Chapter 76: Taking a Human Factors systems approach to slip, trips and falls risks in care environments

1. Introduction

As Human Factors/Ergonomics (HFE) becomes more embedded in healthcare (National Quality Board, 2013) there is an opportunity to consider one of the more intransigent safety problems; slips, trips and falls (STF). This chapter will firstly consider the risks for STF within (a) an HFE design model and (b) a new healthcare architecture risk assessment tool and secondly, reflect on staff and patient engagement in quality improvement (lean and six sigma) projects to reduce both the number of STF and associated injuries.

We start by offering an inclusive definition for healthcare HFE by extending the International Ergonomics Association definition (IEA, 2000) to include concepts of clinical performance from Catchpole *et al.* (2010).

> 'Scientific discipline concerned with the understanding of interactions among humans [*patients, staff, visitors etc.*] and other elements of a [*healthcare*] system [*with the vision of enhancing human experience in a collaborative, inclusive partnership]*.
>
> HFE professionals apply theoretical principles, data and methods to design in order to optimise human well-being and overall system performance. *[Approaches include the study of tasks, equipment, workspace, culture, teamwork and organisation in clinical care and treatment settings].'*

This introduces theoretical models by describing the discipline of HFE in terms of systems and professional practice applications in terms of design.

2. Context

Donaldson *et al.* (2014) describe STF in hospitals as '*seemingly intractable'* in a review of patient deaths due to unsafe care. STF were the second most frequently occurring incident type (after failure to act on/or recognise deterioration, and equal to healthcare associated infection) but have not received the same national priority as infection, deep vein thrombosis and pressure sore risks. The incident rate for STF is approximately 3 times higher in hospitals and nursing homes than in community-dwelling older people (American Geriatrics Society, 2001). It has been suggested that this may be due to a combination of extrinsic risk factors (relating to the environment), for example, unfamiliar setting and wheeled furniture, combined with intrinsic risk factors (relating to the patient) such as confusion, acute illness and balance-affecting medication (Tinetti, 2003; Salgado *et al.*, 2004; Tinker, 1979; Kannus *et al.*, 2006). These have been categorised in Fig. 1 as assessment, communication, monitoring, modify patient, and modify environment (Hignett, 2010).

The main users of hospitals are older people, with people over 65 accounting for 62% of total bed days in hospitals in England, and 68% of emergency bed days (Imison *et al.,* 2012). In 2013 the National Institute for Clinical Excellence (NICE, 2013) summarised the research evidence on STF in hospitals and recommended that all people admitted to hospital over the age of 65 years should automatically be considered to be at high risk of STF. This means that a detailed individual assessment is no longer required and more time/resources can be focussed on, for example, interventions with ward-specific STF run-charts, reducing environmental hazards, providing personal alarms, and communicating patient risk across multidisciplinary teams (Oliver *et al.*, 2010; Donaldson *et al.*, 2014).

In the USA, STF with trauma in hospital are a 'Never Event', with no reimbursement for associated costs (investigation, treatment and additional duration of stay) so there is considerable motivation to reduce (eliminate) both the total number of STF and injuries

(NQF, 2007). This has resulted in STF interventions being prioritised and financially supported with the outcome that STF rates are generally reported at lower rates in the USA (2.0-7.74 falls per 1000 patient bed days) and associated injuries at less than 0.5 per 1000 patient bed days (Wolf *et al.*, 2013; Bouldin *et al.*, 2013; Hempel *et al.*, 2013) compared with the UK (2.1 – 9.0 per 1000 patient bed days; NPSA, 2010) with variations due to reporting mechanisms, clinical speciality and acuity. However despite numerous best-practice interventions STF remain one of the major patient safety and preventable harm issues.

Assessment

Communication
Educate staff
Educate patient (and family) to ask for help
Educate patient (and family) on use of equipment
e.g. nurse call, lighting, bed controls, bathroom facilities
Signs for staff, patients, families
Staff handover; Post fall huddles
Labels on patients (wristbands, socks)

Monitoring
Move closer to nursing station/toilet
Assist patient with transfers at all times
Regular visits, rounding (hourly/2-4 hourly at night)
Shared accommodation (informal monitoring)
Patient sitters (family, volunteers); CCTV cameras
Stay with patient during elimination (bathroom)
Alarms (bed, chair, sock)

