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Silver bullets or buckshot?
Patient falls and a systems model in healthcare facility design

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Falls are associated with increased length of stay in hospitals and higher healthcare costs connected to additional care, discharges to institutional care and litigation claims. Under current US reimbursement programs, organizations are penalized for hospital-acquired conditions, including falls with injury not present on admission. This paper presents the results from a systematic mixed methods literature review on the correlates and interventions for patient falls. While the review is focused on conditions of the physical environment, these must be considered in the context of organizational and people-based factors to fully address the system complexity. A model for systems integration is proposed.

Practitioner Summary: Healthcare organizations continue to struggle with preventing patient falls. Because of the multifactorial contributions to fall risk, falls reduction programs include multiple solutions with no ability to quantify the effectiveness of any particular component, and yet, the question is always asked, “What really worked?” Rather than seek silver bullets, we should establish frameworks that account for the interactions within the system that also a proactive approach to healthcare facility design.

Keywords: review, falls, safety, healthcare, design

1. Introduction

Falls are a key consideration for patient safety and play a prominent role under the US Patient Protection and Affordable Care Act. Falls are associated with increased length of stay in hospitals and higher healthcare costs associated with additional care, discharges to institutional care and litigation claims. Starting in October 2008, organizations are penalized for hospital-acquired conditions (HACs), including falls with injury not associated with the initial hospital admission (CMS, 2013). In 2015, additional penalties have been implemented with the HAC Reduction Program, which includes a composite measure of serious complications, inclusive of a post-operative broken hip from a fall (QualityNet December 2014).

Falls are caused by intrinsic and extrinsic factors. Intrinsic risk factors are integral to each individual, (Tzeng & Yin, 2008) and may be associated with demographics such as age, weight, and gender, as well as previous falls, reduced vision, mental status deficits, development stage (for children), acute illness, and chronic illness, mobility or balance disorders, misperception of the environment, or loss of consciousness (Schaffer et al., 2012; Tzeng & Yin, 2008; Vassallo, Azeem, Pirwani, Sharma, & Allen, 2000). The foremost predictor of patient falls is a prior fall, with age as a contributing factor (Calkins, 2012). Brandis (1999) found that 77 percent of falls occurred in people over the age of 60.

Extrinsic factors can include environmental factors, but also includes staff communication, risk assessments, medications, care planning, and unavailable or delayed care provision (Choi, Lawler, Boenecke, Ponatoski, & Zimring, 2011; Healey, 1994; Schaffer et al., 2012; Tzeng & Yin, 2008; Vassallo et al., 2000). Schaffer goes on to state, “the interactions of these environments may result in increasing or decreasing the risk for a fall and the potential for injury as a result” (p. 11). With respect to extrinsic factors, there is a lack of research to systematically examine environment-related interventions for falls in hospital settings (Calkins, 2012; Choi et al., 2011). Furthermore, most falls researchers do not include building features as discrete variables, making it virtually impossible to determine the relative role of the built environment on fall and fall risk (Gulwadi & Calkins, 2008).

Recent HFE papers start to distinguish between the physical environment of the work system and the external environment that can influence all work system elements (Carayon et al., 2013), but the lack of specificity of the physical environment continues to leave gaps in fully integrated HFE considerations. A more proactive approach can be taken to understand the built environment as a latent condition of falls. This paper presents the results from a systematic mixed methods literature review on patient falls, focusing on the built environment, and recognizing the need for systems thinking in complex healthcare contexts. This work is part of on-going research for the development of a Safety Risk Assessment (SRA) for healthcare facility design to promote discussion for proactive decision-making.

2. Methods

2.1. Search Strategy

Key words were assembled from Medical Subject Headings (MeSH) terms from 10 papers retrieved from a previous grant-related search (as reported in Quist & Joseph, 2013). The most common terms across papers were used and then supplemented through alternate considerations. Searches included various combinations of the search terms. Three databases were used: EBSCOhost - MEDLINE; Thompson Reuters - Web of Science; and EBSCOhost – CINAHL. This was subsequently supplemented by a search using the keyword “falls” in The Center for Health Design knowledge repository, a database specific to built environment implications on outcomes (www.healthdesign.org/search/articles). A bibliography review was also used to assemble the final compilation of papers.

