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A review of environmental hazards associated with in-patient falls

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Slips, trips and falls present the greatest risk to in-patients in terms of exposure (frequency of occurrence) but only present a low severity risk in terms of mortality. The risk factors have been categorized as intrinsic (individual to the patient, e.g. visual impairment, balance problems and medicine use) or extrinsic (environmental). Many recommendations have been made concerning the management of environmental hazards but, of these, only beds rails have supporting research evidence. Other recommendations include patient assessment, footwear, flooring, lighting, staffing levels and bed alarms. However, three systematic reviews and the current narrative review have all failed to find research evaluating the benefits of these recommendations. The most robust evidence relates to the use of bed rails. This research suggests that bed rails not only fail to reduce the frequency of falls, but may also exacerbate the severity of injury. As Maslow's Hierarchy of Needs model has been used as a framework for nursing models of care, it was chosen as the basis for the development of an environmental hazard assessment model. The environmental hazards are revisited using this model in order to take an ergonomic or patient-centred approach for risk assessment.

Keywords: Health-care ergonomics; Patient safety; Falls; User-centred design

1. Introduction

This narrative review will look at the epidemiology of in-patient falls in terms of both frequency and severity in order to comment on the level of associated risk. Many recommendations about environmental hazards have been made in order to reduce the exposure to risk. These include the design and use of the bed, footwear, flooring, lighting, staffing levels, bed alarms and patient assessment tools. A search was carried out to look for research evidence to support the use of these recommendations as single and/or multi-factor intervention(s). In the absence of research evidence a new patient assessment

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framework is proposed based on Maslow's Hierarchy of Needs. This takes an ergonomic approach to the issue by structuring the assessment as patient-centred or assessing risks from the patient's perspective.

2. Frequency and severity of in-patient falls

A fall is 'a sudden, unintentional change in position causing an individual to land at a lower level, on an object, the floor or the ground other than as a consequence of sudden onset of paralysis, epileptic seizure or an overwhelming external force' (Tinetti *et al.* 1997).

For in-patients, falls can lead to prolonged hospital stays and associated strains on the resources of the health-care systems, family and community (Ash *et al.* 1998). An average of 2% of patients fall during their hospital stay (Mahoney 1998) but the risk varies with more patients falling in geriatric wards followed by general medical and surgical wards (Udén 1985, Salgado *et al.* 2004).

The Department of Health (2000) reported that 10% of admissions in National Health Service (NHS) hospitals result in adverse events with harm being caused to patients, mostly related to medication errors. However, in a review of patient safety incidence data at four NHS Trusts in the UK, a ranking exercise for the most frequently occurring incidents found that three care environments (acute hospital, primary care and mental health) ranked falls in first position (table 1). The Ambulance Trust ranked patient injuries from manual handling incidents first, followed by slips, trips and falls (Hignett *et al.* 2004). In the UK, a multi-centre study on adverse events and near-miss reporting found that, of 28 998 incidents, 41% were due to slips, trips and falls (compared with 9% for medication management) and that 66.5% of the incidents occurred on the hospital ward (Shaw *et al.* 2005). Carson and Cook (2000) also found that 62% of the annual incidents in a primary care provider were due to falls. These data suggest that falls should have a high research and risk management priority, as in the USA (Joint Commission on Accreditation of Healthcare Organizations 2004a) for 2005.

The focus for research and interventions has mostly been the community (Gillespie 2004), although the rate of falls appears to be higher in hospitals. Tinetti *et al.* (1988) found that community-dwelling elderly patients had approximately 2.4 falls per 1000 person days, whereas various hospital studies found a rate of falls from approximately

Table 1. Frequency ranking of patient falls in four National Health Service (NHS) Trusts.

