Patient Safety Technology Gap: Minimizing Errors in Healthcare through Technology Innovation

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ABSTRACT

In a world of ever increasing technological advances, users of technology are at risk for exceeding human memory limitations. A gap analysis was conducted through reviewing literature in the field of human error or specifically transition errors in emergency room (ER) operations to identify the current state of technology available. The gap analysis revealed the technological needs of ER healthcare workers. The findings indicate the need for technology such as knowledge management or decision support systems in ERs to reduce the potential for error, enhance patient safety, and improve the overall quality of care for the patient.

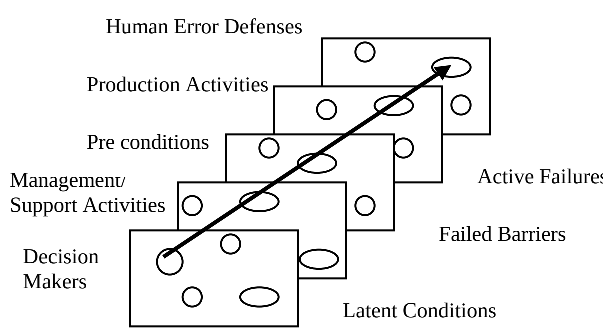
Keywords: Healthcare, Human Error, Medical Error, Patient Safety, and Technology.

1. INTRODUCTION

In a world of ever increasing technological advances, users of technology are at risk for exceeding human memory limitations. A gap analysis was conducted through reviewing literature in the field of human error or specifically transition errors in emergency room (ER) operations to identify the current state of technology available. The review clearly indicates the need for better technology such as knowledge management or decision support systems in emergency rooms to reduce the potential for error resulting in increased patient safety. Past research has indicated a link between safety being compromised because of bottlenecks in operations from inefficient processes [3]. Many medical errors occur at points of transition in emergency room operations. Transition errors can be described as hospital personnel shift changeover, patient transfer from an emergency van to a room, patient transfer to a different floor or room, and written and verbal communication between field personnel, physicians, radiology, nurses, and patient self reports to triage nurse, etc. There is a need for the development of knowledge capture and knowledge management techniques and technologies to assist hospital personnel in reducing the potential of transition errors thus resulting in safer operations.

Humans play the primary role in designing, building, operating, maintaining, managing, and defending hazardous technologies [15]. People are only human and many humans believe that mistakes are just par for the course. "To err is human" [18] is even a phrase used to describe this activity. However, industrial engineers, human factor specialists, safety managers and especially the medical community question that human error (HE) be accepted as part of human nature. As often as errors do occur, a science of error and error reduction should exist [18]. There are many ways to describe HE. Generically, HE can be defined as a "term to encompass all those occasions in which a planned sequence of mental or physical activities fails to achieve its intended outcome, and when these failures cannot be attributed to the intervention of some chance agency" [16]. Another definition of HE is an action "not intended by the actor; not desired by a set of rules or an external observer; or that led the task or system outside its acceptable limits" [18]. Past research has indicated that HE or medical error can be mitigated through the use of increasing automated system tasks [13]. Medical errors can lead to an accident, even if the errors are by people that are far removed from the operation, such as the original system or process designers. Accidents are usually the result of multiple contributing causes and failed layers of defenses, barriers, and safeguards, as illustrated in the Error Trajectory Model in Figure 1 [15].

Figure 1: Human Factors Error Trajectory Model [15]



The types of transition errors that were reviewed are those errors that occur during hospital personnel shift changeover, patient transfer from an emergency van to a room or patient transfer to a different floor or room, and written and verbal communication between hospital personnel. Therefore, the hospital personnel that have been identified as being at risk for transition errors are nurses, physicians, field personnel (such as a paramedic and EMT), triage nurse, patient self reports to triage nurse, radiologists and technicians, etc. There are two continuums working in parallel when looking at transition issues. The first continuum is geographical in that communication and process are built around moving a patient from point A to point B. Examples of geographical movement are moving the patient from the house to the ambulance, and the ambulance to the emergency room. Additional examples are moving the patient throughout the ER such as to a bed, to radiology or other department, and possibly to admission. The second continuum is clinical in that the hospital staff works to move a patient from illness to wellness. The foundation of this is rooted in cognitive levels of knowledge. Through a series of questions and assessments a patient treatment plan is devised and carried out. For example, a patient with chest pain could have pain for reasons other than the heart and through examination the determination is made. Lastly, both continuums (clinical, geographical) are interdependent at some points during a patient stay. For example, the same patient with chest pain that is determined to be cardiac may go to a different bed in the ED, may go to radiology faster than usual and may even require cardiac specific tests done outside of radiology.