Inclusion was limited to the outcome of falls or falls with injury (qualitative and quantitative results), but not intermediate outcomes such as incontinence, gait or postural sway were not included. Populations included patients (adult and paediatric) and staff. Settings included hospitals, but not homes, communities or long-term care/residential settings. Only English-language papers were reviewed. The search was initially conducted in May 2013 and updated in January 2015.

2.2. Search Flow and Critical Appraisal

The search resulted in more than 500 papers. Titles and abstracts were screened, with 89 papers referencing the built environment. Following full text review, 32 papers were included – 27 single study papers and five literature reviews. The five literature reviews found under the search parameters were reviewed and appraised using the AMSTAR appraisal tool, validated by Shea, et al (2009). Each of the included literature reviews established different criteria for inclusion and analysis (e.g. outcomes such as falls or intermediate outcomes related to falls; populations such as adult inpatients; and settings such as acute-care hospitals or long-stay settings.) As a result, the literature reviews were analysed for thematic frameworks and additional citations that would meet the original inclusion criteria for this review.

To avoid citation duplication or secondary citations, literature reviews were not included in the final thematic analysis. The papers included in the final review were by mapped by level of evidence as proposed by Stichler (2010) through the method developed by Marquardt and Motzek (2013) and then critically appraised using a mixed methods critical appraisal tool (Pluye, Gagnon, Griffiths, & Johnson-Lafleur, 2009). This method has been previously reported (Taylor and Hignett, 2014).

Interventions to mitigate the risk of falls are often part of a multifactorial solution with no ability to quantify the effectiveness of any particular component. Table 1 presents the papers included in the review and highlights how numerous interventions or conditions may be present as part of a falls prevention program.

Table 1. Reviewed papers and number of included interventions and conditions to prevent falls (cor. = correlates)

Citations included in literature review	# included interventions
1. Barker, A., et al (2013). J Adv Nurs, 69(1), 112-121.	15
2. Bell, J. L., et al (2008). Ergonomics, 51(12), 1906-1925.	14
3. Brandis, S. (1999). Journal of Quality in Clinical Practice, 19(4), 215–221.	12
4. Calkins, M.P., Biddle, S., & Biesan, O. (2012). (pp. 1-95). Concord, CA: The Center for Health Design.	8 cor.
5. Cozart, H. C. T. (2009). Environmental effects on incidence of falls in the hospitalized elderly. (PhD Dissertation), Texas Woman's University, Denton, TX.	8
6. Dacenko-Grawe, L., & Holm, K. (2008). Medsurg Nurs, 17(4), 223-227.	17
7. Donald, I. P., et al (2000). Clin Rehabilitation, 14(2), 178-185.	5
8. Drahota, A. K., et al (2013). Age Ageing. 42(5), 633-640	4