Ranked position / NHS Trust	1st	2nd	3rd	4th
Acute Hospital	Patient falls	Medication errors	Nurse staffing levels	Communication issues
Primary Care	Patient falls	Medication errors and immunization	No further analysis	No further analysis
Mental Health	Patient falls	Violence and aggression	Medication errors	Suicides
Ambulance	Patient injuries from manual handling incidents	Slips, trips and falls	Road traffic accidents	Medication errors

3.8–7.0 per 1000 patient days for older adults. The American Geriatrics Society (2001) also reported that the incidence of falls in nursing homes and hospitals is almost three times the rates for community-dwelling persons (older than 65 years), producing an annual incidence figure of 1.5 falls per bed. The injury rates were also higher, with 10–25% of institutionalized falls resulting in fractures, lacerations or a need for hospital care. Although their multi-centred study found that falls had the highest risk exposure (with 10 307 incidents), Shaw *et al.* (2005) commented that only 33 were classified as a major or catastrophic event (e.g. death). However, Carson and Cook (2000) found that the most common serious injury (fractures) accounted for 40% of deaths, so although the immediate severity of the fall may have been classified as an injury it is probable that a more serious outcome may result. It is unlikely that this will have been linked to the original incident report, perhaps leading to an underestimate of the severity of outcome for falls incidents.

3. Environmental hazards

Most patient falls in hospitals occur in the room or cubicle (bed space envelope), typically when the patient is attempting to transfer from bed or chair, ambulate or toilet (Leighbody *et al.* 1985, Rohde *et al.* 1990, Rubenstein *et al.* 1996, Mahoney 1998, Joint Commission on Accreditation of Healthcare Organizations 2000, Gowdy and Godfrey 2003). In 2002/03 a falls audit was carried out at a large acute teaching hospital in the UK and found that, of 955 falls in 12 months, 42% were either bed-related or the patient was found in their bed space after the fall (Masud 2003).

Parker (2000) recommended taking a risk assessment approach for falls, with risk factors divided into two categories: (1) exogenous or extrinsic, arising externally to the patient, usually environmental; (2) endogenous or intrinsic, arising from within the patient (table 2, with recommendation source annotated). This definition was also recommended

Table 2. Intrinsic and extrinsic factors.

Intrinsic/Endogenous (patient)	Extrinsic/Exogenous (environment)
Age (older than 65 years)§,**	Bed rails‡
Functional and mobility issues e.g. strength, balance, gait and mobility problems‡,§,¶,‖,**,††	Improper bed height‡
Visual and/or hearing impairment‡,§,¶,**	Attachment to equipment: catheter, ECG leads, IVs, oxygen, chest tubes**
Cognitive impairment, confusion‡,§,¶,**,††	Ill-fitting footwear*,†,¶
Medicine use: taking four or more medications‡,§,¶,‖,**,††	Slippery/wet floors*,‡,¶,††
Postural hypotension, dizziness, vertigo‡,§,¶,**	Poor lighting*,†,‡,§,¶,††
Urinary incontinence or frequency§	Lack of safety equipment§,¶,††
Fear of falling§	Environmental markings*
	Equipment mobility*
	Doorway and furniture design*

*Leighbody *et al.* 1985.
†Anon 1996.
‡Rubenstein *et al.* 1996.
§Accidental Injury Task Force 2001.
¶Department of Health 2001.
‖National Institute for Clinical Excellence 2004.
**Joint Commission on Accreditation of Healthcare Organizations 2004a.
††American Geriatrics Society 2001.

by the Accidental Injury Task Force's Working Group on Older People (Accidental Injury Task Force 2001). The intrinsic factors are defined as states or traits of an individual that increased their risk of falls and extrinsic factors are the social and physical factors that relate to the external environment. Falls among people aged 65–74 years are more likely to be due to extrinsic factors, whereas the intrinsic factors are more important among the 80+ years age group (Accidental Injury Task Force 2001).

The physical environment was cited as the root cause in 44% of patient falls in an analysis in the USA between 1995 and 2003 (Joint Commission on Accreditation of Healthcare Organizations 2004b). The first three root causes were given as training/orientation, communication and patient assessment, all human factors issues. The traditional response to incident investigation has been to attribute blame to human acts or omissions immediately preceding the event (Department of Health 2000) rather than seek latent conditions relating to the operational systems or environmental design. Implementing change based on training has been suggested to be an easy option for an employer (Graveling 1991), whereas looking at the design of the environment presents a much greater challenge.

Salgado *et al.* (2004) found that the risk of falling was exponentially linked to the number of risk factors and that the presence of two or more risk factors was significantly associated with falls. They suggested that intervention programmes aimed directly at reducing risk factors, as well as strategies for maximizing physical functioning and ward safety, might offer particular benefits in falls prevention in this setting.

