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Firefighting to Innovation: Using Human Factors & Ergonomics to tackle Slip, Trip and Fall Risks in Hospitals

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Abstract

Objective: To use a theoretical model (bench) for Human Factors & Ergonomics (HFE) and a comparison with occupational slips, trips and falls (STF) risk management to discuss patient STF interventions (bedside).

Background: Risk factors for patient STF have been identified and reported since the 1950s and are mostly unchanged in the 2010s. The prevailing clinical view has been that STF events indicate underlying frailty or illness and so many of the interventions over the last 60 years have focussed on assessing and treating physiological factors (dizziness, illness, vision/hearing, medicines) rather than designing interventions to reduce risk factors at the time of the STF.

Method: Three case studies are used to discuss how HFE has been, or could be, applied to STF risk management as (1) a design-based (building) approach to embed safety into the built environment; (2) a staff (and organisation)-based approach; and (3) a patient behaviour-based approach to explore and understand patient perspectives of STF events.

Results & Conclusion: The results from the case studies suggest taking a similar HFE integration approach to other industries, i.e. a sustainable design intervention for the person who experiences the STF event - the patient.

Application: Proactive problem solving using HFE principles (bench/book) to understand the complex systems for facility and equipment design and include the perspective of all stakeholders (bedside).

Précis: Slips, trips and falls are a frequent adverse event in hospitals. Three case studies outline how HFE has been, or could be, applied and suggest using a similar HFE integration approach to other industries, i.e. reducing risk factors for the person who experiences the STF event - the patient.

1. Introduction

Slips, trips and falls (STF) by patients in hospital have been described as a *'seemingly intractable cause of harm'* (Donaldson, Panesar & Darzi, 2014); they are the second most frequent cause of death after failure to recognise or act on deterioration, and slightly exceed hospital acquired infection, pressure sores and venous thromboembolism. In the United States (US), STF with injury in hospital are classified as a 'Never Event', with no reimbursement for associated costs (investigation, treatment and additional duration of stay) so there is a considerable motivation to reduce (eliminate) both the total number of STF and associated injuries (National Quality Forum, 2007). In Europe, STF are the most common cause of occupational accidents resulting in serious injury to workers (European Commission, 2010). The aim of this paper is to discuss whether patient STF interventions are using innovative approaches based on Human Factors & Ergonomics (HFE) to reduce and eliminate risks or if the interventions are simply firefighting by repackaging previous approaches without addressing underlying causes and permanence (sustainability) of improvements. A theoretical model (bench) for HFE is used and a comparison is made with occupational slips, trips and falls (STF) risk management.

2. Contributing factors

Falls are usually the result of slips (e.g. fluid, or dry/dusty floor contamination) and trips (e.g. obstructions or uneven surfaces) but can also occur without slipping or tripping related to individual frailties e.g. fainting or loss of balance. (EU-OSHA, 2008; Kemmlert & Lundholm, 2001).

Risk factors for patient STF have been identified and reported since the 1950s and are mostly unchanged in the 2010s (Morgan, Mathison, Rice & Clemmer, 1985; Oliver, Daly, Martin, & McMurdo, 2004; Mahoney, 1998; Healey, Monro, Cockram, Adams, & Heseltine. 2004). STF intervention (prevention) programmes typically involve multiple components (packages of care or bundles of interventions) designed to improve staff processes (assessment, communication, monitoring), and patient capabilities (Hignett, 2010). The prevailing clinical view has been that STF events indicate underlying frailty or illness and so many of the interventions over the last 60 years have focussed on assessing and treating physiological factors (dizziness, illness, vision/hearing, medicines). This approach resulted in a multitude of clinical assessment tools trying to identify high risk patients as a '*physiologically anticipated*' group (Morse Tylko, & Dixon, 1987). However, the value of assessment tools has been questioned (Schwendimann, Buhler, Geest, & Milisen 2006; Oliver *et al.*, 2007) and recently a review of research evidence in the United Kingdom (UK) recommended that as STF assessment tools had little predictive value, all people admitted to hospital over 65 years should automatically be considered to be at high risk of STF (National Institute for Health and Care Excellence, 2013). So, despite numerous best practice interventions, STF remain one of the major patient safety events and preventable harm issues.

