

**Cost utility analysis of a shock-absorbing floor intervention to prevent injuries from falls in hospital wards for older people**

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## **Abstract**

### **Background**

Hospital falls place a substantial burden on health care systems. There has been limited research into the use of hospital flooring as an intervention against fall-related injuries.

### **Objective**

To assess the cost-effectiveness of shock-absorbing flooring compared to standard hospital flooring in hospital wards for older people.

### **Design**

A cost-utility analysis was undertaken drawing upon data collected in a pilot cluster randomised controlled trial and the wider literature.

### **Setting**

The trial included eight hospital sites across England. Four sites installed shock-absorbing flooring in one bay, and four maintained their standard flooring.

### **Measurements**

Falls and resulting injuries and treatment were reported by hospital staff. Data on destination of discharge were collected. Patients were followed-up at three months and further resource use data were collected. Health related quality of life was assessed, allowing quality adjusted life years (QALYs) to be estimated. The incremental cost effectiveness ratio of the shock-absorbing flooring was assessed compared to standard hospital flooring.

### **Results**

In the base case, the shock-absorbing flooring was cost saving, but generated QALY losses due to an increase in the faller rate reported in the intervention arm. Scenario analysis showed that if the shock-absorbing flooring does not increase the faller rate it is likely to represent a dominant economic strategy – generating cost savings and QALY gains.

### **Conclusion**

The shock-absorbing flooring intervention has the potential to be cost effective but further research is required on whether the intervention flooring results in a higher faller rate than standard flooring.

## **BACKGROUND**

Falls in hospital is a significant problem of international concern.[1-9] Research has been undertaken on the effectiveness of fall and injury prevention strategies,[10,11] however, the effectiveness of interventions can be limited due to poor compliance.[12] In this economic evaluation we focus on an alternative injury prevention strategy –a shock-absorbing flooring in elderly care wards.

## **METHODS**

We conducted an economic evaluation as part of the Helping Injury Prevention in Hospitalised Older People (HIP-HOP) Flooring Study.[13] We took a modelling approach so that costs and outcomes could be extrapolated beyond the end of the trial and to combine multiple data sources.

The trial was a prospective pilot cluster randomised controlled trial that included eight hospitals across England. Four sites installed shock-absorbing flooring (Tarkett Omnisports EXCEL [14]) in one ward bay, and four maintained their standard flooring. The wards were predominantly for older people. The trial recruited 226 participants to each arm during the intervention period, with the intervention group showing a non-significant increase in the incidence of falls (adjusted incidence rate ratio = 1.07, 95% confidence interval =0.64 to 1.81), but a non-significant reduction in injuries (adjusted incidence rate ratio = 0.58, 95% confidence interval =0.18 to 1.91).

### **Economic analysis**

We undertook a cost-utility analysis. This approach takes into account the differential health impact of different types of falls through the measurement of quality adjusted life years (QALYs) and allows the results to be compared against National Institute for Health and Clinical Excellence (NICE) funding thresholds. The analysis took the National Health Service (NHS) and Personal Social Service (PSS) perspective over a patient's remaining life, as recommended by the NICE. [15] The analysis includes intervention costs, hospital costs, post-discharge health care and social care costs, together

with patient mortality and quality of life. Where appropriate, costs and benefits were discounted at 3.5% per annum.[15] Cost-effectiveness is summarised by an incremental cost effectiveness ratio (ICER).

### **Model design**

A decision tree was developed to estimate the cost-effectiveness of the intervention. This describes patient pathways from admission to hospital until death, taking into account falls, costs and QALYs. A section of the decision tree model is illustrated in Figure 1. For simplicity the full tree is not shown – the complete pathway is only illustrated for ‘Fall’ followed by ‘No injury’. Severity of injury is classified as; ‘Minor’ (complaint of pain, requires ice, dressing, cleaning of wound, elevating limb or medication); ‘Moderate’ (requires suturing, steri-strips, splinting or temporary bed-rest); ‘Major’ (requires surgery, casting, traction, neurological consultation for change in level of consciousness).

### **Transition probabilities**

The proportion of patients falling within an admission and their severity of injury are taken from the trial (Table 1). Probabilities for subsequent events were based on trial data, however, where event numbers were small these were supplemented with literature estimates. The probabilities for pathways subsequent to falls are given in Appendix 1.