Modify Patient
Medication (poly pharmacy)
Continence management (regular toileting, condom catheter)
Strength and balance (exercises, physical therapy)
Falls training (how to get up from the floor)
Walking aids; Impact protection (hip protectors, helmets)
Vision (review and treatment)
Podiatry, foot wear, anti-skid socks

Modify Environment
Bed height; Restraints (bed rails, enclosed bed, wrist/body)
Decrease impact (anti-slip mats, flooring, cushions)
Remove obstacles (de-clutter)
Clear (and marked) pathway between bed and toilet
Keep items (water, call bell, telephone) within reach
Commode next to bed; Grab rails in bedroom and bathroom
Toilet height; Maintain equipment, environment
Close doors to decrease noise; Lighting
Design of room, ward (inappropriate door openings, layout)

Figure 1. Interventions for in-patient falls (Hignett, 2010)

3. HFE design model for STF

The Systems Engineering Initiative for Patient Safety (SEIPS) model has been widely used as an intervention framework in healthcare (Carayon *et al.*, 2006, 2014). It describes the process of care and treatment as 5 components in an interdependent work system where the care provider (people factor) performs various tasks using tools and technology in a given environment within an established organization to achieve patient and hospital outcomes. We suggest that SEIPS 1.0 (Carayon *et al.*, 2006) perpetuated the passive role of patients as care recipient in a minimum risk environment described by Miller and Gwynne (1972) as the '*warehousing model of care'* (passive), in contrast to a more stimulating, riskier (active) environment described as the '*horticultural model of care'*. In 2013, Holden *et al.* introduced SEIPS 2.0 with modifications to more clearly articulate the role of the patient in the system as '*patient work'*. This is very welcome but, we suggest, implies a compliant role where patients engage with the system and follow instructions to deliver their '*work'*. For STF, where over 70% of incidents are un-witnessed (Healey *et al.*, 2008), we suggest that a model relying on patient engagement in the system is less applicable. Many unwitnessed STF will be associated an independently initiated activity (e.g. feeding, grooming, bathing, dressing, bowel and bladder care, and toilet use) without calling or waiting for assistance (Hignett *et al.*, 2014).

To address this theoretical gap, we have developed an HFE design model for STF (DIAL-F) to consider which interventions are likely to be the most sustainable and embedded within the care/treatment system. The DIAL-F model (Fig. 2; Hignett *et al.*, 2013; Hignett, 2013) describes system elements in terms of stability or transience (duration of action/involvement). The telephone DIAL shape represents a dynamic system with the most change (and motion) in the outer rings; F is for falls. The building design (layouts, decor, signage, lighting levels etc.) is at the core as the least frequently changing element requiring a major project for either refurbishment or new build. Organisational policies and procedures (defining the organisational culture) of the hospital or care facility will probably be modified/updated on an annual basis. Technology is likely to change more frequently either through the introduction of new equipment, furniture and medical devices or by being moved between wards and departments.

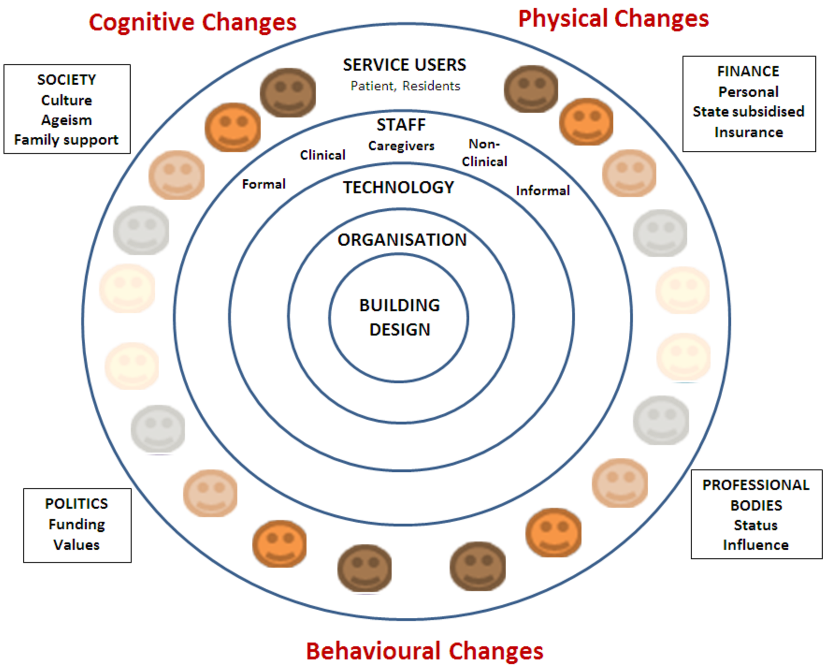

Figure 2. DIAL-F (Hignett et al., 2013)