In contrast, the focus of occupational STF risk management has not been to identify the people most at risk, but instead to design interventions for a wide range of people (inclusive design) by considering the event from the perspective of the person experiencing the STF to understand what happened and explore how it could have been prevented. This might mean designing wet floor signage that is readable by people with visual changes (Vitale, Cotch, & Sperduto, 2006) or resurfacing flooring to remove uneven surfaces and trip hazards (Bell *et al*. 2007). Intrinsic factors have been considered for occupational STF (Gauchard, Chau, Mur, & Perrin, 2001), but it is suggested that there is a difference in the duration of exposure, which may allow the worker to 'adapt themselves to the environment' (Swensen, Purswell, Schlegel, & Stanevich, 1992) in contrast to patient exposure where the first week of a hospital stay in an unfamiliar environment is associated with the greatest risk of STF (Vassallo, Sharma, Briggs, & Allen, 2003). This is reflected in more recent interventions with, for example healthcare STF flooring focussing more on shock absorbency properties to mitigate injury severity (Latimer, Dixon, Drahota, & Severs, 2013) rather than consideration of flooring friction properties (slip-related for low friction or trip-related for high friction) to prevent the STF event (Beschorner, Redfern, Porter, & Debski, 2007). This is related to a lack of regulatory mandates due to complications of slip-resistance interactions, such as tasks being performed, the surface conditions, and footwear (OSHA, 2003). For example, the most recent Americans with Disabilities Act Accessibility Guidelines is not prescriptive but defines slip resistant surfaces as providing *'sufficient frictional counterforce to the forces exerted in walking to permit safe ambulation'* (ADAAG, 2010).

This paper uses an HFE theoretical model, DIAL-F (Figure 1; Hignett, Griffiths, Sands, Wolf, & Costantinou, 2013) as the framework to represent levels of stability or transience within the healthcare system. A rotary telephone DIAL shape (used for telephone design from 1920s to 1980s) represents a dynamic system with the most transience (change and motion) in the outer rings and the most stability in the inner rings; F is for falls.

Building design is represented as the most stable element (core) followed by organisational policies and procedures, and technology (equipment, furniture, medical devices). The people are described as the least stable elements in the system, firstly with staff fluctuation in terms of permanence, numbers, knowledge, skills and competency levels and secondly patients, as most transient group with rapidly changing physical, cognitive and behavioural characteristics.

[Insert Figure 1 here]

Figure1. DIAL-F. Model of STF risk management system (Hignett et al, 2013a)

Three case studies are used to discuss how an HFE integration approach has been, or could be, applied to STF risk management:

1. Design-based (building) approach (Taylor & Hignett, 2014a) to embed safety into the built environment.
2. Staff (and organisation)-based approach (Wolf *et al*, 2013, Wolf, Hignett, & Costantinou, 2014) using quality improvement (QI) methods (Lean and Six Sigma).
3. Patient behaviour-based approach (Hignett, Youde, & Reid, 2014; Wolf & Hignett, 2015) to explore and understand patient perspectives of STF events.

3. Design-Based approach

The design-based approach describes a study to embed evidence-based safety decisions for STF during the design and construction of healthcare facilities as a Safety Risk Assessment (SRA) toolkit (Taylor, Joseph, Quan, & Nanda, 2014).

3.1 Method

The first stage of the SRA development was a systematic literature review (Taylor & Hignett, 2014b) to identify features of the built environment associated with STF. The literature search used MeSH terms and key word alternates for searches in MEDLINE, Web of Science, and CINAHL. The search identified 380 papers, of which 139 were reviewed by abstract and 77 were screened as full text, resulting in 17 papers included in the final review; most papers were excluded due to a lack of built environment interventions. The second stage of the SRA development used a multi-disciplinary collaborative process with subject matter experts from diverse backgrounds (including architecture, facilities management, medicine, HFE, occupational health, and healthcare administration). A modified Delphi technique was used to gain consensus from participants with 2 online consensus surveys, followed by a nominal group approach for a final consensus meeting. The online survey presented statements to link research with potential design considerations, many of which were referenced (requirements or best practice recommendations) in professional guidelines (FGI, 2014). Statements (inclusion and wording) had to achieve at least 70% for consensus (Creamer *et al*., 2012; Lee *et al.,* 2013).