4. Environmental interventions

A narrative literature review was carried out by searching two key databases, Medline and Ergonomics Abstracts, using the combined terms 'patient', 'fall', 'human', 'movement', 'bed', 'motivation', 'hospital'. The inclusion criteria required that the paper reported recommendations for interventions and/or evaluations.

Three systematic reviews were found from Oliver *et al.* (2000), Gillespie *et al.* (2003) and Chang *et al.* (2004). Oliver *et al.* (2000) reported that there were no adequate randomized controlled trials of multi-factorial interventions to reduce falls among hospital patients. Chang *et al.* (2004) found only one trial evaluating interventions to reduce falls in hospitals and a Cochrane systematic review (Gillespie *et al.* 2003) included only three small hospital-based randomized controlled trials on bed alarms, identification bracelets and flooring.

The following sections summarize the published research in terms of the environmental (extrinsic) risk factors listed in table 2.

4.1. *Bed rails*

Bed rails were first introduced in the 19th century for agitated psychiatric patients as a precautionary measure against falls (Levine 1994). O'Keeffe *et al.* (1996) carried out a survey in an acute district hospital and found that the most common reason for the use of bed rails was the belief that rails were beneficial for reducing the risk of falls. This survey was repeated in 2003 by Hignett *et al.* (2005) with similar results, that the most frequent reason for using rails related to concerns about patient falls (42%). However, Mahoney (1998) found that between 37 and 90% of falls from hospital beds are reported to occur with raised bed rails, which suggests that, as Oliver *et al.* (2000) later confirmed, there is no evidence to support bed rails (restraint use) for falls prevention.

Gallinagh *et al.* (2002) surveyed rehabilitation wards looking at the use of restraints and documentation. They found that the most commonly used restraints were bilateral side rails, unilateral side rails and placing the bed flush with the wall, and that only 35% of those restrained had nursing documentation with supporting rationale for restraint use. The most common reasons for use were to prevent falls (58%), prevent wandering and to promote positional support. They suggested that a decrease in staffing levels might be associated with an increased use of restraints (including side rails). However, Gaebler (1993) found that patients who fell from the bed were likely to remain a single faller (one reported fall) unless they were restrained following a first fall and hospitalized for longer when they moved into a 'repeat faller' category, where multiple falls were reported. Data were also found linking the use of bed rails to entrapment injuries (Hignett and Griffiths 2005). O'Keeffe (2004) summarized the research on bed rails associated with entrapment and falls. His conclusion was that bed rails do not reduce the frequency of falls and, more seriously, may increase the severity of injury.

4.2. *Bed height and alarms*

Mahoney (1998) and Joint Commission on Accreditation of Healthcare Organizations (2000) recommended a lower bed height so that the patient could touch the floor. Bed manufacturers have responded by producing low level beds (e.g. Versacare 2004). No published research was found to evaluate these recommendations.

Tideiksaar *et al.* (1993) assessed the value of using bed alarms compared with a control group and found no significant difference in the number of falls between the two groups.

4.3. *Attachment to equipment: catheter, ECG leads, IVs, oxygen, chest tubes*

No published research was found looking at the risk of falling in relation to attachment to equipment.

4.4. *Footwear*

Mion *et al.* (1989) noted that in 20% of falls the patients had improper footwear; however, no published research was found for studies of footwear examining patient falls as an outcome (Oliver *et al.* 2000).

4.5. *Flooring*

Two studies were found comparing carpet with other flooring. Simpson *et al.* (2004) reported that wooden carpeted floors were associated with the lowest number of fractures per 100 falls in care homes. They also highlighted that carpet floor covering might also have an impact on other issues, e.g. infection control, cleaning and moving wheeled equipment. Donald *et al.* (2000) compared the incidence of falls on vinyl and carpet floors in a randomized controlled trial but only had a small sample and the results were not statistically significant.

Durá *et al.* (2005) looked at the frictional properties of floors for five groups of patients; below knee ambulation; hip arthritis; knee arthritic; hemiplegia; and Parkinsons disease. They proposed a minimum safety requirement for flooring in wet

conditions to give a dynamic coefficient of friction greater than 0.4. These findings support the results from Buczek *et al.* (1990), suggesting that people with limited walking abilities require more friction for safe walking than able-bodied people.

