Human Factors and Lean in the ER: A Review of the Literature

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A major healthcare group in a large metropolitan area has expressed interest in developing a collaborative effort with Mercer University to apply lean and human factors approaches to improve both patient outcomes and the efficiency of the emergency department. To support this initiative, a review of the literature regarding human factors and lean in emergency department operations is underway. The results of this review and resulting directions for implementation and future research are presented here.

INTRODUCTION

The Mercer University Department of Industrial Engineering and Industrial Management has an ongoing collaborative relationship with a major healthcare group in a large metropolitan area. A number of student projects, including a series of projects focused on patient safety in the operating room and a project applying lean methods to the registration process of the emergency department, have demonstrated the benefit of this collaboration. The healthcare group is currently undertaking a major initiative to improve the efficiency and patient outcomes in the emergency departments in all hospitals in the group. This initiative provides an excellent opportunity for continued collaboration with Mercer University to develop and implement a series of projects to incorporate lean and human factors approaches in these efforts. These projects may include short-term class projects, two-semester senior design projects, and/or longer-term undergraduate research.

To this end, a critical review of the literature regarding the application of human factors and lean in emergency rooms has been undertaken. Because emergency departments are complex, dynamic sociotechnical systems, they have become an important target of human factors research. At the same time, because the nature of emergency departments lead them to be the areas of the hospital most prone to bottlenecks and inefficiencies, they have become obvious candidates for process improvement initiatives like the application of lean principles. While both human factors research and lean applications have a number of verifiable successes to attest to their effectiveness, an approach that integrates the two disciplines more fully might prove to be more effective still. Under that premise, research and case studies related to such issues as lean, macroergonomics, cognitive and physical ergonomics, task analysis, workload, communication, situation awareness, cognitive resilience, and usability were reviewed with the aim of identifying opportunities to integrate specific human factors activities within the framework of lean approaches to process improvement.

Because of the breadth and depth of literature available for both human factors and lean in healthcare industry, the literature reviewed here is best seen as a representative sampling that is primarily focused on the specific needs of emergency departments.

HUMAN FACTORS LITERATURE

The real and potential contribution of human factors and ergonomics to improve patient safety and overall efficiencies in emergency departments has been discussed by a number of researchers and practitioners. For example, Wears and Perry (2002) provide a hypothetical case study that illustrates a number of human factors and ergonomics issues that can arise during a typical encounter in the emergency room. In addition, Wears, Woloshynowycz, Brown, and Vincent (2010) provide an overview and analysis of research on patient safety in the emergency department.
Healthcare systems, whether large-scale hospitals or emergency departments, are complex systems of people and technology with distinct organizations and cultures that impact the effectiveness of process improvement initiatives. Macroergonomics, a subdiscipline of human factors that “grew out of the need for the ergonomics profession to take a ‘larger-systems’ perspective”, provides a number of tools and methods for research and evaluation of this type of complex sociotechnical system (Kleiner, 2006, p. 81-89). Carayon (2006, p. 525-535) provides a rationale for the application of macroergonomics to healthcare. Karsh and Brown (2010, p. 674-681) investigated the effect on patient safety of organizational levels (patient, nurse, physician, shift, organization, etc.) and concluded that the differences between and interaction among levels require that these be explicitly addressed when researching and implementing interventions designed to improve patient safety. In addition to informing the design of large-scale work systems, macroergonomics is also recommended as a comprehensive approach to the design of health information systems (Samaras & Horst, 2005, p. 61-74). Even before the term “macroergonomics” was coined the issue of the effect of organization and culture on the behavior of healthcare providers (see for example Dejoy, Murphy, & Gershon, 1995 for an evaluation of a variety of factors on nurses’ adherence to occupational safety procedures.)

With the potential high cost of error in the emergency room, research regarding human error ranges from classification of errors (Cosby, 2003) to a proposed framework for an error reporting system (Karsh, Escoto, Beasley, & Holden, 2006). Based on quality assurance committee reports, Cosby developed a classification of errors reported in the emergency room. In order to encourage reporting of errors and improve overall performance, Karsh et al. investigated the sources of aid for and obstructions to error reporting and present a theoretical framework for the design of a healthcare error reporting system.

