the use of shock-absorbing flooring in hospitals or care homes, with a target population of older adults (or staff, if evaluating adverse events). A comprehensive search incorporated the findings from a previous scoping review and updated the search strategy to identify newly published evidence. We searched six electronic databases (AgeLine, Cumulative Index to Nursing and Allied Health Literature, MEDLINE, Scopus, Web of Science and the NHS Economic Evaluation Database; last searched 29 September 2019), websites, trial registries, conference proceedings, and the journal *Age and Ageing*; conducted forwards and backwards citation searches of included studies; and liaised with researchers in the field. We screened the titles and abstracts of the search results in duplicate against the eligibility criteria. Two independent review authors assessed publications that appeared relevant, and all clinical effectiveness and cost-effectiveness records identified by the former scoping review, in full, against the eligibility criteria.

Clinical effectiveness methods

Data extraction and risk-of-bias assessments were undertaken independently in duplicate; a third review author and discussion were used to resolve disagreements. Data were collected on study population characteristics, interventions, comparators, outcomes, settings, study methods, and public and patient involvement. Study results pertaining to seven prioritised outcomes were assessed for risk of bias using one of three complementary tools, depending on the study design: the Cochrane Risk of Bias tool version 2.0, the Risk of Bias tool version 2.0 extension for cluster trials and the Risk Of Bias In Non-randomized Studies – of Interventions tool. Data were pooled in meta-analyses depending on the data type, using rate ratios or risk ratios (for falls, injuries and head injuries) with generic inverse variance analyses (random effects), or odds ratios with Mantel–Haenszel analyses (fixed effect) when outcomes were rare (fractures and hip fractures). We derived data when feasible and obtained missing data from study investigators.

We explored the influence of setting, flooring type and study design on the measures of effectiveness, and conducted sensitivity analyses to determine the robustness of the findings to our analysis decisions, risk-of-bias assessments and use of unpublished data. Heterogeneity was assessed through visual inspection of forest plots, tests for homogeneity (χ^2), and measures for inconsistency (I^2) and heterogeneity (τ^2). The quality of the evidence, including an assessment of potential selective reporting, was evaluated using the Grading of Recommendations Assessment, Development and Evaluation approach and summarised in tables.

Qualitative synthesis methods

Qualitative studies were synthesised using meta-aggregation. Two independent review authors critically appraised each study, extracted data and rated the credibility of each study finding. Disagreements were resolved through discussion. Study findings were organised into categories of similar meanings and aggregated into synthesised findings. The quality of the synthesised findings was summarised using the Confidence in the Evidence from Reviews of Qualitative research approach.

Cost-effectiveness methods

Economic studies were reviewed against good-practice guidelines (Consolidated Health Economic Evaluation Reporting Standards). Data were extracted on whether or not studies addressed a well-defined research question; used an appropriate type of study design, with a full description of options; provided a rationale for the structure; and had relevant outcomes, with an appropriate perspective and time frame, as well as appropriate costs, assumptions and methods. Key data were estimated when possible. One review author carried out assessments, which were then checked by another review author; disagreements were resolved through discussion. We tabulated and narratively summarised the findings. We adjusted all costs to 2019 Great British pounds values using gross domestic product deflators and using relevant exchange rates for international comparisons.

Results

We screened 3444 records after removal of duplicates; 79 of these were assessed in full. Twenty-nine papers reporting 22 studies met the inclusion criteria.

Summary of clinical effectiveness results

We identified 12 quantitative studies, 10 of which contributed data to the prespecified outcomes (three to seven studies per outcome). We analysed data from three randomised controlled trials (one care home-based and two imprecise hospital-based studies) and seven observational studies (three care home-based and four hospital based), with problems of confounding. There is high-quality evidence that a novel shock-absorbing underlay produces similar injury and falls rates to those produced by a plywood underlay with vinyl overlays and concrete subfloors in care homes. Including three observational care home-based studies presents very low-quality evidence that shock-absorbing

flooring may reduce the number of falls resulting in injury, but no further data contributes to the analysis of injurious falls rate in care homes. We found very low-quality evidence that shock-absorbing flooring use in hospitals may reduce injuries without increasing the rate of falls. Data on fractures and head injuries were generally too imprecise to determine effectiveness; however, one observational study at high risk of bias indicated that fewer hip fractures were likely to occur on wooden subfloors than on concrete subfloors.

Novel floors, sports floors and carpet all demonstrated a reduction in injuries (very low-quality evidence), depending on how the data were analysed (i.e. as a rate or risk), while retaining the probability that they may not increase the falls rate or risk of being a faller. Head-to-head comparisons of different shock-absorbing flooring types were all based on one imprecise study, and the evidence remains uncertain. Although some adverse events were described, there is very low-quality evidence that novel and sports floors do not result in more staff injuries in 2 years' follow-up. However, shock-absorbing floors do affect the work environment, resulting in adaptations to staffing levels and schedules to accommodate the increased effort required to move wheeled objects. Implementing shock-absorbing flooring will not successfully protect people from injury in all falls; however, upwards of 75% of falls in the studies we assessed occurred on the intervention flooring when at least the bedded areas were covered with the intervention floor.