### **Costs and Outcomes**

#### ***Quality of Life***

Participants were followed up 3 months after discharge from the ward, at which point the EQ-5D questionnaire was completed (n= 123). The EQ-5D is a generic instrument that measures health-related quality of life across five domains, producing a single index value for health status (or ‘utility’). [16] Utilities were calculated for each fall type, although for some types data were very

scarce and assumptions had to be made based upon the literature.[17] The utility scores for the different fall types are presented in Table 1.

### ***Mortality***

An estimated survival time was applied to the final node of each decision tree pathway. Survival times for patients who were alive at discharge were estimated based upon proportions that remained alive at 3 month follow-up using exponential parametric survival models. Models were fitted for fallers (n=32) and non-fallers (n=238) with complete data at follow-up – separate models could not be reliably fitted for the different types of fall due to the limited event numbers (n= 16, 4 and 2 for minor, moderate and major falls, respectively). Based upon the HIP-HOP data, patients who experienced no fall had an expected survival time of 1.24 years, and fallers had estimated mean survival of 0.81 years. By combining estimated lifetimes with utility scores we calculated the number of QALYs associated with each pathway in the decision tree.

### ***Costs***

Installation costs for the shock-absorbing flooring were £164 per square metre (2009/10 price levels). The cost per patient was based upon this cost, the area covered in the intervention bays (209 square metres), the number of beds in the bays (20), the average length of stay in these beds (21.46 days), bed occupancy (50%) and the expected lifetime of the floor (15 years). Based upon these estimates the flooring costs £13.43 per patient.

The cost of the initial hospitalisation was based upon length of stay data from the HIP-HOP trial combined with relative risks to reflect the increase in cost associated with moderate and severe falls (Table 1). Post discharge resource use data were collected using patient questionnaires administered three months after discharge. Patients (or carers, or GP practices) were asked about hospital admissions, outpatient appointments and other health care visits in the three months since discharge, together with their current place of residence. Post-discharge resource use was

estimated separately for fall type and for place of residence. Due to missing and scarce data, assumptions had to be made based upon the literature [17] for more serious falls.

Resource use data were combined with unit costs from standard sources for use in the economic analysis.[15,18,19] The post discharge resource use and cost data are presented in Appendix 4.

### **Sensitivity analysis**

Scenario sensitivity analyses were run to demonstrate which parameters are particularly influential for the cost-effectiveness results. These examined the impact of changes to risk of falling, utility scores, cost differences by fall type and occupancy rate.

## **RESULTS**

The model estimates costs and QALYs to be £39,100 and 0.425 per patient in the control group and £38,257 and 0.419 in the intervention group. The flooring is, therefore, associated with a cost reduction of £843 per patient, a QALY loss of 0.006 and ICER of £134,903. Strictly speaking, the flooring intervention is considered cost effective as the costs saved per QALY lost are greater than £20,000 (or alternatively, the additional costs per QALY gained for conventional flooring are greater than £20,000 which is the more typical expression of the decision rule).

Our scenario analyses revealed that the results were extremely sensitive to the overall risk of falling, but were not sensitive to utility scores, cost differences between fall types, or occupancy rates (Appendix 5). If an equal risk of falling is assumed for the two groups, but with the lower proportion of severe falls observed in the trial maintained, the flooring intervention becomes a dominant treatment strategy – it is cost saving and provides QALY gains.

## DISCUSSION

Our base case analysis suggests that the intervention flooring is likely to be cost-effective, but this is due to the intervention producing fewer QALYs at lower cost than standard flooring. Theoretically the intervention should be implemented because more than £20,000 is saved for every QALY lost, however, implementing an intervention that is expected to produce worse health outcomes is rarely considered acceptable.[20]

The underlying trial was quite small with high rates of missing data for post-discharge costs and quality of life. This required literature estimates to be combined with trial data, or be used in their place. This process was necessarily subjective and so there is considerable uncertainty around the accuracy of these parameters.

Our results are extremely sensitive to the faller rate. A higher proportion of fallers were observed in the intervention arm in the HIP-HOP trial. This may be plausible – the floor is ‘different’ and may cause problems for patients.[21-23] However, the difference in the proportion of falls between groups was not statistically significant, consequently we are not able to conclude definitively whether the shock-absorbing flooring is likely to cause an increase in the faller rate.[13]

If the intervention flooring does not cause more falls to occur, it is likely to be a dominant or cost effective strategy, providing there exist some excess costs associated with minor, moderate and major injuries compared to falls that cause no injury. However, if the intervention flooring does cause more falls to occur, but results in fewer injuries, the overall effect is not certain as falls that cause no injury have cost and health implications that can outweigh the benefits of small reductions in more severe injuries.