The theme of collaboration, teamwork, and problem solving in complex systems carries through a number of research approaches. “Cognitive resilience” refers to a person’s ability to adapt to quickly changing situations and is of particular interest in the investigation of collaborative work in a complex environment like the emergency room. Bracco, Gianatti, and Pisano (2008) discuss a Skills-Rules-Knowledge (SRK) framework for modeling cognitive resilience. A study attitudes toward teamwork in the emergency room found that the discipline of each team member affected that person’s attitudes and perceptions and that these differences can affect team performance (Ummenhofer et al., 2001). Cooper et al. (2010) have developed an instrument for evaluating the effectiveness of teams performing emergency resuscitations. Kelly, Mahoney, Bonner, and O’Malley (2012) evaluated the effectiveness of using a “Transitional Minimum Data Set (TMDS)” to facilitate the transfer of critical patient information when patients are transferred from a skilled nursing facility to the emergency department of a hospital.

Research on the impact of communication style between clinicians and managers in healthcare organizations in the UK suggests that a key barrier to productive communication is the tendency for interactions to be dialectic rather than dialogic (MacIntosh, Beech, & Martin, 2012, p. 332-359). Furthermore, the researchers conclude that addressing this issue at the local level is the most effective means of fostering productive dialogues. Similarly, Greig, Entwistle, and Beech (2012, p. 305-312) suggest that “activity theory (AT)” is more appropriate than a “knowledge transfer (KT) theory” approach to understanding the process of policy implementation at the local level, and that AT can be useful for understanding the difficulties encountered when trying to implement “best practices” policies across a diverse group of hospital settings.

Understanding the impact and implication of workload in the emergency room has been the focus of a great deal of research. Nemeth, Cook, and Wears (2007) provides a concise overview of a number of studies of work processes and workload in the emergency room. Workload was evaluated as part of a comprehensive task analysis of emergency physicians working in community and academic emergency departments, with the aim of identifying potential sources of error and providing a framework for assessing future changes (Chisholm, Weaver, Whenmouth, & Giles, 2011, p. 117-122).
Levin et al. (2006) outline a method for tracking workload over time in the emergency department that reflects the time-dependent nature of workload in this complex and dynamic environment. In a subsequent study (Levin et al., 2007) they investigated the distribution of workload among teams of physicians in the emergency department, where workload was defined in terms of patient load per physician. The results of that study indicate that care needs to be taken at shift change to ensure that residents on one shift do not incur a disproportionately high patient load. In a related study, Gurses and Carayon (2009) undertook a study to identify a number of factors that impacted workload, performance, patient safety, and quality of life for nurses in the intensive care unit. Through a series of qualitative interviews, they determined that nurses most often noted the physical environment, family relationships, and equipment issues as factors with negative impact.

The impact of technology on workload has also been investigated. France et al. (2005) investigated the effect of electronic whiteboards on emergency physician workload and concluded that the use of the whiteboards resulted in fewer interruptions and greater efficiency (however, they note that the study suffered from small size and restricted design), but that technology alone is not sufficient to alleviate all sources of inefficiency in the emergency room. Pennathur et al. (2011) demonstrated that simulation can be effectively used to evaluate patient tracking systems in the emergency department, while Dekker (2012) proposes the use of signal detection theory to evaluate the effect of the introduction of new technology in clinical practice.

Because technology can have both positive and negative consequences for emergency department personnel and patients, research into the effect of technology in healthcare settings plays an important role in successful human factors approaches to process improvement in the emergency room. For example, Harrison, Koppel, and Bar-Lev (2009) address the unintended consequence of the introduction of Healthcare Information Technologies (HIT) into the healthcare sociotechnical system and present a model of the interaction called “Interactive Sociotechnical Analysis (ISTA)”. Using this model, the authors believe that researchers and developers will be able to better understand how the organization of a sociotechnical system including HIT will behave.

Montague, Kleiner, and Winchester (2009) have developed an instrument for measuring and understanding trust in technology specific to healthcare. After empirically determining that trust in medical technology is different than trust in other technology, the researchers validated the instrument for use in evaluating trust in medical technology (Montague, 2010).

Xiao, Schenkel, Faraj, Mackenzie, and Moss (2007) investigated how a particular artifact, the standard whiteboard, is used to facilitate efficient communication and collaboration in a trauma center operating suite with the expectation that similar results would be found in the emergency department. They found that the physicians used the whiteboards in a number of ways related to communication, management, collaboration, problem solving, and socialization and that a key feature of the whiteboard is the ability for the team to configure it to suit their specific needs.

**LEAN LITERATURE**

The principles of lean manufacturing, also known as Toyota Production Systems (TPS) have been gaining traction in the healthcare industry. The foundational principle of lean is the elimination of *muda* (waste) and the goal of any lean effort is to identify and eliminate waste so that all the activities associated with producing a product or service are *value added* (Womack & Jones, 1996, p 15). The overall lean process is described as follows (from Womack & Jones, p 16-26):

1. **specify value** from the customer’s viewpoint;
2. **identify the value stream** or set of all actions required to move a ‘product’ through all phases of the process, and use this to identify and eliminate unnecessary waste;
3. **create flow** among the value-adding actions;
4. develop processes within which products or services are **pulled** by the customer rather than pushed by the process; and,
5. repeat this cycle until you have achieved perfection.