Literature on slips, trips and falls from other industries found that using footwear with worn tread and time-saving behaviour were contributing factors in 50% of slip, trip and fall accidents of postal delivery workers (Haslam and Bentley 1999). Staal *et al.* (2004) looked at solutions to slipping from areas outside the health-care industry, e.g. commercial fishing and restaurant industries. They looked at footwear with positive grip shoe covers over regular footwear and recorded no slipping incidents during the trial and suggested that this might be especially useful for moving and handling activities in shower areas.

4.6. *Lighting*

Mion *et al.* (1989) noted that, in 43% of falls, the patients lacked eye glasses and in 18% poor lighting was present. This finding is similar to Haslam and Bentley's research with postal delivery workers, where poor lighting were contributory factors in 20% of incidents (Haslam and Bentley 1999).

4.7. *Patient assessment*

The Department of Health has identified a number of gaps in knowledge with regard to falls (Department of Health 2002). These include the need for validated multiple risk assessment tools to identify those at risk of falling and a systematic examination of the causal network of falls and falls injury. A number of authors have recommended assessment tools (Vassallo 2000) but these rely on nursing staff both carrying out the assessments and implementing the recommendations. Three studies suggest that reported record keeping and documentation completion may be variable (Udén *et al.* 1999, Semin-Grossens *et al.* 2003, Hignett *et al.* 2005). These studies found that the documentation was only completed for between 52 and 71% of patients. Vassallo (2000) concluded that evidence was still lacking in the use of functional tools to reduce falls for in-patients.

4.8. *Environmental marking (cues)*

Coltharp *et al.* (1996) suggested that the phenomenon of wandering was a natural process of searching for security and familiarity. They advocated the use of visual barriers, cues and a reduction in background noise as methods for dealing with wandering but did not report any measurable benefits from these recommendations.

4.9. *Staffing levels*

Dunton *et al.* (2004) reported that higher fall rates were associated with fewer nursing hours per nursing day and a lower percentage of registered nurses in four acute care units. They classified nursing staffing as a latent failure, the same as organizational processes. They used payroll data and patient days (midnight census) to calculate and compare falls data from incident reports. There was no evidence that over 15 h nursing staff per patient day had any benefit on fall rates. Fall rates were highest on medical wards so they

suggested that targeting increased staffing to medical wards would have the greatest impact on falls reduction. However, Shaw *et al.* (2005) found that slips, trips and falls occurred at a fairly even rate throughout the 24 h day.

5. Patient assessment: Maslow's Hierarchy of Needs

The previous section presented very little evidence to substantiate recommendations for falls management in acute hospitals. Only the effect of bed rails on falls has been researched in any depth. The bed height and equipment attachment recommendations were associated with neither intervention nor evaluation research. Footwear, flooring, lighting and staffing levels were all shown to have an association with falls incidents but no research was found to evaluate the benefit of implementing recommendations to address these risk factors.

In order to design an intervention strategy to tackle the complex factors involved with falls, it is suggested that a multi-factorial, patient-centred systems approach should be taken (Leighbody *et al.* 1985, Salgado *et al.* 2004). The risk of a fall will only present when there is movement – an unconscious or paralysed patient has a negligible risk level. Movement usually implies a movement goal and for a patient this is likely to be due to physiological motivators. There are many theories of motivation but as Maslow's Hierarchy of Needs Theory (Mullins 1993) has been used as a framework for models of nursing care this will be used to develop an environmental hazard assessment model.