Citations included in literature review	# included interventions
9. Dykes, P. C.,et al . (2009). J Nurs Adm, 39(6), 299-304.	9
10. Fonda, D., et al . (2006). Med J Aust, 184(8), 379-382.	28
11. Goodlett, D., et al (2009).. Nursing, 39(2), 20-21.	9
12. Gowdy, M., & Godfrey, S. (2003).. Jt Comm J Qual Saf, 29(7), 363-368.	26
13. Gutierrez, F., & Smith, K. (2008).. Crit Care Nurs Q, 31(2), 127-139.	37
14. Healey, F. (1994). Nurs Times, 90(27), 40-41.	10
15. Hitcho, E. B., et al . (2004).. J Gen Intern Med, 19(7), 732–9.	8 cor.
16. Krauss, M. J., et al . (2008). Infect Control Hosp Epidemiol, 29(6), 539-545.	28
17. Lopez, K. D., et al . (2010).. J Am Med Inform Assoc, 17(3), 313-321.	15
18. Mosley, A., et al . (1998). J Nurs Care Qual, 13(2), 38-44.	20
19. Ohde, S., et al (2012). BMC Health Serv Res, 12, 197.	23
20. Schaffer, P. L., et al (2012). J Spec Pediatr Nurs, 17(1), 10-18.	6
21. Shorr, R. I., et al (2012). Ann Intern Med, 157(10), 692-699.	8
22. Tzeng, H. M., & Yin, C. Y. (2008). J Nurs Care Qual, 23(3), 233-241.	15
23. Vassallo, M., et al (2000). Int J Clin Pract, 54(10), 654-657.	1
24. Vieira, E. R., et al . (2011). BMJ Qual Saf, 20(5), 440-448.	21
25. Warren, C. J., & Hanger, H. C. (2013). Clin Rehabil, 27(3), 258-263.	3
26. Wayland, L., et al (2010). J Healthc Qual, 32(2), 9-14; quiz 14-15.	12
27. Wolf, L., et al (2013). HERD, 7(1), 85-101.	24

3. Results

3.1. Thematic Coding

NVivo 10 was used to code the papers by broad categories of falls-related factors for caregivers/staff; patients; organizational policy/operations, and the environment/building design. To build a comprehensive theoretical model of fall risk considerations and interactions, subcategories were included for each broad category, and conditions were coded as correlated to the occurrence of falls, part of an intervention, but not individually quantified (i.e. included as a multifactorial "bundle"), or individually quantified through empirical research.

3.2. An HFE Overlay of the Falls Literature Review

3.2.1.Physical Ergonomics

In reviewing HFE literature for established design frameworks, it was apparent that while the environment is often referenced, it is rarely defined. Karwowski (2006) devotes one chapter to workplace and equipment design (ranging from auto interiors to hand tools) and one to the environment (including noise, illumination and vibration). Carayon's Handbook of Human Factors and Ergonomics in Health Care and Patient Safety (2011) provides two chapters in the physical ergonomics section. One chapter addresses a range of topics, such as individual built environment components, climate and thermal environments (clothing and heat exchange), air quality, noise, vibration and illumination, and the second chapter discusses musculoskeletal disorders as it pertains to patient handling. The IEA defines physical ergonomics as "*concerned with human anatomical, anthropometric, physiological and biomechanical characteristics as they relate to physical activity. (Relevant topics include working postures, materials handling, repetitive movements, work related musculoskeletal disorders, workplace layout, safety and health.)"* (International Ergonomics Association). According to the Human Factors and Ergonomics Society (HFES), member research for environmental design has focused on sustainable environments, as well as "*the physical layout of a variety of places, such as the home, office, classroom etc., how to combine ergonomic accessories to create effective and efficient workstations that promote comfort and productivity, and how to provide ambient conditions that promote health and well-being*" (HFES).

As a result of this lack of clarity, the analysis defines four subset "components" of physical ergonomics that have been drawn from the literature (Carayon, Alvarado, and Hundt, 2003; Karwowski, 2012; Wilson and Corlett, 2005). These are:

(1) Ambient environment - the physical environment of thermal, air, noise, and illumination considerations;

(2) Workspace envelope - the wider workplace including the building characteristics, arrangement of personal workspace items, and space constraints;

(3) Personal workspace - the layout of the “workstation” or immediate area of use, including the relationship of equipment, furniture and controls to the user (including anthropometrics), and

(4) Products - the selection/specification of equipment, furniture or controls..