The staff layer includes clinical, non-clinical (including contractors), formal and informal (visitors, family) caregivers. Clinical staff may vary in terms of their permanence, number on duty, knowledge, skills and competencies between shifts and areas in the organisation. The patient is the most transient element of the system and is represented in the outer layer in contrast to more usual person-centred HFE models (Bogner, 2005). The external factors (society, finance, politics and professional bodies) impact throughout the system on patient expectations, staff terms and conditions as well as organisational policies.

Patients are described as personas - fictitious representations used in design to describe groups of archetypal (rather than actual) people (Adlin and Pruitt, 2010). Personas have been used to describe patients with physical changes at 5 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 personas do not include cognitive or behavioural changes; a systematic review of risk factors for falls in dementia identified 8 categories including visual and functional impairments (Härlein *et al.*, 2009) which could be used to develop a wider range of personas.

The DIAL-F model was used to discuss the results from a STF audit, which confirmed the role of the active patient, where significantly more than expected patients needing mobility assistance indicated that they would mobilise independently to the toilet. Building design and technology risks were identified with only 24% of bedside areas having no obstacles/hazards (Hignett *et al.,* 2014). The STF risks were found to vary with patient characteristics with 2 distinct groups identified; patients needing mobility assistance (frail) and patients with cognitive changes (confused) with only a small overlapping population.

4. Safety Risk Assessment (SRA) tool for healthcare architecture

The design process for healthcare architecture is notable for its ability to address complexity but traditionally follows a lengthy and complex process that balances scope, schedule and budget that often results in conflicting goals (silos) for service, care and long-term efficiency. As the ramifications of healthcare facility design are felt for the next 30-50 years or more, the integration of research evidence is very important. Over the lifespan of the building (and sometimes the lifecycle of a project) priorities will change, models of care will change, staff and patients will change and technology will change. So a building design requires systems-thinking that addresses physical, cognitive, and organizational issues and design teams must navigate from simple 'functions' to a more complete understanding of the user actions that the building has to support (Attaianese and Duca, 2012). To promote a proactive process there is a need to understand the integration of hazard and risk reduction, for example, many emergency events are not entirely unexpected and could be reasonably mitigated (Bosher *et al.*, 2007). The built environment has the potential to be an enduring and viable approach to improving outcomes but requires new perspectives to encourage innovative design solutions (Steinke *et al.*, 2010).

To address this gap The Center for Health Design (CHD) is developing a proactive safety risk assessment (SRA) tool based on the premise that the built environment is a critical component of the healthcare system (Taylor *et al.,* 2014). The goal was to create safer healthcare environments by developing a toolkit to enable careful consideration of built environment factors that impact safety, proactively, during the design and construction of healthcare facilities.

The first stage (Delphi Process; Gallagher *et al.*, 1993) constructed evidence statements to link research evidence (Ulrich *et al.*, 2008;Quan *et al.*, 2011) with guidelines (FGI, 2014). These were developed, tested and achieved consensus for 6 safety issues: healthcare associated infection, patient movement and handling, falls and immobility, medication safety, security and behavioural health (Taylor *et al.*, 2014; Fig 3).