Maslow's theoretical model for basic human needs consists of a hierarchy (figure 1) in which physiological needs and the needs for safety and belonging and love can be said to be homeostasis-related. The highest needs levels in the hierarchy are for esteem and

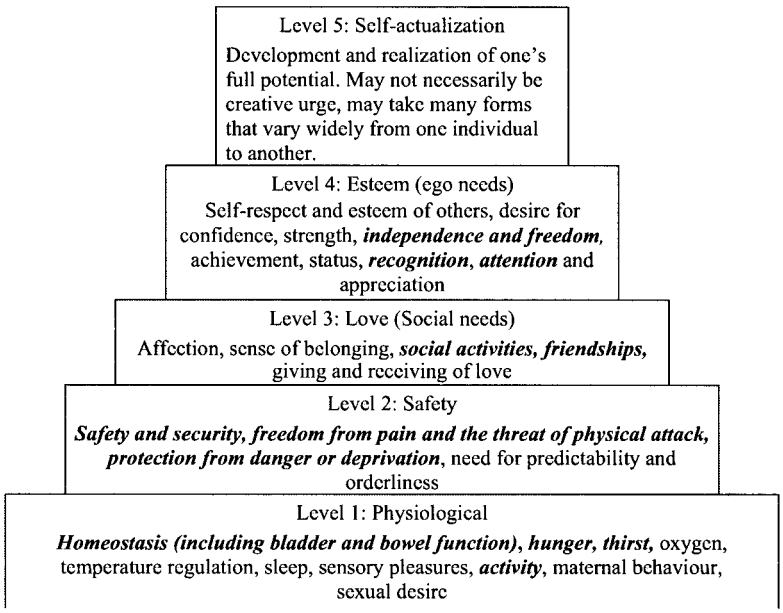

Figure 1. Maslow's Hierarchy of Needs. Suggestions for specific needs for falls are indicated in bold/italics.

self-actualization that are intrinsically motivation-related. Maslow suggested that people are 'wanting beings', always wanting more than they already have, so when one level of the hierarchy is met they will move to another level (Mullins 1993). There have been criticisms of Maslow's model but Wicker *et al.* (1993) suggests that this may be because critics have usually tested only part of the theory rather than the whole multi-faceted theory.

The influence of Maslow's model on nursing care has been discussed by Heidenborg (1981), Fagerström *et al.* (1998), Sloan Devlin *et al.* (2003) and Davidson *et al.* (2004). Heidenborg (1981) described the adequacy of need-satisfaction measures in two patient groups using Maslow's model to classify basic needs, finding that the basic human needs of the patients in her study were not met in an adequate way. The main reason for the deficiency was the demands placed on the nursing personnel by the hospital organization, preventing them from providing individualized patient care. Fagerström *et al.* (1998) suggest that Maslow has influenced the view of patients' need of care in nursing science with a change in emphasis to human health resources and the possibilities of growth and development. Davidson *et al.* (2004) describe the Human Needs Model of Nursing, derived from Maslow's Hierarchy of Needs. It emphasizes patient problems arising from unmet needs at higher as well as lower levels to stress the importance of addressing all human needs, such as emotional and esteem issues, particular in busy clinical environments.

To apply Maslow's model for falls, the levels were reviewed using a patient-centred model for movement and specific needs for falls are suggested as shown in figure 1 in bold/italics. In level 1 (physiological needs) motivation for movement may include bladder and bowel function (to support homeostasis), hunger, thirst and activity. When these basic needs are fulfilled, the motivation for movement may involve safety issues including freedom from pain, the threat of physical attack and protection from danger or deprivation. Levels 3, 4 and 5 are perhaps less likely to be activated for the 'at risk' group, although an independently mobile patient may be trying to fulfil needs at these higher levels. The application of the hierarchy of needs can also be seen in rehabilitation models, where the major goals are mobility and self-care without the assistance of another person (Cameron and Kurrie 2002). Level 1 needs (physiological) are reflected in the widely used Barthel Index (Mahoney and Barthel 1965, Sulter *et al.* 1999) for self-care: feeding; grooming; bathing; dressing; bowel and bladder care; and toilet use). If these needs are not met by caregivers, then the patient will be highly motivated to achieve them independently, resulting in movement from the bed and introducing the risk of falling.

To take an ergonomic systems perspective, the extrinsic factors will be considered from a patient-centred perspective, as shown in figure 2. Taking the patient as the centre of the system, the first hazard interactions will be the bed (rails and height). If the patient is successful in moving themselves from the bed, then footwear may present the next hazard with personal or hospital-supplied soft indoor footwear interacting with non-carpet flooring, which may have a lower friction coefficient (increased slip risk) than the patient was expecting compared with their domestic bedroom setting. Lighting is rarely designed to illuminate the floor, with either overhead fluorescent lighting or individual cubicle spotlighting. At night the hospital cultural norm maintains a low level of lighting that may contrast with the patient's home, where a light would probably be put on for a nocturnal toilet visit. The risks will be compounded by the unfamiliar surroundings and a lack of walking aids, grab rails, helpfully placed furniture and environmental markings (e.g. doorway design).