While it is of value to determine the accuracy of estimates of cost and utility differences associated with different fall types our analyses demonstrated that these parameters were of secondary importance in our economic model. It is clear that it is of most value to concentrate further research



on determining whether the intervention flooring is likely to result in more falls than standard flooring.

### **Conclusions**

The shock-absorbing flooring intervention has the potential to be cost effective compared to standard flooring, but conclusions on the actual cost-effectiveness cannot be confidently made without further research directed towards determining whether the intervention flooring causes an increase in the faller rate.

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## **Key Points**

- This is the first UK-based economic evaluation investigating shock-absorbing flooring as an injury prevention strategy.
- If shock-absorbing flooring does not result a higher number of falls, it is likely to reduce costs and improve health outcomes.
- Further research is required to determine whether shock-absorbing flooring is likely to increase the faller rate.

## **Funding**

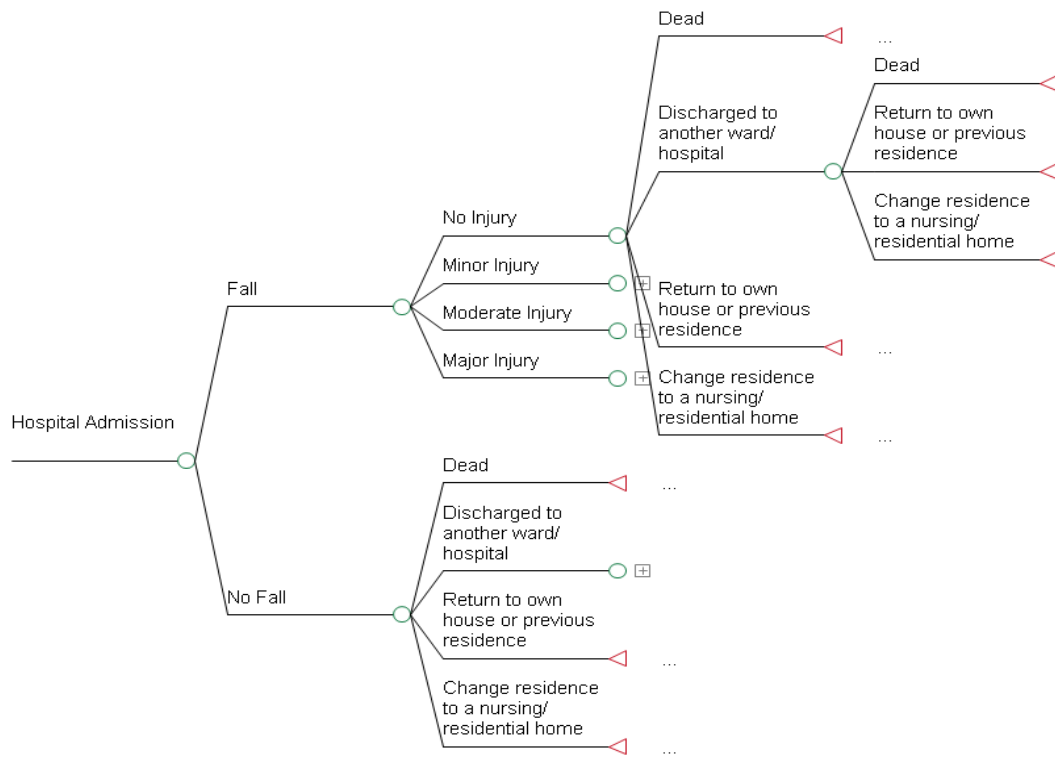
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## References