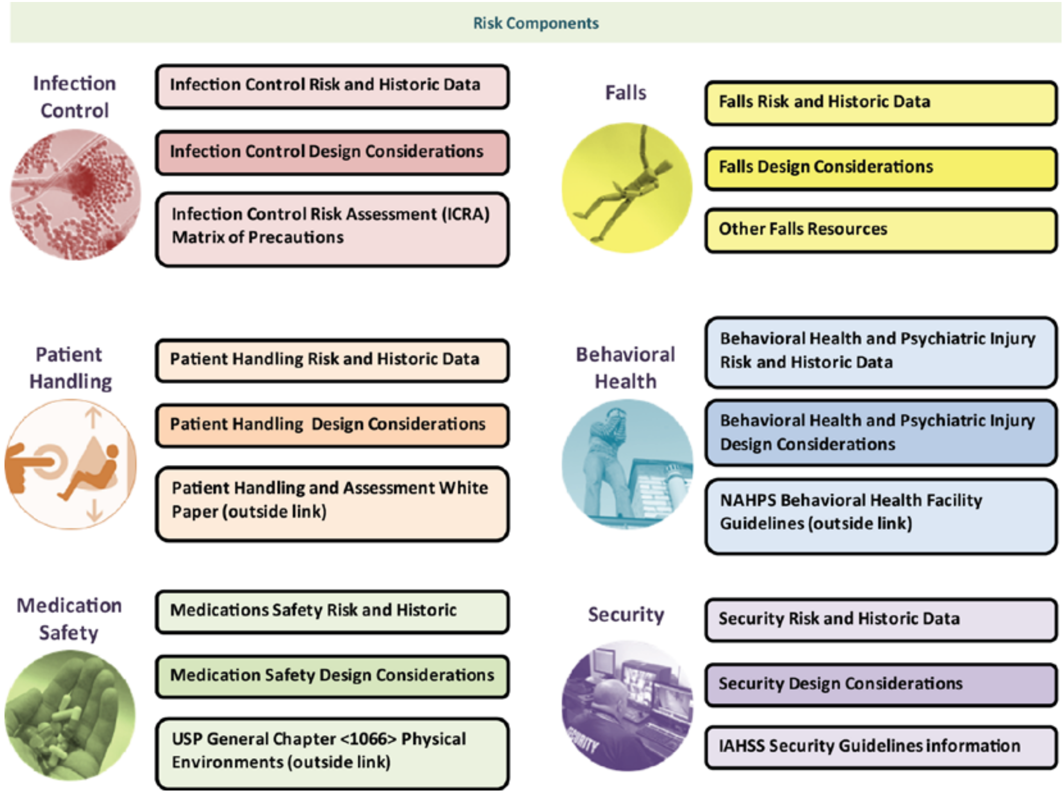

Figure 3. Safety Risk Assessment Components (reproduced with permission of CHD)

Items were indexed and reviewed for setting (e.g. hospital, ambulatory care), hospital department (e.g. nursing unit, diagnostic and treatment), unit (e.g. emergency, medical/surgical, ICU), population (e.g. elderly, rehabilitation), built environment design category (e.g. building envelope, room layout) and a subset of conditions leading to the built-environment hazard (e.g. acoustical environment, visibility). The consensus process used an online survey in which participants evaluated both inclusion and wording of a statement (Fig. 4). Any unresolved statements (less than 70% agreement) were reviewed in a second consensus round after which any residual unresolved statements were included in the Nominal Group Technique (NGT, Gallagher *et al.*, 1993) workshop.

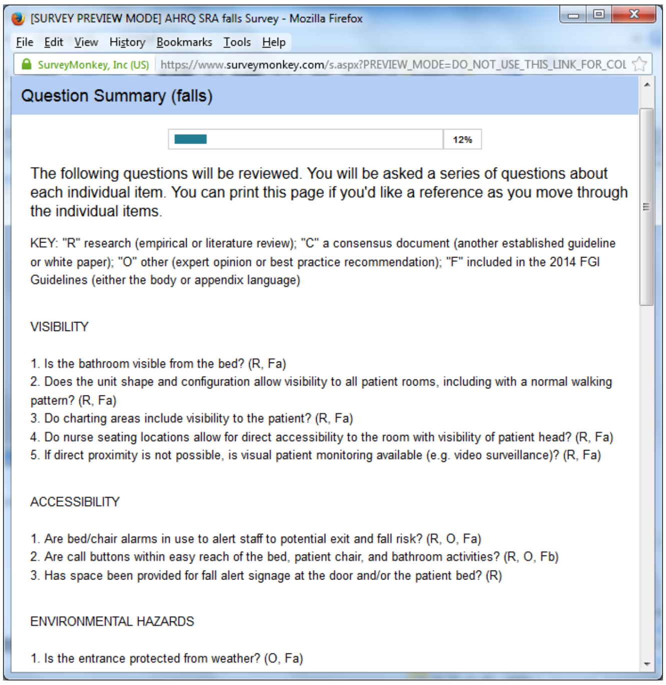

Figure 4. Delphi process

For the Falls and Immobility group, 36 evidence statements were reviewed by 15 participants in the Delphi process (online) with 32 statements (as design questions) finally included at the NGT workshop by 8 participants. The risks are mapped into 6 categories for environmental hazards (e.g. slippery floors), ergonomics (physical interactions, anthropometry), interior layout (family friendly environment, proximity), light quality/levels and noise, accessibility and visibility (Fig. 5).