At the start date of the literature review, there were few acknowledgements of the patient playing an active part in HFE thinking. More recently, experts in the field have started developing models to recognize patient activities or “work” (Hignett, 2013; Hignett et al., 2013; Holden, Schubert, and Mickelson, 2015; Valdez et al., 2014). Because many of the falls design considerations are centred on patient activity or condition, the subset components of the physical environment include the patient’s personal workspace (e.g. the bed area, the bathroom), workspace envelope (e.g. the room layout), the ambient environment (e.g. noise, light), and products (e.g. patient furniture, call systems).

3.3. Identified Interventions for Falls Prevention

3.3.1.Environment

Interventions in the environment span the four subset physical environment categories. The interventions and literature sources are summarized in Table 2. Interventions sometimes address direct correlates of falls (i.e. quiet zones as a result of noise). Other interventions address correlates in the other broad review categories (i.e. organization, people), such as providing protection of entrances from weather (addressing organizational maintenance of the space) or providing visual cues such as falls risk hallway signage for patient rooms (alerting to risk assessment results). Still others address less linear relationships to directly identified correlations such as leaving doors open to reduce workload, increase visual/physical proximity, etc. While these less direct interventions may be operational on the surface, the design needs to support their effective use. For example, a door can only be left open if it has been designed so that it does not impede egress or block other common functions of care. This may also need to be considered with respect to noise, ensuring that equipment (e.g. ice machines) or building services (e.g. elevators) are located away from patient rooms.

Table 2. Summary of Physical Environment Falls Interventions

Environment subset	Intervention	Sources (See Table 1 for source key)
Ambient environment	Lighting	2, 4, 10, 12, 14, 18, 22, 24, 27
	Quiet zones	13
Workspace envelope	Clutter-free spaces	2, 9-10, 12-14, 16, 22, 24
	Doors open	12-13
	Family presence	9-10, 13, 16, 18-19, 22, 24, 26-27
	Floor type	7-8, 10, 14, 24
	Patient lifts	2
	Unit layout	13, 17, 23-24
	Visual cues (corridors)	3, 6, 9, 12-13, 16, 18-20, 27
	Weather protection	2
Personal workspace	Call system accessibility	10, 12-13, 18-19, 22
	Bedside charting	13
	Bedside commodes	13, 16, 22, 27
	Falls prevention rooms	4, 5, 13
	Identify level change	2
	Items within reach	1, 9, 13, 16, 22
	Secure cords/ tubing	2
	Visual cues (room)	1, 6, 10, 16-17, 26
Products	Assistive devices (grab bars)	10, 19
	Bed/chair alarms	1, 6, 9-10, 12-13, 15-17, 19, 21, 22, 24, 27
	Bedside mats	10, 16, 27
	Furniture	1, 10, 12-13, 15-16, 18-19, 22, 27
	Hall mirrors	12
	Video surveillance	11, 15, 17

3.3.2. Organization

Organizational conditions and interventions are numerous, and as a result, were categorized into subset themes: organizational culture, patient assistance, communication, patient evaluations and interventions, maintenance, and staffing. Culture (an overall culture of safety, leadership awareness, the incorporation into a quality improvement initiative and/or a pilot program, the presence of a task force, participatory staff engagement) is most often a condition related to a falls prevention program - not a direct intervention. However, a specific culture-based intervention included monitoring adherence to the falls program policies and procedures. The organizational results are summarized in Table 3.

Table 3. Summary of Organizational Falls Interventions

Organizational theme	Intervention	Sources (See Table 1 for source key)
Organizational culture	Adherence monitoring	10, 13, 16, 19, 27
Patient assistance	Rounding	1, 6, 12-13, 15-16, 22, 24, 26
	Toileting supervision	1, 6, 12, 15, 19
Communication	Reporting	1, 5-6, 13-14, 16-20, 26
	Post fall documentation	10, 12-13, 16, 19, 21, 26-27
	E-records	6, 17, 19, 24, 27
Patient evaluations	Hospital protocol	1, 10, 13, 21
	Meds/lab review	12, 14, 16, 18-19, 24, 27
	OT/PT order	12-13
	Risk Assessment	1, 3, 5-7, 9-13, 16-21, 24, 26-27
Patient interventions	Segregate populations	3, 5, 7-8, 10, 13
	Universal fall precautions	5, 6, 16, 18-19, 22
	Custom interventions	1, 5-6, 12-13, 18-21, 26
	Placement	13, 15-19, 24, 27
	Diversion Activity	12-13, 16
	Anxiety/pain reduction	13
	Hearing/vision tests	14
	Mobilization	3, 10, 13
Staffing	Sitters volunteers	6, 10, 12, 15-16, 18, 22
	Staff levels/ratios	13, 24