3.2 Results

Literature review resulted in 36 environmental design statements, of which 20 achieved consensus in the first survey (n=12 participants). In the second round (n=15 participants) 4 more statements achieved consensus for inclusion and wording, and 6 more statements for inclusion, but not wording. The 9 statements that did not achieve full consensus were brought forward to the nominal group seminar (n=10 participants). Eight more statements achieved 70% consensus and 1 was deleted, resulting in 32 items to be considered during the design process (Figure 2).

1. Is the bathroom door clearly identifiable from the bed?
2. Does the unit layout allow staff to easily see the patient head in all rooms from work stations or a routine circulation pattern?
3. Does the design maximize the ability of staff to view patients?
4. If direct visibility is not possible, is additional patient monitoring available (e.g. video surveillance, alarms)?
5. Are all call button/systems accessible and usable?
6. Is there space for safety alert signage at the patient room entrance and/or the patient bed?
7. Is the entrance protected from weather?
8. Does the room layout provide clear and unobstructed paths of travel?
9. Is space provided on the opening side of the patient toilet room door to facilitate the use of equipment and/or assistive devices?
10. Are the use of unnecessary restraints minimized (including the use of bilateral full-length bed rails)?
11. Does furniture selection/specification support independent mobility?
12. Are there smooth transitions in walking surfaces or between flooring types to avoid surface irregularities leading to trips?
13. Does selection/ specification of floor materials and pattering accurately convey the floor conditions (level floor vs. stair/threshold)?
14. Does the design (e.g. flooring, lighting, windows) minimize glare?
15. Is contrast designed to differentiate between the floors and walls and minimize transitions between colours and/or materials?
16. Are mats, rugs and carpeting secured to the floor?
17. Are floors slip-resistant in potential wet areas (e.g. bathrooms, entrances, kitchens) and on ramps and stairs?
18. Are grab bars and hand rails located to support patients while ambulating to the toilet?
19. Are grab bars located on either side of the toilet to support patients getting up and down toileting?
20. Are grab bars and hand rails in the bathroom mounted to support people of different heights?
21. Are lifts being used to assist staff in performing transfer of patients?
22. Have beds been selected to afford low height positions and brakes?
23. Has ergonomic design been considered in furniture selection?
24. Has toilet accessibility been considered (e.g. height)?
25. Are flooring and subflooring materials selected to mitigate injury in the event of a fall?
26. Is there space for families to be present in the patient room to encourage communication with caregivers about falls and increase the level of patient surveillance?
27. Has lighting been designed to eliminate abrupt changes in light levels?
28. Is low-level lighting available in night time/dark conditions?
29. In areas where lighting needs to be dimmed for treatment purposes, is there sufficient light to navigate safely?
30. Are call and communication systems designed to minimize public noise?
31. Is noise controlled through the design (e.g. material selection)?
32. Is the bathroom located in close proximity to the bed?

Figure 2. Included statements for STF

Each statement was grouped thematically in 6 categories and linked with a research rationale (Table 1). The categories are:

1. Design for monitoring, e.g. visibility, space for families, location of call bells.

2. Navigation, including clear and unobstructed paths of travel, safety signage.
3. Support for patient mobility e.g. grab rails, bed/toilet height.
4. Noise reduction, including communication systems and selection of materials.
5. Lighting, with adequate illumination in ambient (day and night) and task lighting and consideration of contrast, reflection and glare.
6. Flooring e.g. materials, colour, thresholds, contrast, slip resistance.

Category	Rationale	Design Consideration Question/Statement
Navigation	*One study found that bathroom locations visible from the bed, with the door open and out of the way, resulted in fewer falls, while a review referenced angled door and room layouts to provide better sight lines.*	Provide room layout so that the bathroom door is clearly identifiable from the bed.
Flooring	*Changes in floor surfaces (e.g. soft surface to hard surface and/or slip resistance) and unevenness (e.g. minor changes in height requiring transition strips, holes/cracks needing repair) can be a contributing factor for falls.*	Allow for smooth transitions in walking surfaces or between flooring types to avoid surface irregularities leading to trips.
Noise reduction	*Noisy environments can lead to confusion in older hospitalized patients, sometimes leading to restlessness and the risk of falls. One study found that when both overhead paging and alarms were rated as occurring "frequently," falls were statistically higher.*	Select call and communication systems designed to minimize public noise.