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 5. Preliminary Included statements (design questions) for Falls and Immobility

These design questions have been tested in three design projects and multiple hypothetical scenarios, and the final SRA toolkit is available from the Center for Health Design (http://www.healthdesign.org/). This provides an evidence-based resource in building design to both integrate and support the elements in the DIAL-F model.

5. Staff and patient engagement in STF risk management through Quality Improvement (QI) projects

This section describes 2 projects on oncology wards using Lean and Six Sigma to introduce interventions by engaging patients and staff in the risk management process. The results will be discussed using the DIAL-F model to consider the sustainability of interventions using quality improvement (QI) methods.

5.1 QI and HFE

Although Lean and Six Sigma methodologies began in other industrial sectors they have been implemented in healthcare for over ten years. The most common uses of Lean and Six Sigma have involved through-put, length of stay, resource utilization and patient safety (Graban and Prachand, 2010).

Lean is a QI method that requires employee engagement to solve problems by eliminating waste. The fundamental concepts include focussing on the process, respecting every individual (employees, partners, suppliers), quality assurance at the source, continually seeking perfection, embracing scientific thinking (value stream analysis, problem solving), transparency, standardizing tasks, and going to the source of work and observing all the tasks (Liker, 2004).

Six Sigma is a systematic, fact-based, data-driven, problem-solving QI process that aims to increase business performance by reducing defects (unexpected outcomes) and process variation (inconsistent methods and results) (Junewick, 2002). It is comprised of 5 phases: Define-Measure-Analyze-Improve-Control (DMAIC) and focuses on strong leadership tools and an emphasis on bottom-line financial results (Benbow and Kubiak, 2005).

The definitions of HFE and QI overlap substantially with the design of work, workplace and work environment leading to quality deficiencies, human error and physical/cognitive harm (Eklund, 1997). Wolf (2013) compared Lean, Six Sigma and HFE approaches using the dimensions of philosophy, focus, data collection strategies, improvement tools, techniques for understanding tasks and workflow, data transparency and analysis:

- Each approach has a unique philosophy (epistemology) but share a common goal of improving the process for the user, with a safer, more efficient system.

- The focus for all 3 approaches is to develop a process that matches the needs of the human (supplier, customer, user/operator) who will use it or benefit from the output of the process.
- Six Sigma and HFE are more closely aligned than Lean for data collection strategies. Lean projects typically collect data with a quick (hourly or daily) snapshot in time and may not include the impact of long term issues.
- There is evidence of transfer of improvement tools with the most overlap between Lean and Six Sigma (value stream mapping, standard work and voice of the customer).
- Techniques for understanding tasks and workflow are similar but each has a different complexity level. For example a Lean spaghetti diagram will simply illustrate where a worker travels along a floor plan by linking one location to the next whereas in HFE a task analysis can be very complex with added meaning (weighting or importance) to each link.
- Lean typically uses very simple, visual process control charts which can easily be updated throughout the day to provide timely feedback. Six Sigma and HFE tend to use more complex quantitative and qualitative data analyses.

5.2 Lean

The first project used Lean techniques on three oncology wards (97 beds; 71 single rooms) with the aim of reducing patient STF and associated injuries (Wolf *et al.*, 2013). STF in oncology wards were often found to involve patients who would not call for help (even when instructed to do so) and specific risk factors associated with medications (i.e. benzodiazepines, sedatives/hypnotics) and disease-associated pathologies which could cause altered elimination (frequent urination or diarrhoea).

A systematic, data driven process was used starting with a 3-day Rapid Improvement Event (RIE). There was excellent leadership support from hospital and unit level management which allowed front-line nursing staff to attend the RIE as well as other members of the multi-disciplinary team (physical and occupational therapy, pharmacy, physicians, information systems, low bed equipment vendor, and clinical operations). The hospital leadership performed a SIPOC (Supplier/Input/Process/Output/Customer) to select the roles to be represented in the RIE and a key stakeholder assessment was conducted to identify potential areas of support and resistance.