3.3.3. People

Results of people-based interventions are summarized in Table 4. People include both staff and patients and the interventions often address behavioural modifications for staff. The only overlapping intervention for patients and staff is education and awareness surrounding falls risk.

Table 4. Summary of People-based Falls Interventions

People subset	Intervention	Sources (See Table 1 for source key)
Staff	Education/ awareness	1-3, 6, 9-13, 16-19, 21, 24, 26-27
	Teamwork	3, 6, 9, 11, 13. 17-19, 22, 27
	Communication	9, 11-12, 16-17, 20, 24, 26-27
	Behaviour recognition	11, 13
Patient	Visual cues	3, 6, 9-10, 12-13, 16-17, 18, 20
	Education	6, 11-13, 16, 18, 22, 24
	Footwear	2, 6, 12, 14, 16, 18, 22, 24
	Walking aids	8, 12, 15-16, 18, 24
	Gait belt or hip protectors	27, 3
	Buddy system	18
	Exercise	7, 16, 24

4.

5. Discussion

5.1.1.HFE Design Principles

While falls correlates and interventions were coded into the three broad categories of Organization, People, or Environment, there was no framework to unify these findings. Hignett (2013) offers a new systems model (Dial-F) that describes the elements in terms of the level of flexibility or transience (duration of action/involvement). The author suggests that the building design is the least frequently changing component and is therefore represented at the core of a falls management system that considers the patient/resident as an active (though transient) member of the risk management endeavour. However, this framework does not differentiate the wide variations within the physical environment, although the temporal nature of moving furniture and equipment is addressed in a technology layer. Furthermore, Hignett, Griffiths, Sands, Wolf and Costantinou (2013) suggest future development of this model through a better understanding of the population groups involved.

However, the relationship of the system elements may not always be clear with respect to the interactions or conditions that need to be understood for more successful design. As a result, five HFE design principles have been adapted from Carayon, Alvarado and Hundt (2003) and include: (1) optimize decision-making; (2) optimize manipulation; (3) optimize perception; (4) optimize movement; and (5) minimize human strength requirements. While they may not always be mutually exclusive, these principles establish a structure to investigate systems relationships in design, as they pertain to falls prevention. The integration of the expanded environment categories within the Dial-F model, overlaid with the HFE design principles, and the findings of the literature review are illustrated in Figure 2. This framework will be used to further the analysis of integrating systems thinking into understanding the complexity of preventing falls.

6. Conclusion

Hignett (2013) argues that poor design can permeate throughout the system and result in a reliance on behaviour changes rather than beginning with the design, fitting the user to the environment, rather than fitting the environment to the user. The built environment can therefore either enhance safe practices and policy or act as a barrier for safe patient care. Reducing patient falls is not simple, and there is no silver bullet solution. While it is tempting to look for single design interventions that will solve the problem, the reality is that a package of interventions is required – essentially, a buckshot approach. While we endeavour to understand the effectiveness of individual components, it may need to be considered in a different construct to better relate the interactions within the systems.

Designing or renovating a facility offers the opportunity to be proactive in considering the appropriate options. At a design level, these options need to be considered in the context of the permanence of the physical environment decision, the organization and their operations and policies (as well as the model of care and workflow) and people – the demographics of those providing care, as well as the demographics and individual conditions of the patient. The proposed model offers a structure for understanding the integration of systems solutions during design.