Table 1: Examples of final STF content

This case study illustrates that many elements of STF interventions require risk management decisions (i.e. likelihood and consequence) to be made during the design and construction of healthcare facilities. If knowledge about human interaction (HFE) is embedded into the most stable element of the system (Figure 1), then STF interventions will have mitigated some of the environmental (extrinsic) risks rather than implementing improvements based more on human behaviour, as discussed in the following 2 case studies.

4. Staff (and organisation)-based approach

The second case study includes elements from the organisation layer (policies and procedures) as well as staff (training, permanence, knowledge and skills). Two QI projects were used to develop and implement STF interventions.

The first project used Lean techniques to standardise working processes for the fall risk assessment and intervention selection on three oncology wards (97 beds; 71 single rooms) with the aim of reducing patient STF and associated injuries (Wolf *et al.*, 2013). The second project used Six Sigma as a systematic data-driven process method to support continuous improvements and process redesign to investigate root causes of falls. One oncology division (38 beds with 26 single rooms) was selected for the second project based on management support and heightened staff engagement (Wolf *et al.*, 2014).

4.1 Lean

STF in oncology wards were found to have specific risk factors associated with medications (i.e. benzodiazepines, sedatives/hypnotics) and disease-associated pathologies which could cause altered elimination (frequent urination or diarrhoea), and also often involved patients who would not call for help. The Lean project started with a 3-day Rapid Improvement Event (RIE) attended by a wide range of stakeholders including nurses, physical and occupational therapists, pharmacists, physicians, information systems specialists. The current state was documented with a process map with swim lanes for each ward using Lean methods to resolve issues and encourage input from all participants such as fist-to-five, silent voting, affinity diagramming and brainstorming round-robin techniques. The initial gap analysis found that assessments for gait and mental status were not being carried out in a consistent manner and there were delays in implementing interventions e.g. bed alarms and low beds. The future state map included gait and mental status assessment being completed every shift (and when patient condition changed); support for nursing staff in the selection of appropriate interventions (algorithm); collection of information immediately after an incident with more detailed follow up investigation; and shared post incident data with a wall-mounted Fall Tracker Board.

Various problems and barriers were encountered during implementation including training provision, acceptance of new mental status assessment (which was withdrawn and replaced by standardizing questions in the existing ‘alert and oriented’ mental status assessment), availability and delivery of low beds and bed alarms, and the information system interface for documentation of gait and mental status data (added as free text). The results are reported in section 5.3.

4.2 Six Sigma

There were side benefits from the Lean project, including increased staff engagement through newsletters, practice updates, and feedback to leadership. Based upon this heightened engagement one of the wards was selected to participate in a collaborative Six Sigma project with the Joint Commissions Center for Transforming Healthcare (DuPree, Fritz-Campiz, & Musheno, 2014). The intervention was conducted with 87 high STF risk patients where 6% (n=5) experienced a STF. The project followed the 5 phases of the DMAIC (Define-Measure-Analyse-Improve-Control) process:

*1. Define***.** The SIPOC (Supplier, Input, Process, Output, and Customer) and Solution Tree (affinity diagram) methods were used to collect the Voice-Of-the-Customer with information about equipment, environment, call lights, communication, staffing, staff education and awareness, patient assessment, patient and family education.

2. Measure. A cause-effect matrix was used to explore the most critical factors, using fishbone diagrams to determine root causes for further investigation. These included call light response time, patient activity and behaviour (engagement), medications, and changes in patient condition in the preceding 24 hours.

3. Analyse. A creative combination of Failure Mode Effects Analysis (FMEA) and an impact matrix method was used to explore possible barriers or failure routes for the proposed intervention (figure 3). Traditional factors of severity, probability and detectability were addressed in this simplified method to meet the needs of the Six Sigma team.

4. Improve. The intervention was called ‘patient partnering’ with the aim of increasing patient engagement in risk management of STF through education and encouragement to seek assistance when moving about in the room, especially during toileting activities; this included a video and demonstrating/practicing the call bell with the patient.

5. Control. The intervention was implemented by the Advanced Practice Nurse (APN) who both personally conducted patient partnering with 87 patients over a one year period and also disseminated it to the nursing staff at staff meetings and by individual coaching.