The current state was documented in a process map with swim lanes for each ward using traditional Lean methods to resolve issues such as: fist-to-five, silent voting, affinity diagramming and brainstorming round-robin techniques to ensure input from all participants and was subsequently verified by direct observation. The initial gap analysis found that assessments for gait and mental status were not being carried out in a consistent manner and that there were delays in implementing interventions (e.g. bed alarm or low bed). The future state map included:

- STF risk assessment to be completed every shift (and when patient condition changed) including gait and mental status assessment using the Get-Up-and-Go test (GUG, Currie, 2008) and Short Portable Mental Status Questionnaire (SPMSQ, Pfeiffer, 1975).
- Implementation using an intervention algorithm (Fig. 6) based on a Linking Evaluation and Practice (LEAP) grid and the Johns Hopkins risk assessment methodology (Poe *et al.*, 2007) to assist nursing staff in linking the risk assessment results to the selection of appropriate interventions.
- Collection of incident data within 60 minutes following a STF (post incident huddle) followed by a more detailed investigation by the Advanced Practice Nurse (APN).

- Data transparency (post incident) for all staff with a wall-mounted Fall Tracker Board (FTB) to display data from the post fall huddle and APN investigation.

The algorithm was used, for example, with a patient having an ‘altered gait’ (failed GUG test) with recommended interventions to use a low bed, floor mat, bedside commode, gait belt and request physical and occupational therapy. If the same patient also had altered elimination (frequent toileting) no additional interventions would be required. However, if this patient subsequently became confused (missed 3 or more questions on the SPMSQ) the algorithm would recommend bed and chair alarms as additional interventions.

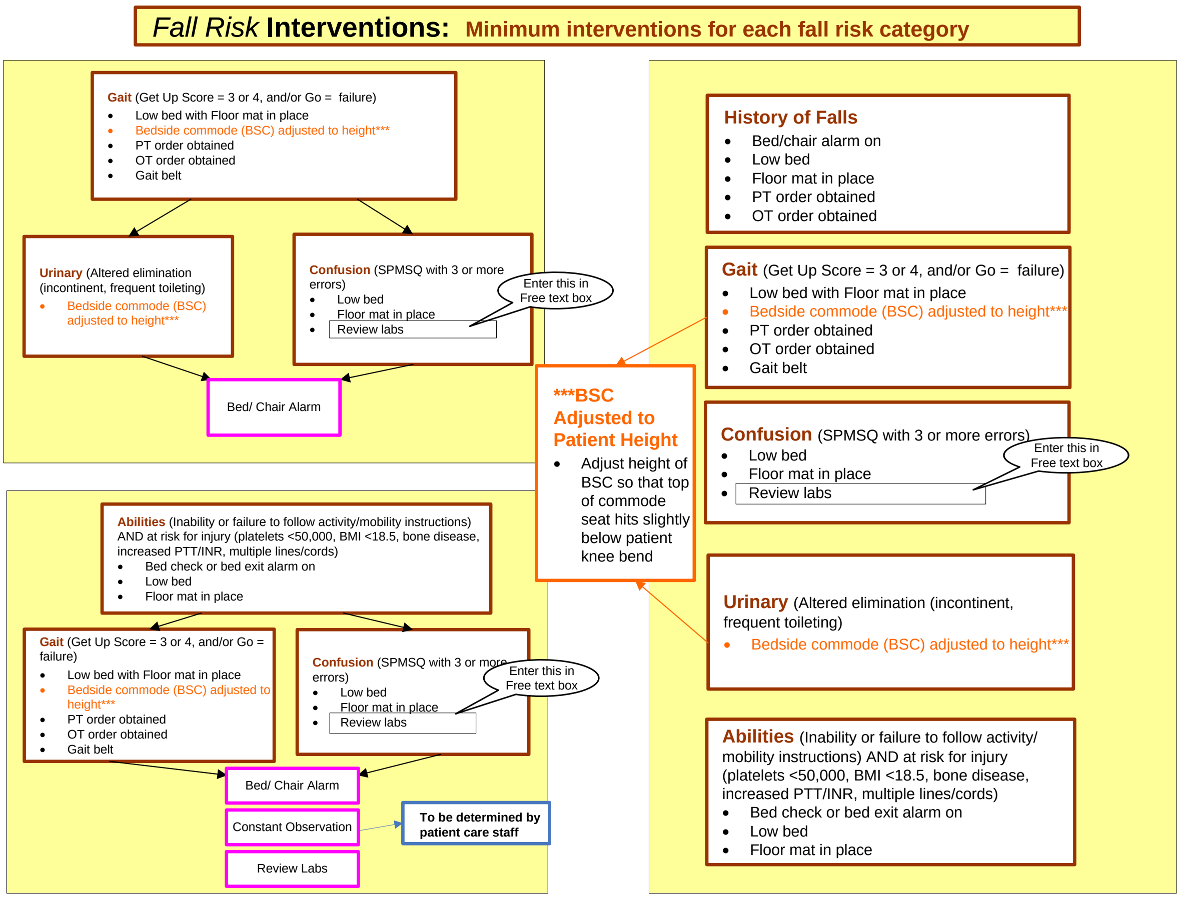

Figure 6. Algorithm for linking Fall Risk Assessment to Appropriate Intervention

The action lists (e.g. educational materials, standard work processes, training for approximately 150 nurses, communication to the MDT) from the RIE took approximately four weeks to prepare before ‘Go Live’. Each action plan complied with the W-W-W methodology (WHAT action is needed –WHEN must it be completed – WHO is responsible).

