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## Advancing theory in HC facility design: Bridging EBD and HFE

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<https://www.hfes.org/web/HFESMeetings/2017HealthCareSymposium.html>

PUBLISHER

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VERSION

AM (Accepted Manuscript)

PUBLISHER STATEMENT

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REPOSITORY RECORD

Hignett, Sue, and Ellen Taylor. 2019. "Advancing Theory in HC Facility Design: Bridging EBD and HFE".  
figshare. <https://hdl.handle.net/2134/23695>.

**Submission Type:** Individual Presentation (Lecture or Poster)

**Track:** Hospital Environments Track

**Preferred Presentation Format:** Lecture

**Presentation Type:** Theory

**Primary Target Audience:** Designers and Developers,

**Presentation Objectives:**

Based on a completed PhD research project:

1. Proactively advance safety in healthcare (HC) facility design through a structured approach of considerations to prompt discussion.
2. Present a purposed process that bridges the domains of EBD and HF/E to establish an understanding of the problem being solved during facility design and renovation
3. Propose a framework of participatory mesoergonomics based on constructed grounded theory to engage multiple stakeholders in the process of problem-solving in facility design.

**Summary:**

**Objective:** The presentation reframes healthcare (HC) facility design as an ergonomic problem of fitting the environment to the user by presenting grounded theory to support proactive safety-related solutions. A framework of participatory mesoergonomics is proposed for proactive thinking, informed by use of a Safety Risk Assessment (SRA), to bridge the domains of evidence-based design (EBD) and HF/E. Portions of this project were supported by AHRQ grant number R13HS021824. The content is solely the responsibility of the author and does not necessarily represent the official views of AHRQ

**Background:** Adverse events are a pervasive issue in healthcare, with causes and prevention measures under increased scrutiny for the past 15 years. With gaps between disciplines, healthcare safety is clearly a problem of greater complexity than originally perceived and needs more sustainable solutions than have been undertaken to date. While Reason's Swiss Cheese model may create an easy-to-understand framework for the role of the environment in safety (one of many defenses), the most recent discussions about safety center on a shift from the "old" notions of safety (Safety-I) to one of resilience engineering (Safety-II). Safety II considers the ability of systems to adapt to variation, disruption, and degradation of expected conditions (Hollnagel and Woods 2006, Woods and Hollnagel 2006). The reactive approach of Safety-I should be complemented (not replaced) by proactive Safety-II approaches that attempt to develop ways to support things that "go right" (Braithwaite, Wears, and Hollnagel 2015).

This type of proactive approach is necessary for HC facility design, where issues are both complicated and complex, and the implications of decisions can be felt for decades. In the early phases of design the definition of function often relies on historical data, interviews, observation, and the completion of room data sheets that do not capture the complexity of work as performed versus work as imagined in healthcare environments. There are often challenges in understanding the real problems being solved, especially in the area of healthcare safety. By focusing on a limited aspect of what is already known, there may be a danger of missing the larger multi-factorial problem. It may be tempting to focus on simple fixes - the low hanging fruit - rather than address

the fundamental underlying issues that take a more prolonged period to study (Henriksen 2011).

While architects excel at problem solving, they are not always fully versed in the interactions of work tasks, flow, and function. There is an ongoing challenge in integrating HF/E and facility design. Hall-Andersen and Broberg (2014) cite numerous studies corroborating that when ergonomic information is provided via a document (i.e., standards or handbooks), integration is not ensured, and in fact may go unrecognized, be misinterpreted, or not be integrated into design solutions at all (Hall-Andersen and Broberg 2014). Lu and Hignett (2005) described when ergonomic reasons behind design guidance of NHS Estates Health Building Notes were lacking (or inconsistent across sources), architects ignored or misunderstood the information.

Methods: Using hospital falls as a case study topic, the grounded theory was constructed from research that leveraged grant-funded testing for a Safety Risk Assessment (SRA) toolkit for HC facility design. Testing was conducted through hypothetical scenarios using expert workgroup panels and real-world conditions at three hospital sites whose team was undertaking a facility design project.