[Insert Figure 3 here]

Figure 3. Modified Failure Mode Effects Analysis (FMEA) (Wolf et al., 2014)

4.3 Results

The bar chart in figure 4 shows results of the 2 QI projects with STF rates (and serious injuries) calculated by the number of incidents divided by the number of patient days, multiplied by 1,000. Calculating this rate also allows comparison of phases with different time periods (baseline 24 months, Lean 17 months and Six Sigma 18 months post intervention). A STF with serious injury includes incidents resulting in a moderate injury (e.g. contusion resulting in stiches), a major injury (e.g. broken bone resulting in surgical intervention) or death. STF rates were tracked for 17 months after the implementation of the standard work intervention in project 1 and 18 months after implementation of the patient-partnering intervention in project 2. As with any real world project there were other organisational and local initiatives such as new low beds, new fall risk assessment implemented in the electronic medical record, high turnover rate in staff and management.

[Insert Figure 4 here]

Figure 4. Falls and Falls with Serious Injury rates from 2009-2014 on one oncology division (Wolf et al., 2014)

This oncology ward experienced success in STF prevention even before the 2 QI projects. The biggest decrease in total STF was seen during the 'best practice' phase before the start of project 1 - the first 7 months after the arrival of an Advanced Practice Nurse. All her job activities were devoted to STF prevention in a manner that could not be sustained as additional priorities became more demanding so the 2 QI projects aimed to maintain the momentum of STF prevention.

Seventeen months after implementing the standard work process in project 1 (Lean), a 34% reduction in total STF was achieved (4.49 vs 6.85 fall rate at baseline). This was the only statistically significant result at ($p<0.05$) Mann Whitney U (U-value is 57, critical value of U at $p \leq 0.05$ is 87).

Although not statistically significant, there are some notable trends in STF with serious injury. There were no STF with serious injury for 14 months during project 2 (a record for this ward); a 56% decrease compared to baseline. STF with serious injury are such a rare event that the rate is greatly impacted by each occurrence requiring a very long post intervention period to have enough statistical power to realize significance. The final case study will explore the patient's role in STF risk management.

5. Patient-based approaches

One factor that has been identified as important for success in the reduction of both occupational and patient STF is human engagement (participation). Occupational STF risk management projects may have an advantage as employees are contractually required to comply with occupational safety and health policies and procedures. However the relationship of patients with safety procedures is rarely as clearly established or recognized as a priority. It has been suggested that only about 50% of the patients may participate in or adhere with STF prevention initiatives (Nyman & Victor, 2011). One of the reasons for non-adherence can be a difference in expectations between staff and patients, for example in the use of, and response to, a call bell. Tzeng, Hu, Yin, & Johnson (2011) found that more use of call bells resulted in fewer STF, but that patients expected a call bell to be answered in 2.5 minutes, but this was not always possible due to staffing numbers and acuity of other patients. Throughout a hospital stay, patients often experience information overload so a deeper understanding of their perceptions and expectations may help to identify solutions that can be embedded and sustained. In this section 2 projects are reported which explored patient perceptions of STF risks in the UK (Hignett *et al,* 2014) and US (Wolf & Hignett, 2015).

5.1 Patient engagement with STF risk management (UK)

The first project used a clinical audit approach to explore patient engagement with the STF risk management process on medical (admission/assessment units, general medical wards, cardiology, respiratory, orthogeriatrics, care of the elderly and rehabilitation units (Hignett *et al*, 2014). Data were collected from nursing assessment records about individual patient profiles (mobility, cognitive function, continence and vision) and recommended STF interventions, e.g. use of bed rails. Data were collected on every 2nd bed, excluding patients who were inappropriate for observation (e.g. infection control measures or end of life care). The data were analysed descriptively (frequencies) and the risk factors were compared with the whole sample and explored with the Chi-squared and Fisher's exact tests.

Data were recorded for 156 patients, with over 85% aged 65+ years (50% aged 80+ years); 78% had mobility problems, 43% had continence problems and 27% were recorded as having cognitive changes (dementia and delirium). Most patients were in multi-bed bays (87%) with 51% sitting in the bedside chair at the time of the audit (40% in bed and 9%

absent). The patient profile analyses indicated that those with a STF risk (aged 65 years and over; NICE, 2013) were significantly more likely than expected to have mobility problems ($P<0.001$), continence problems ($P<0.005$) and be identified as at risk for pressure ulcers ($P<0.001$) but were not significantly more likely than expected to have cognitive changes.