Various problems and barriers were encountered during implementation including training provision (resolved by using nurse champions), acceptance of SPMSQ (withdrawn and replaced with the existing mental status assessment questions), use of low beds and bed alarms (addressed by increasing availability and reducing delivery time), and documentation of gait and mental status data in the electronic medical record (EMR; added as free text).

Initially the reported STF decreased by 26% and associated injuries decreased by 38%, however the success was not sustained after nine months (Fig. 6). There were benefits through increased staff engagement with newsletters, practice updates, feedback to leadership, improved data from the FTB and EMR and, 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 *et al*., 2014).

5.3 Six Sigma

The second project used Six Sigma on one oncology ward over 12 months with a one year post intervention period to investigate the root causes of enduring risk factors such as unassisted toileting and continuously changing patient conditions (Wolf *et al.*, 2014). The intervention was conducted with 87 high fall risk patients where 6% (n=5) experienced a fall.

The 5 phases in the DMAIC (Define-Measure-Analyse-Improve-Control) Process were:

*1. Define***.** The issues were defined using the SIPOC (Supplier, Input, Process, Output, and Customer) and Solution Tree (Affinity Diagram) methods to collect the Voice-of-the-

Customer (equipment, environment, call lights, communication, staffing, staff education and awareness, patient assessment, patient education, and family education).

2. Measure. A cause-effect matrix was used to determine the most critical factors and represented on fishbone diagrams to determine root causes which were then investigated in more detail.

3. Analyse. Additionally 5 common issues were recorded and analysed: call light response time; patient activity and behaviour at the time of the STF; medications given and changes in patient condition in the preceding 24 hours. The Failure Mode Effects Analysis (FMEA; Ashley *et al.,* 2010) was used to explore possible barriers or failure routes using the Impact Matrix technique for likelihood and severity. These included: no power to hold staff accountable; turnover (with 100% change in ward management during the project); lack of APN time (initially the daily report preparation required 1 hour but was reduced to 30 minutes with data from the EMR); and lack of nursing engagement.

4. Improve. The chosen intervention was ‘Patient Partnering' to encourage patients to call for help and participate in preventing their own STF risks. The APN reviewed all patients at risk and mentored nurses to partner with patients with the aim of empowering patients to seek assistance when moving about in the room, especially during toileting activities. This included a video and demonstrating and practicing the call bell with the patient (with follow review after 2 hours).

5. Control. The intervention was disseminated through staff meetings and individual coaching. It was found that nurses would cooperate with the APN in patient partnering, but did not initiate the partnership themselves due to the perceived additional time requirement.

5.4 Did the QI projects sustain and an embedded impact?

Although the 16 months after the RIE showed 33% improvement in total STF rate; 10 months after the completion of the Six Sigma project the total STF dropped to only 6% improvement over baseline (Fig. 7), however STF with minor injuries increased after project

2. The percent of STF with serious injury decreased from 10% in 2010 to 6% in 2011 and there were no STF with serious injury in 2013.