Summary of qualitative evidence

Five qualitative studies generated 69 findings (61 unequivocal and eight credible), creating 10 categories, which generated three synthesised findings. The quality of the studies was generally good, albeit the philosophical perspectives were unclear: one study lacked clarity around the researchers' cultural/theoretical positions and another lacked representation of the participants' voices. Based on these findings, we have a moderate level of confidence that shock-absorbing flooring is viewed by many as a potential solution to help protect people from fall-related injuries, with a potential side effect of improving environmental comfort. We have a high level of confidence that changing flooring has consequences for the wider system (e.g. affecting the ease of moving equipment), potentially leading to further adaptations and adjustments in behaviours, attitudes, equipment, processes and staffing. We have a moderate level of confidence that installation may be an initial concern, but can be effectively managed; however, cost and funding considerations need to extend beyond the initial purchase and installation to consider potential adaptations in staffing/processes/equipment, and potential cost-savings from fall-related injury prevention (should the floor be effective).

Summary of economic results

Five studies contributed economic data, four of which were very low quality. Although there was heterogeneity between the floors, settings and population groups assessed, the assumptions made in the poorer-quality studies may have been unduly optimistic. Three of these found that shock-absorbent floors dominated standard floors in that costs were lower and outcomes improved, and one estimated that shock-absorbing floors increased both costs and the number of quality-adjusted life-years gained, but at a cost per additional quality-adjusted life-year that was well above the accepted threshold level. The quality-adjusted life-year gains in these studies were a result of assuming relatively large quality-adjusted life-year losses due to hip fracture. Only the higher-quality study collected data on quality of life. This study found reduced quality-adjusted life-years, albeit with reduced costs, which, despite a favourable incremental cost-effectiveness ratio, was noted to be a result that was unlikely to lead to implementation. The reduced quality-adjusted life-years in this study were based on the assumption that shock-absorbing flooring increases falls risk; a sensitivity analysis demonstrated that, if shock-absorbing flooring does not increase the number of fallers and reduces the number of injurious falls, the intervention floor would become dominant.

Conclusions

The quantitative evidence relates to novel floors, sports floors, carpet and different subfloors, whereas the economic and qualitative evidence relates mostly to novel and sports floors. Apart from two randomised controlled trials, the quantitative studies were generally assessed as being at serious risk of bias for most outcomes, and were heterogeneous in terms of comparisons assessed, settings of care, outcome definitions and study designs; that noted, most meta-analyses were statistically homogeneous, albeit many had few contributing studies.

Implications for health and social care

The evidence suggests that one type of novel, shock-absorbing floor in care homes may be no more effective than rigid flooring; however, gaps still exist in the knowledge. There is very low-quality evidence that shock-absorbing flooring may reduce injuries in hospitals and care homes, without increasing falls, and that wooden subfloors may result in fewer hip fractures than concrete subfloors. The economic evidence (based on sports flooring) suggests that, if injurious falls are reduced and the number of falls is not increased, then shock-absorbing flooring would be a dominant strategy. The evidence in favour of shock-absorbing flooring is, however, of very low quality, meaning that future research may change our understanding, and there is much uncertainty. If future research indicates an increased risk of falling on shock-absorbing flooring, then the economic evidence suggests that this would result in an undesirable reduction in quality-adjusted life-years, even if injurious falls were reduced.

The review findings indicate that introducing shock-absorbing flooring to care settings has wider workplace implications, meaning that adaptations may be required in staffing levels, schedules, equipment and processes. Staff find it harder to manoeuvre wheeled equipment on shock-absorbing floors, and the evidence indicates both that adaptations are made to accommodate this and that there is no overall increased risk of flooring-related staff injuries (very low-quality evidence). The evidence indicates that, if planning to install shock-absorbing flooring, it is important to consider the wider impacts (and related costs) on the workplace and how best to manage these; the current economic evidence has not evaluated these costs.