The majority of the literature reporting applications of lean to emergency departments and other healthcare settings focuses on the development and use of value stream maps to identify and eliminate waste. The typical approach is a kaizen or rapid improvement event in which a team consisting of members of the department under investigation dedicate a period of time (a week or so in most cases) to developing the value stream map, identifying sources of waste, and developing and implementing strategies to eliminate them. Holden (2011) conducted a critical review of 15 lean initiatives reported in the literature from the US, Australia, and Canada, and discussing the methods used, results, shortcomings, and potential for the application of lean in healthcare.

King, Ben-Tovim and Bassham (2006) used value stream mapping to improve patient flow and reduce overcrowding in the ED. Cookson, Read, Mukherjee, and Cooke (2011) reported identifying sources of waste and opportunities for improvement in their emergency department and implementing projects to reduce patient wait times for an initial assessment. A series of kaizen events was also reported by Mari et al. (2008), who introduced lean principles to a healthcare system through events conducted in the emergency room, radiology department, and human resources. In the emergency room, the kaizen event resulted in reduced time between the patient entering the ER and meeting with a doctor. Crane (2008) reports the transformation to a “lean ED”, as illustrated through two projects. Similar projects and results were reported by Ng, Vail, Thomas, and Schmidt (2010); Piggott, Weldon, Strome, and Chochoinov (2011); Finamore and Turris (2009); and, Migita, Del Beccaro, Cotter, and Woodward (2011).

While the majority of the literature report immediate results, Dickson, Anguelov, Vetterick, Eller, and Singh (2009) found similar results when evaluating lean implementations at four hospitals, with more sustainable improvements found in hospitals when leadership commitment to lean remained strong.

As in other industries, the tools of Six Sigma quality improvement are often combined with lean in healthcare process improvement projects. Johnson et al. (2004) applied the Define, Measure, Analyze, Improve, and Control (DMAIC) improvement format from Six Sigma to reduce wait times in the emergency department. Similarly, Wolf (2009) reports the results of a series of projects and events designed to improve the overall process from admission to discharge of patients.

While the majority of the literature is devoted to reporting applications of lean, there are a few researchers reporting research and development efforts. For example, McClean, Young, Bustard, Millard, and Barton (2008) propose a framework for developing value streams using a “Markov phasetype model” to identify common patient paths through the system. Case studies from the emergency department and a stroke patient are used to illustrate the model. Robinson, Radnor, Burgess, and Worthington (2012) propose combining discrete-event simulation with lean and provide examples of how simulation can improve the impact of lean.

While the benefits of lean have been demonstrated in a number of applications, there are also a number of barriers to success that must be overcome. Waring and Bishop (2010) conducted an ethnographic study of lean implementation in one department in a UK NHS hospital and identified potential sources of tension between clinicians and leadership that could become impediments to successful implementation. Furthermore, Radnor, Holweg, and Waring (2012) suggest that a number of fundamental “organisational” and “managerial” differences between the manufacturing and healthcare industries will limit the benefits of lean by impeding the progress from localized, tool-based improvements (e.g., kaizen events that improve the patient flow in a department) to system-wide improvements.
DISCUSSION

The application of lean principles to process improvement is fundamentally focused on the needs of the customer and the experience of the people working within the system. As a result, there are a number of naturally occurring opportunities to integrate human factors into lean. A simple review of the literature discussed here identifies several, including:

- using the research tools and techniques of human factors to elicit customer definitions of value, perform task analyses, understand workload levels, etc.;
- enhancing value stream efforts by incorporating understanding not only of patient load but cognitive demand, collaborative work, sources of error, etc.;
- providing specific human factors knowledge to kaizen project teams that will inform the development and evaluation of project ideas;
- conducting human performance, acceptance, and usability evaluations to supplement measures such as wait time and throughput; and,
- applying the tools and techniques of macroergonomics to address the challenges associated with “scaling up” lean to the systems level.

A “big picture” reading of this review of the literature on human factors and lean in the emergency department leads to a fairly obvious observation – namely, the human factors literature is dominated by reports of research studies while the literature on lean is dominated by descriptions of implementation. This is no doubt due in large part to the domain within which each group of practitioners works and writes, and bringing these two groups together will draw on the strengths of each and improve the results of lean initiatives.

REFERENCES


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