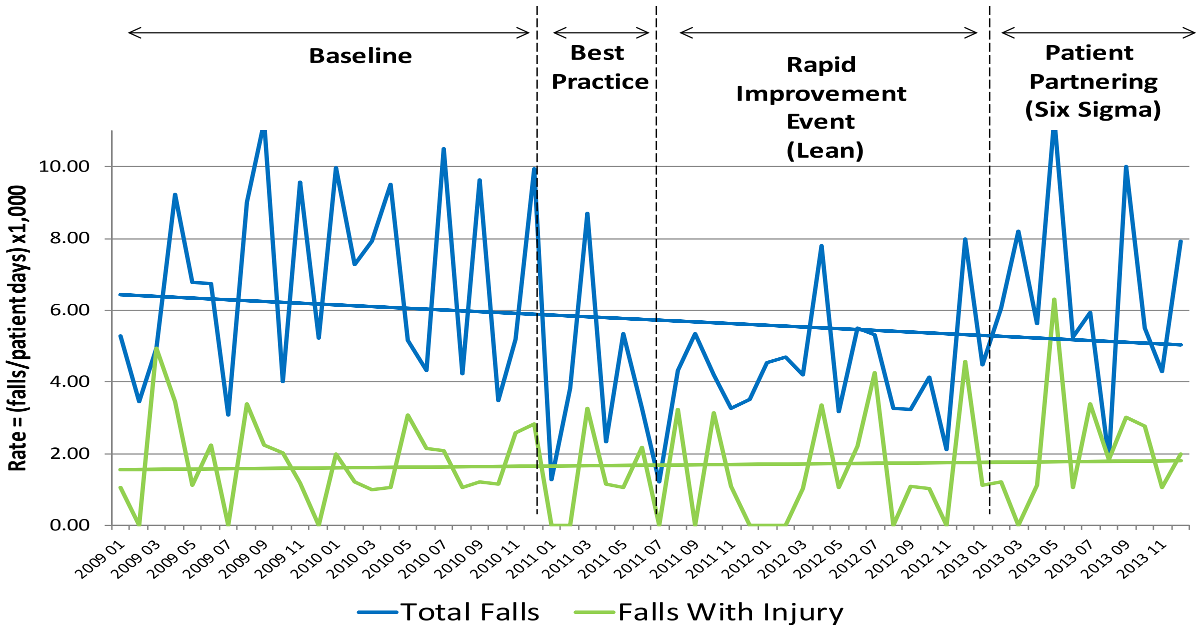

Figure 7. Falls and falls with injury rates in oncology from 2009-2013 rate (Wolf et al., 2014)

It was concluded that a deeper understanding of patient and staff perceptions was needed to create more sustainable solutions.

6. Discussion

The use of QI approaches has been very popular in the 2000s with multi-million dollar projects. In England, the Productive Ward initiative was based on Lean with the aim of increasing '*the proportion of time nurses spend on direct patient care, to improve experiences for staff and patients, and to make structural changes to the use of ward spaces to improve efficiency'* (NNRU, 2010, 2011). Pockets of success were reported but despite positive bias in the evaluation, there were reports of difficulties in sustaining change (Wright and McSherry, 2013; NNRU 2011). This has also been identified as a problem for Six Sigma, for example Christopher *et al*. (2014) highlighted the difficulty in maintaining '*longevity of these strategies …. [and] a sustainable process to prevent falls*' in despite heightened staff awareness and engagement. For STF risk management there is some evidence of short term success with expensive (labour intensive) solutions that increase staffing (Veluswamy and Price, 2010). However, as these QI programmes matured, compliance waned possibly due to a failure to achieve the culture shift required to achieve a sustained impact. So, a simultaneous drawback and benefit to using QI methods is that they require a culture change in every employee (Radnor et al. 2012) and healthcare workers, as an industrial sector, are susceptible to change fatigue (NNRU, 2010) due to the frequent shift in initiatives (Ferlie and Shortnell, 2001).

These problems can be described in terms of the DIAL-F model, where initiatives focussing on the outer layers (patient partnering, staff training) have failed to impact on the more central organisational layer. Dy *et al.*, (2011) compared STF with other patient safety events using 11 dimensions (regulatory versus voluntary, setting, feasibility, individual activity versus organisational change, temporal (one-time vs repeated/long-term), pervasive versus targeted, common versus rare events, patient safety practices maturity, degree of controversy/conflicting evidence, degree of behavioural change required for implementation, and sensitivity to context. They describe STF initiatives as previously having been based on individual activity (patient assessment) rather than organisational change. However the QI projects described in this chapter have attempted to impact on organisational (and safety) culture with limited success.

Dy *et al.* (2011) continue by describing the research for patient safety practices relating to STF risk management as conflicting and controversial, with a high need for behavioural change (described as human factors). We suggest that a more comprehensive interpretation and application of HFE is needed, based on the IEA (2000) definition to '*apply theoretical principles, data and methods to design in order to optimise human well-being and overall system performance'*. The DIAL-F model seeks to achieve this by locating the more sustainable element (building) as the central component in the design of the system for STF risk management. We contend that if the design of the physical (micro) environment (core element) is intrinsically unsafe then no amount of improvement interventions at staff (meso) or organisational (macro) levels will produce an embedded reduction in STF risks.

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