- [1] Kerzman H, Chetrit A, Brin L, et al. Characteristics of falls in hospitalized patients. *J Adv Nurs* 2004;47:223-9.
- [2] Kannus P, Parkkari J, Sievänen H, et al. Epidemiology of hip fractures. *Bone* 1996;18:S57-63.
- [3] Lauritzen JB. Hip Fractures: Incidence, Risk Factors, Energy Absorption, and Prevention. *Bone* 1996;18:S57-63.
- [4] Stevens JA. Falls among older adults: risk factors and prevention strategies. *J Safety Res* 2005;36:409-11.
- [5] Morse JM, Prowse MD, Morrow N, et al. A retrospective analysis of patient falls. *Can J Public Health* 1985;76:116-8.
- [6] National Audit Office. *Health and Safety in NHS Acute Trusts in England*. London: The Stationary Office 1996.
- [7] Zacker C, Shea D. An economic evaluation of energy-absorbing flooring to prevent hip fractures. *Int J Technol Assess Health Care* 1998;14:446-57.
- [8] Robinson D. A sure footing. *Hosp Dev* 2001;32:33.
- [9] Chang JT, Morton SC, Rubenstein LZ, et al. Interventions for the prevention of falls in older adults: Systematic review and meta-analysis of randomised clinical trials. *BMJ* 2004; 328:680-3.
- [10] Vassallo M, Vignaraja R, Sharma JC, et al. The relationship of falls to injury among hospital in-patients. *Int J Clin Pract* 2005;59:17-20.
- [11] Oliver D. Prevention of falls in hospital inpatients: Agendas for research and practice. *Age Ageing* 2004;33:328-30.
- [12] Gillespie WJ, Gillespie LD, Parker MJ. Hip protectors for preventing hip fractures in older people. *Cochrane Database of Systematic Reviews* 2010, Issue 10. Art. No.: CD001255. DOI: 10.1002/14651858.CD001255.pub4.

- [13] Drahota A, Ward D, Udell JE, Soilemezi D, Ogollah R, Higgins B, Dean TP, Severs M. Pilot cluster randomised controlled trial of flooring to reduce injuries from falls in wards for older people, submitted to Age and Ageing (AA-12-0388)
- [14] Tarkett Sports. Omnisports EXCEL technical data sheet [Internet]. 2010 Mar 29 [cited 2012 Apr 13]. Available from <http://www.tarkett-sports.com/sites/default/files/FT-Ominisports%20EXCEL-Uk%20pr.pdf>.
- [15] National Institute for Health and Clinical Excellence. Guide to the methods of technology appraisal. London: NICE, 2008.
- [16] Dolan P. Modeling valuations for EuroQol health states. *Med Care* 1997; 35: 1095-108.
- [17] Iglesias CP, Manca A, Torgerson DJ. The health-related quality of life and cost implications of falls in elderly women. *Osteoporos Int.* 2009 Jun;20(6):869-78.
- [18] Department of Health (2011) NHS Reference Costs 2009-10.
- [19] Curtis L. Unit Costs of Health and Social Care 2010, Personal Social Services Research Unit 2011, University of Kent.
- [20] Dowie J. Why cost-effectiveness should trump (clinical) effectiveness: the ethical economics of the South West quadrant. *Health Econ* 2004; 13(5):453-9.
- [21] Redfern MS, Moore PL, Yarsky CM. The influence of flooring on standing balance among older persons. *Hum Factors* 1997; 39(3): 445–55.
- [22] Dickinson JI, Shroyer JL, Elias JW. The influence of commercial-grade carpet on postural sway and balance strategy among older adults. *Gerontologist* 2002; 42(4): 552–9.
- [23] Wright AD, Laing AC. The influence of novel compliant floors on balance control in elderly women – a biomechanical study. *Accid Anal Prev* 2011; 43(4): 1480–7.

Figure 1: Model Design



**Table 1: Key model parameter values**

Event	Probability Value <sup>1,2</sup>		Utility score <sup>3</sup>	Excess hospital stay costs <sup>4</sup>
	Intervention Group	Control Group		
Fall	13.6%	9.8%	-	-
No Injury	10.1%	4.0%	0.36	£3,331.77
Minor Injury	3.5%	3.1%	0.34	£3,331.77
Moderate Injury	0.0%	1.8%	0.32	£12,741.27
Major Injury	0.0%	0.9%	0.27	£27,468.10
No Fall	86.3%	90.2%	0.38	£0.00

<sup>1</sup>Trial data; <sup>2</sup>Note: these figures correspond to fall rates per admission. Taking into account readmissions, these are equivalent to faller rates per patient of 9.9% and 13.8% for the control and intervention groups, respectively. [13] <sup>3</sup>Details in Appendix 2; <sup>4</sup>Details in Appendix 3