Hypothetical testing was conducted at Kaiser Permanente's Garfield Innovation Center. Three setting types were developed for teams to use as part of the testing process. These included a meeting format, a low-fidelity mock-up (less detailed), and a high-fidelity mock-up (more detailed). Four hypothetical scenarios were developed, based on combinations of data from real projects. Six expert panels were assembled (a purposive criterion sample) and established according to areas of risk category expertise (e.g., falls, infection control). Teams were combined to address potentially overlapping areas of interest (i.e., falls and patient handling; security and psychiatric/behavioral health injury).

All teams started with the meeting format, then in a round-robin method completed the low-fidelity and high-fidelity testing, as well as a module for considering dissemination, and an overall team debrief before concluding the event. The teams were encouraged to use a think-aloud process where the participants were asked to articulate their thoughts and explanations while moving through the various considerations in each scenario (Ericsson and Simon 1993). Van Someren, Barnard, and Sandberg (1994, 1) cite this process as suited to the architectural design process where accounts of how people design may be described "neatly in terms of the formal design methods that they acquired during their professional training, whereas the real design process deviates from these methods." Real-world projects for testing were sought in varied regions of the US and in different stages of the design process - block diagrams, schematic design, and design development. An opportunistic sample was selected and included Barnes Jewish Healthcare (BJH) in St. Louis, MO, the University of California Irvine Medical Center (UCI) in Irvine, CA, and the Memorial Sloan Kettering Cancer Center (MSK) in New York, NY. Each used the SRA in a meeting format for several hours. The process of using the tool evolved iteratively through each set of tests and findings.

All test sessions were recorded using digital audio devices selected for their ability to capture voices in all areas of the space (360-degree coverage when hung from the ceiling or placed on a table, 270-degree coverage when mounted on a wall). The audio files were used to

supplement field notes and create a partial transcription, which was expanded following multiple stages of coding during qualitative analysis. Recordings and transcript templates were imported into NVivo (QSR International 2012). As the case study was hospital falls, all falls workgroups were analyzed. Additionally, three other non-falls modules were analyzed as a control to determine whether there were any differences in themes among groups. Qualitative analysis followed the approach of grounded theory outlined by Corbin and Strauss (Corbin and Strauss 2014, Barbour 2008, Thornberg and Charmaz 2014). Corbin and Strauss (2014) emphasize that qualitative research is often used to explore the experiences of participants, explore an area not yet thoroughly researched, and take a holistic approach to the study of phenomena.

Coding was started following the expert workgroup sessions (Garfield Center testing), moving between an inductive and abductive approach that integrated domains of observations and ideas (Thornberg and Charmaz 2014). During analysis, codes were expanded from the initial provisional coding and concepts evolved through open coding (Corbin and Strauss 2014). The second iteration of coding was to further advance the synthesis of patterns (Miles, Huberman, and Saldaña 2013). Axial coding (Corbin and Strauss 2014) was used to further relate categories and subcategories. This was a process of integrating and refining categories into the start of a theoretical construct, by reducing data from the multiple cases into relational categories (Corbin and Strauss 2014). Finally, selective coding defined the central phenomena or major theme that unifies all others (Benaquisto 2008, Strauss and Corbin 1998).

Results:

What evolved out of the coding and comparative analysis was the benefit of both user and expert input into the process, with the SRA becoming a participatory tool to engage in discussions. This leveraged a range of information (experiential to empirical), adapted to learning styles of participants, and resulted in a synthesis of solutions, both for specific safety topics (e.g., falls) and for integration of multiple topics that balanced multiple safety considerations across different topics within the SRA.

The emergent central theme recognized the value of a participatory process to advance safety, although not only in the sense of engaging a number of people but through collaboration and consensus-building as compared to silos of a departmental user-group approach. This participatory process relied on views reflected through stakeholders representing diverse roles and expertise (recognizing that the number of participants alone is not a guarantee of success). The theory captured several existing paradigms faced by architects and owners identified in a prior part of the study, as well as insights into the evidence base (using, sharing, and managing knowledge) and guidance that is synthesized into solutions to mitigate risk in HC facility design.