The observational data recorded that most of the items usually found on the bedside table (e.g. drink, spectacles) were within reach (>80%) but that the call bell (on a cord from the wall) might have fallen out of reach (<60% within reach). Only 21% of walking aids (frames, crutches and sticks) were within reach, and the bedside table was often observed to be obstructing the bedside area (only 24% of bedside areas had no obstacles/hazards).

61% of patients (n=95) were willing and able to answer questions; as the sampling strategy was not based on STF risk, patients agreeing to respond were not more or less likely than expected to be at risk of a STF. When asked what they would do when they wanted to go the toilet, 51% (n=39) said they would *'go alone',* either not calling or not waiting for assistance. Of these, significantly more than expected patients assessed as needing mobility assistance stated that they would go to the toilet alone ($P<0.001$).

5.2 Patient perceptions of STF risks (US)

To explore patients' perception of STF risks, 30 newly admitted patients on an oncology division in a large inner-city academic medical centre agreed to be interviewed (Wolf & Hignett, 2015). The patients ranged in age from 26 to 83 years, with 43% men and 57% women and were all assessed as being at moderate or high risk of STF. Semi-structured interviews were recorded, transcribed and imported into NVivo for thematic coding.

Almost all patients strongly disagreed that they were at risk of a STF during in their hospital stay, even patients who had fallen within the previous 6 months thought that a STF was a chance occurrence and unlikely to happen again. Some of the reasons for a low perceived risk of STF included desiring independence, for example a high fall risk patient often forgot to use her call bell when she got out of bed. When the nurse told her they were going to have to put an alarm on her bed she started crying and said she felt she was losing her independence. Other reasons included awareness of surroundings, using caution when walking around, and denying a need for help, feeling strong and stable while standing and walking, and feeling protected and safe in the hospital. There were interesting themes emerging about lack of control and frustration with respect to difficulties relating to:

- getting about due to clutter (obstacles) and trip hazards (e.g. bathroom threshold);
- finding and using the call bell;
- getting help and information when, and in the way, they 'want' it.

These 2 projects identify a mismatch between patient expectations and STF risk management packages (often based on staff perceptions of STF risk management). These results suggest that, in both US and UK, patients have a desire to retain control over their activities and information access, and will continue to mobilise independently.

6. Discussion:

As over 70% reported patient STF are un-witnessed (Healey *et al*, 2008) and research indicates there are benefits from retaining mobility associated with continence, cognitive function and pressure care (Lahmann *et al,* 2015), there is an argument to design STF interventions to support patient mobility and autonomy. Using HFE and an inclusive design approach allows consideration of the event from the perspective of the person experiencing the STF, similar to approaches used for occupational STF risk management interventions.

The design-based approach aimed to embed safety decisions for STF during design and construction by looking at human activities (tasks) and interactions including space, layout, information for navigation, noise, lighting and flooring.

The staff-based approaches typify the most common approach to patient safety; using a QI approach to improve processes rather than focussing on human behaviour (Hignett *et al*, 2015). It is worth repeating that the reduction in the total STF rate reported from the Lean and Six Sigma projects was time-limited and had dropped to only 6% improvement over baseline within 12 months of the end of the Six Sigma project. Barker *et al* (2009) suggest that a lack of change in total STF rate with an improvement in the injury rate the explanations may be associated with an increase in reporting non-injurious STF, change in reporting system, definition of a STF and risk assessment screening. These explanations do not apply to the Six Sigma project reported in this paper but two additional explanations are offered related to staff engagement and permanence. The intervention was very successful when delivered by the APN but was not consistently implemented by the nursing staff, possibly as it was perceived as requiring additional time. There were also difficulties related to staff turn-over; a problem that impacts on all process-based (QI) interventions as the team for STF prevention must include all staff (physician, nurse, patient care technician) and ancillary staff (dietary, housekeeping).

Unlike some patient safety issues (e.g. pressure ulcer prevention) where patient could be described as a passive recipient of preventive care, for STF prevention, patients must be an active participant as described in Figure 1. The DIAL-F model supports suggests a change in bedside interventions from a passive model of providing care and treatment (analogous to a production line with inanimate components) to an active model representing independent functional activities with changed physical, cognitive and behavioural capabilities. These 2 models were described by Miller & Gwynne (1972) with respect to risk-taking, with the minimum risk environment called the '*warehousing model of care'* (passive), and the more stimulating (active), riskier environment described as the '*horticultural model of care'*.