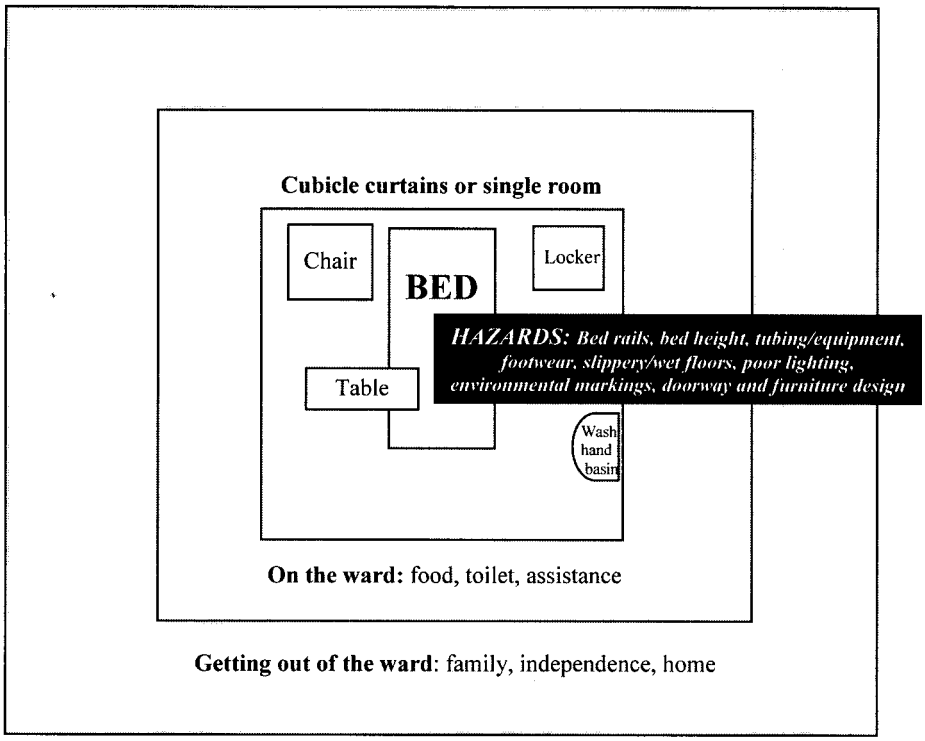

Figure 2. Extrinsic risk factors.

6. Conclusion

This review found that there has been little published research to support recommendations to reduce falls other than that relating to bed rails. The potential harm from using bed rails for falls of 'at-risk patients' is identified from both repeat falls data (Gaebler 1993) and bed rail entrapment data (Hignett and Griffiths 2005). The bed height and equipment attachment recommendations were associated with neither intervention nor evaluation research. Footwear, flooring, lighting, alarms, patient assessment tools and staffing levels were all shown to have an association with falls incidents but three systematic reviews and this narrative review all have failed to find research evaluating the benefits of these recommendations.

Risk assessment tools are needed for both the patient (intrinsic) and the environment (extrinsic) factors. A theoretical framework for an environmental assessment model was proposed using Maslow's Hierarchy of Needs. This ergonomic viewpoint has taken a patient-centred approach to assess the risk factors from the patient's perspective. To be effective, a risk assessment tool needs to be sensitive to the system in which the patient is receiving treatment and care. This will be a dynamic system, where the environmental factors are perhaps the most static elements, whether this is a physical change (new ward or new location on the ward), human change (different staff on duty), or micro changes with regard to the bed height. To detect these changes a risk assessment tool will need a high level of complexity to model the dynamic risk factors. A systematic examination of the causal network of falls is likely to find that there are common environmental risk factors in the design of both the systems and the physical

interactions. These should be considered as part of the evidence-based design initiatives, where the outcome measures not only include reduced length of stay but also reduction in harm.

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