Discussion:

Hospitals are among the most complex of building types serving stress-filled purposes with competing needs of diverse user groups, intricate organizational structures, and rapidly changing technology (Shumaker and Pequegnat 1989). Hignett (2013) argues that poor design can permeate throughout the system and result in a reliance on behavior changes rather than beginning with a design that does not require behavior change. This is fitting the user to the environment, rather than fitting the

environment to the user (Hignett 2013, Dul et al. 2012). Latent conditions of the built environment can contribute to hazards and risk within the system (Henriksen, Joseph, and Zayas-Caban 2009, Joseph and Rashid 2007, Hignett and Masud 2006, Hignett et al. 2010). Healthcare safety has been addressed on the macro, micro, and mesoergonomic levels (Carayon 2011, Fray, Waterson, and Munro 2015, Holden et al. 2015, Karsh 2006, Karsh, Waterson, and Holden 2014). Micro, macro, and meso levels have their origin in organizational theory and behavior. For example, Bronfenbrenner (1977) defines the ecological environment as topologically conceived in a nested arrangement of structures that include microsystems (an immediate setting), a mesosystem (interactions), an exosystem (external influences), and a macrosystem (overarching institutional patterns). Importantly, Bronfenbrenner highlights the complexity of ecological research and posits that the environment, and the process taking place within, must be viewed as interdependent and analyzed in system terms.

Influenced by other organizational theorists (House, Rousseau, and Thomashunt 1995), Karsh et al. define mesoergonomics as an integration of microergonomics and macroergonomics across nested performance inputs and outputs (Karsh et al. 2006). The nested mesoergonomic inputs include patient/provider - individual; work system/unit - team/group; organization, and external environment - industry). According to Karsh et al., mesoergonomic research can help to understand "cross-level interactions that shape an outcome of special interest or might be important in helping to scope the design of workplace related improvements or interventions; and, informing the choice of concepts which can be used to further develop theory" (Karsh, Waterson, and Holden 2014, 47). The framework has been used for several healthcare safety topics such as medication safety (Karsh and Brown 2010), infection control (Waterson 2009), and patient handling (Fray, Waterson, and Munro 2015).

Following the construction of grounded theory through data from SRA testing, a theoretical framework of "participatory mesoergonomics" was proposed by integrating the participatory ergonomics framework (Haines and Wilson 1998) with the mesoergonomic framework of inquiry (Karsh, Waterson, and Holden 2014, Karsh 2006). The SRA tool and literature review content become inputs over the course of a HC facility design project to achieve safety.

Specific audience "takeaways."

1. Grounded theory demonstrates the value of a participatory process to advance safety through collaboration and consensus-building as compared to silos of a departmental user-group approach.
2. The research and theory contribute to a more comprehensive understanding of healthcare facility design as ergonomic problem of fitting the environment to the user.
3. Attendees will understand the physical environment as the stage for all activity that takes place. The impact of decisions made during design or renovation will be in place for decades, and a proactive approach to safety in design can improve outcomes for patients and staff.
4. The proposed theory of "participatory mesoergonomics" bridges an evidence-based design process with HF/E through methods that may be familiar to design teams in a modified context. This also offers semi-structured options for research in facility design projects.

**Learning Objectives/Knowledge Advancement:**

There is significant worth in discussing EBD in HC facility design as a HF/E problem. This goes beyond work as imagined and offers opportunities to identify what may promote or impede desired behaviors for safety, rather than trying to modify behavior after the fact. This process of understanding the real "in use" characteristics of space can proactively inform decision-making through a purposed process that bridges the domains of EBD and HF/E.