The DIAL-F model (Hignett *et al*, 2014) proposes that HFE interventions should design environments and systems that support and facilitate (rather than change and restrict) the activities being undertaken (by all stakeholders) as well as mitigate risks of injury if a STF does occur. It offers a new HFE integration model (e.g. work system in Systems Engineering Initiative for Patient Safety (SEIPS) model with '*Person'* in the centre, Carayon *et al*, 2006, Holden *et al,* 2014) by describing the system elements in terms of the level of flexibility or transience (duration of action/involvement). The patient is the most transient element of the system and is represented in the DIAL-F model as personas (archetypal descriptions) in the outer layer. Patients could be described as voluntary, reluctant (not wishing to be a patient), and with some sort of impairment or just not aware or have a realistic understanding of their capabilities. Personas have previously been used for physical changes at five levels of functional mobility ranging from ‘independent for activities of daily living with or without a mobility aid but susceptible to fatigue’, through to ‘wheelchair users with some or no ability to stand and sit without support’, and finally to ‘fully dependent patients (bed bound) to describe terminal stages of care (ArjoHuntleigh, 2012). However, these do not include cognitive or behavioural changes which are an important intrinsic factors of STF and so are included in the DIAL-F model. A systematic review of STF risk factors for people with dementia identified 8 categories including visual and functional impairments (Härlein, Dassen, Halfens, & Heinze, 2009) which could be used to develop a wider range of personas.

The more active model offers an HFE approach that could be similar to occupational participatory ergonomics (Haines, Wilson, Vink, & Koningsveld, 2002) where engagement or involvement was mapped across 9 dimensions: permanence, level of involvement (full direct, partial direct, representative), influence, decision making, mix of participants, requirement (compulsory, voluntary), focus (e.g. design equipment, tasks), remit (process development, problem identification, solution development/evaluation), and role of HFE input.

Risk management solutions for occupational STF seek to enable activities in the workplace to ensure that the intervention has minimal impact on productivity and performance. In healthcare, we suggest, a similar approach should be taken by designing interventions for STF that seek to support and enable patient mobility. The challenge is to design inclusive interventions to benefit a range of patients that do not introduce barriers or problems for staff and other system stakeholders. For example poor balance linked to rising from a chair might be assisted by building and technology design solutions, or not using an out of reach assistive device could be addressed by providing accessible equipment and timely assistance (Tuunainen, Jäntti, Pyykko, Moisio-Vilnenius, & Toppila, 2013).

7. Conclusion:

Slips, trips and falls are a frequent adverse event in hospitals. We propose a step change for STF (and other) patient safety initiatives to use HFE principles as both the overarching (top down) and underpinning (bottom up) framework (Hignett, 2001). This offers an opportunity to integrate HFE with embedded QI knowledge and experience (from over 30 years of interventions) by focusing on human behaviour to understand and design interventions rather than identifying variation and implementing change based on testing different approaches to achieve the desired outcome (Hignett *et al*, 2015).

This paper has highlighted that STF interventions in other industrial sectors use both design and systems approaches to improve wellbeing and performance. Rather than continuing to fight this seemingly intractable fire with complex packages (or bundles) of care, we suggest it is time to look proactively at this problem with an HFE approach to facility design and other interventions that include the perspective of all the stakeholders. Our case studies suggest that innovations in STF prevention may best be achieved with a similar approach to other industrial sectors, by designing the HFE intervention with input from the person who experiences the STF event; the patient.

Key points:

- Slips, trips and falls are a very frequent adverse event in hospitals and interventions typically involve multiple components designed to improve staff processes (assessment, communication, monitoring), and patient capabilities
- DIAL-F is a new Human Factors/Ergonomics (HFE) integration model that uses a telephone DIAL shape to represent a dynamic system with the most change (and motion) in the outer rings (F is for falls)
- Three case studies are used to discuss how HFE has been, or could be, applied to STF risk management as (1) a design-based (building) approach to embed safety into the built environment; (2) a staff (and organisation)-based approach; and (3) a patient behaviour-based approach to explore and understand patient perspectives of STF events.
- The results from the case studies suggest taking a similar HFE integration approach to other industries, i.e. a sustainable design intervention for the person who experiences the STF event - the patient.

Key words: Hospital Slips, Trips, Falls, Facility Design, Lean, Six Sigma, Dynamic Systems Approach, Participation

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