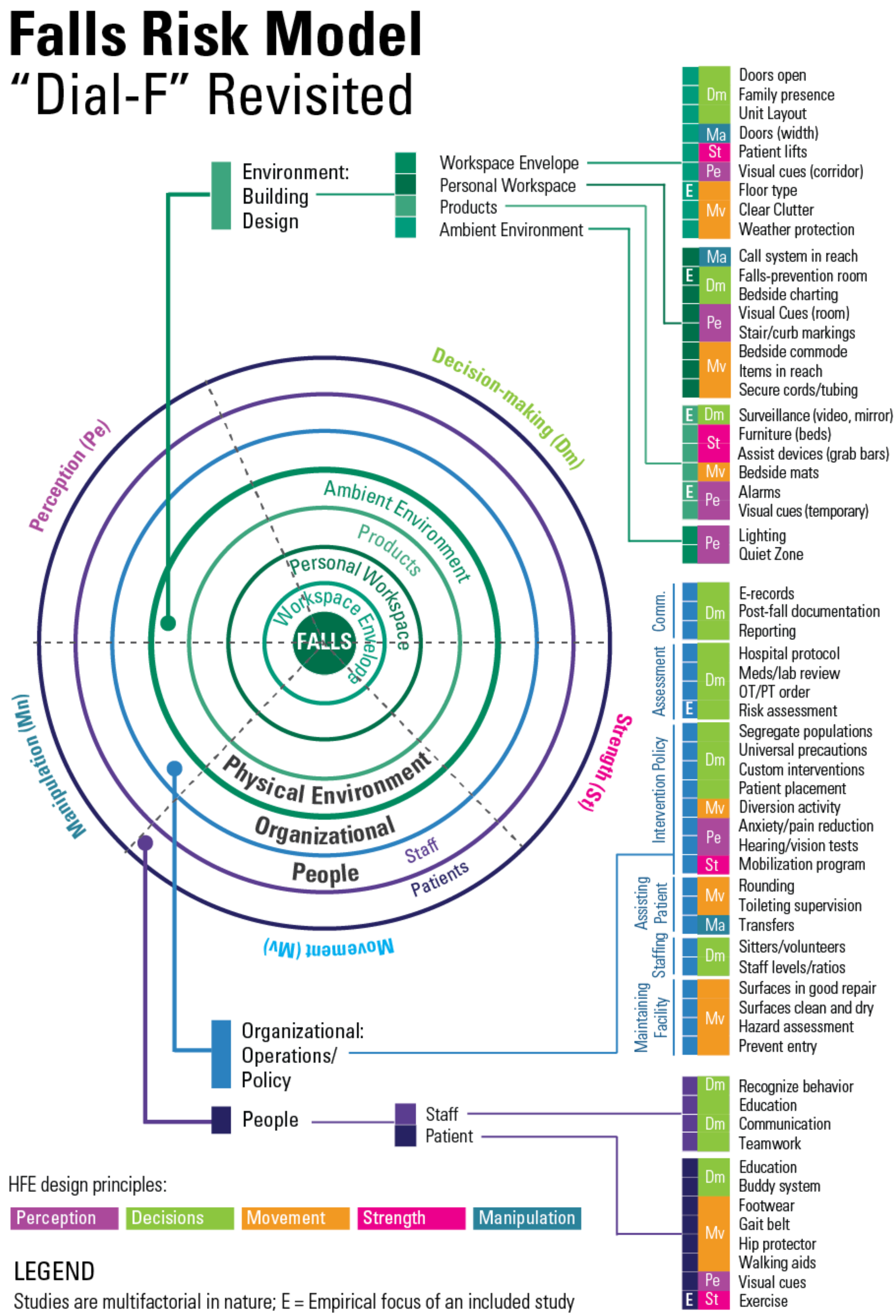

Figure 2: A Preliminary Risk Model for Falls – Revisiting and Expanding the Hignett (2013) Dial-F Model

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