It has been stated that healthcare is arguably more complex than any other broadly equivalent industry and is extremely resource sensitive, making the evidence base critical and the return on investment difficult to gauge (Catchpole 2013). The complexity is further aggravated by the segregation of organizational silos. Although health care providers work together, they are trained in separate disciplines where the primary emphasis is the mastery of the skills and knowledge to diagnose ailments and render care. In the pursuit of becoming as knowledgeable and skillful as possible in their individual disciplines, a challenge facing nursing, medicine, and the other care specialties is to be aware of the reality that they are but one component of a very intricate and fragmented web of interacting subsystems of care where no single person or entity is in charge (Henriksen et al. 2008,3).

Although HF/E recognizes the physical environment as a system component, the ergonomic definition of the environment lacks clarity and influences are frequently considered at a microergonomic level. Additionally, "Despite the most acknowledged definitions of ergonomics or human factors that ergonomic design of environments bring the same concerns as any other kind of systems, and even though a poor building design affects a whole physical, cognitive and organizational aspects of ergonomics in a given situation, a comprehensive methodology purposed to designing ergonomic buildings is still lacking" (Attaianese and Duca 2012, 187). An integrated systems approach has the potential to provide a more comprehensive understanding of the safety problems being addressed in HC facility design. While the use of EBD has been growing, there is criticism that while EBD has advocated a change in how architects work, it has not focused on adequately equipping clients and designers with the means to improve the quality of design (Phiri 2015). Grounded theory suggests design for safety as a proactive process to anticipate harm through an interdisciplinary team that participates to integrate complex considerations into the design solutions. Haines and Wilson's participatory ergonomics framework was combined with a Karsh's mesoergonomic framework of inquiry to advance a theoretical framework of participatory mesoergonomics. Rather than segregating the user, the task, and the task environment as discrete units, the process endeavors to integrate these categories. Ultimately, this advances the IEA definition of human factors and ergonomics to "understand of interactions among humans and other elements of a system and optimize human well-being and overall system performance."

**Value:**

HF/E often studies the user, the task, and the task environment as discrete units, and as a result the issues of "who the users are, what they do, and how their 'lived-in' (e.g., social, technological,

organizational) environments constrain them" is segregated and may obscure important interactions of the system (McNeese et al. 1995, 346). There are many descriptions of the environment from an HF/E perspective. None considers overall building design as a systems warranting an HF/E approach. Corbin and Strauss (2014) explain the choice for grounded theory as a method that "can be used to gain new insights into old problems, as well as to study new and emerging areas in need of investigation" (Corbin and Strauss 2014, 11). This is an approach suited to investigating EBD and HF/E, as architecture and space have often been conceived from a phenomenological approach to develop "authentic conceptual portrayals of the various dimensions of the person-environment relationship" (Seamon 1982, 121) - the interaction with an artefact. Evidence-based design, a process using research as a foundation for decision-making, acknowledges the complexity of interactions in HC facility design, but has focused on understanding specific facility design interventions on outcomes such as safety, efficiency, quality of care, and satisfaction. While the EBD process acknowledges the importance of system factors, its focus is still on understanding specific facility design interventions on outcomes such as safety, efficiency, quality of care, and satisfaction.

Since its inception, the frameworks of resilience and Safety-II have been applied to healthcare and the built environment (Nemeth et al. 2008, Hollnagel, Braithwaite, and Wears 2013, Braithwaite, Wears, and Hollnagel 2015, Hassler and Kohler 2014). Proponents have urged a proactive approach taking into account that those remote from the clinical front line base solutions on work as imagined, rather than work as performed (Braithwaite, Wears, and Hollnagel 2015). From a resilience perspective, the built structure is one part of a functioning system, such that a hospital needs to adapt through continual rebuilding (both organizationally and physically) (Hollnagel 2014b). Unfortunately, the role of structures is not often described in Safety-II, and according to Hassler and Kohler (2014, 125) "the composition and dynamic of the built environment prove to be very complex and attempts at description remain very general."

While EBD supports desired outcomes of a system through building design, and HF/E more often supports desired outcomes of the system through work design, the research inquiry explored how proactive thinking in safety can be used to bridge the domains of EBD (research-based building design supporting a system) and HF/E (understanding humans interacting with a system) in HC facility design to advance a proactive Safety II approach.