Recommendations for research

The following recommendations for research have been prioritised:

- The current evidence base is diverse concerning how outcomes are defined, prioritised, measured, analysed and reported. In addition, there are complexities related to unit of analysis (i.e. individuals may experience multiple falls and injuries of different severities and in different setting locations), which complicate analyses and future syntheses. A clearly defined core outcome set needs to be established, which should include recommendations for measurement, analysis and reporting.
- The majority of quantitative studies included in this review were observational, judged to be at serious risk of bias, and did not address the primary outcomes of injurious falls rate and falls rate. Certain questions (e.g. regarding carpets and different subfloors) may lend themselves well to observational study designs; however, these should address the above core outcome set and comprehensively deal with potential confounding. Other questions (particularly regarding new flooring interventions) lend themselves more readily to pragmatic randomised controlled trial designs, of which there is a paucity.
- The dearth of robust research on the effectiveness of shock-absorbing flooring in hospital settings should be addressed. Hospitals differ from care homes, for example regarding the population characteristics, patient turnover, equipment in use and environmental characteristics.
- Implementing shock-absorbing flooring leads to workplace adaptations. Future research should plan for these adaptations in the study design, for example with process evaluations and risk management plans to better mitigate, manage and evaluate the risks to staff. A shock-absorbing flooring intervention could entail the implementation of a package of measures for the protection of patients and staff (such as new equipment suitable for softer surfaces, an additional staff member to support manual handling activities, etc.). As part of these considerations, further research and innovation is required to identify how best to adapt the workplace to accommodate shock-absorbing flooring.

- There is currently limited high-quality economic evidence exploring flooring interventions. Future economic evaluations should:
  - provide improved specifications of the alternatives evaluated
  - distinguish falls by severity and type
  - specify the processes by which reductions in type of falls were expected to lead to improved health
  - use appropriate time frames, particularly when mortality is included
  - provide greater levels of detail to enable different definitions of costs to be used in estimated incremental cost-effectiveness ratios; consideration should be given to the costs of additional workplace adaptations.
- With the uncertainty surrounding current flooring solutions, research and innovation is required to establish the specifications for improved products to support fall-related injury prevention in care settings.

We are unaware of any ongoing studies in these areas.

Study registration

This study is registered as PROSPERO CRD42019118834.

Funding

This project was funded by the National Institute for Health Research (NIHR) Health Technology Assessment programme and will be published in full in *Health Technology Assessment*; Vol. 26, No. 5. See the NIHR Journals Library website for further project information.

Health Technology Assessment

ISSN 1366-5278 (Print)

ISSN 2046-4924 (Online)

Impact factor: 4.014

Health Technology Assessment is indexed in MEDLINE, CINAHL, EMBASE, the Cochrane Library and Clarivate Analytics Science Citation Index.

This journal is a member of and subscribes to the principles of the Committee on Publication Ethics (COPE) (www.publicationethics.org/).

Editorial contact: journals.library@nihr.ac.uk

The full HTA archive is freely available to view online at www.journalslibrary.nihr.ac.uk/hta. Print-on-demand copies can be purchased from the report pages of the NIHR Journals Library website: www.journalslibrary.nihr.ac.uk

Criteria for inclusion in the *Health Technology Assessment* journal

Reports are published in *Health Technology Assessment* (HTA) if (1) they have resulted from work for the HTA programme, and (2) they are of a sufficiently high scientific quality as assessed by the reviewers and editors.

Reviews in *Health Technology Assessment* are termed 'systematic' when the account of the search appraisal and synthesis methods (to minimise biases and random errors) would, in theory, permit the replication of the review by others.

HTA programme

Health Technology Assessment (HTA) research is undertaken where some evidence already exists to show that a technology can be effective and this needs to be compared to the current standard intervention to see which works best. Research can evaluate any intervention used in the treatment, prevention or diagnosis of disease, provided the study outcomes lead to findings that have the potential to be of direct benefit to NHS patients. Technologies in this context mean any method used to promote health; prevent and treat disease; and improve rehabilitation or long-term care. They are not confined to new drugs and include any intervention used in the treatment, prevention or diagnosis of disease.

The journal is indexed in NHS Evidence via its abstracts included in MEDLINE and its Technology Assessment Reports inform National Institute for Health and Care Excellence (NICE) guidance. HTA research is also an important source of evidence for National Screening Committee (NSC) policy decisions.

This report

The research reported in this issue of the journal was funded by the HTA programme as project number 17/148/11. The contractual start date was in February 2019. The draft report began editorial review in August 2020 and was accepted for publication in January 2021. The authors have been wholly responsible for all data collection, analysis and interpretation, and for writing up their work. The HTA editors and publisher have tried to ensure the accuracy of the authors' report and would like to thank the reviewers for their constructive comments on the draft document. However, they do not accept liability for damages or losses arising from material published in this report.

This report presents independent research funded by the National Institute for Health Research (NIHR). The views and opinions expressed by authors in this publication are those of the authors and do not necessarily reflect those of the NHS, the NIHR, NETSCC, the HTA programme or the Department of Health and Social Care. If there are verbatim quotations included in this publication the views and opinions expressed by the interviewees are those of the interviewees and do not necessarily reflect those of the authors, those of the NHS, the NIHR, NETSCC, the HTA programme or the Department of Health and Social Care.

Published by the NIHR Journals Library (www.journalslibrary.nihr.ac.uk), produced by Prepress Projects Ltd, Perth, Scotland (www.prepress-projects.co.uk).