2. IMPORTANCE OF HUMAN ERROR IN MEDICINE

To reduce transition errors, ER processes need to be streamlined, human performance needs to be enhanced, and techniques to better manage and capture knowledge need to exist. The Institute of Medicine (IOM) of the National Academies published "To Err Is Human" report which addresses the importance of reducing medical errors in a rigorous effort to significantly increase patient safety [8]. The 1999 government report from the National IOM sparked a lot of this activity to improve patient safety when it estimated that preventable medical errors kill between 44,000 and 98,000 people in U.S. hospitals each year. Even using the lower estimate, more people die from medical mistakes each year than from highway accidents, breast cancer, or AIDS. Another report published titled "Crossing the Quality Chasm: A New Health System for the 21st Century" further describes the urgent nature of the matter for the medical industry to enhance efficiency and redesign the health care system so all Americans can benefit [7]. Bogner investigated human error in medicine to strive for enhancements in patient safety [4]. In 2003, the Robert Wood Johnson Foundation began a new initiative to help relieve crowded emergency departments and raise local awareness about the over-taxed healthcare safety net [17]. Crowded emergency departments can create an undue amount of stress on workers that can lead to safety and efficiency bottlenecks. These bottlenecks create an environment for errors to occur thereby resulting in patient safety being compromised. In 2003, the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) released for public comment a proposed standard to address emergency department overcrowding [10]. The draft standard call on hospitals to resolve what the JCAHO said is a growing crisis that puts patients at high risk of treatment delays or inadequate care. Proposed requirements include implementing plans to efficiently move patients through an organization regardless of patient volume; incorporating ER overcrowding into performance improvement activities; using performance indicators to predict and monitor the capacity of areas that receive emergency patients; and planning for the care of patients placed in temporary beds. JCAHO also has published patient safety standards further emphasizing the importance of patient safety.

3. LINKING SAFETY & EFFICIENCY

Literature suggests that not only patient safety but also bottlenecks in processes together can contribute to emergency department (ED) overcrowding. Auburn Engineers suggests that efficiency bottlenecks and safety bottlenecks are both important to address when dealing with enhancing human performance through redesigning processes to mitigate error [3]. In taking a simplistic example such as in a factory environment whereby a person injures themselves or another person, the person is then taken out of the factory line. Therefore, a safety bottleneck is also a cause for an efficiency bottleneck. The Massachusetts Department of Health has published a statistic supporting the link between safety and efficiency bottlenecks [1]. The statistics indicate that 20% of Massachusetts hospitals have to cancel surgeries to avoid diversion. Furthermore, ED Physicians believe that 60% of the diversions cause adverse outcomes and that 72% of the diversions compromises patient care. The Massachusetts Health Policy Forum looked into the root cause of diversion [1]. The findings suggest that calls for ambulance diversion are rising because of gridlock when hospitals are full and EDs are occupied with patients awaiting admission. A report by the United States General Accounting Office indicates the rising tide of volumes in inpatient admissions of all ages have experienced a 15% increase from 1996 to 2000 [19]. ED's are in need of risk assessment studies outlining recommendations for improvement to help streamline ED throughput.

The Health Care Advisory Board discusses some common bottlenecks that occur within different stages of throughput for the ED as well as overall hospital bottlenecks that contribute to those present in the ED [6]. Bottlenecks within the ED consist of the ED patient, surgery patient, patient admissions, critical care, telemetry, medical/surgical unit, discharge, and post-discharge care. With the ED patient, throughput begins to be affected through a lack of knowledge in the ED on bed availability within different units. When bed control is contacted, the information given to the ED is incomplete causing confusion as to where there is room to send the patient for various needs such as radiology. Furthermore, patients requiring observation become admitted through the ED versus directly to the appropriate floor due to a lack of dedicated beds. With the surgery patient, delays are caused with inefficient patient transfer protocols and poor communication with bed availability. With patient admissions, bottlenecks exist with incomplete information from referring physicians, calls to the insurer required to clarify reimbursement issues, and lack of clarity with patient placement protocols. With the critical care unit, throughput continues to be affected due to patients unnecessarily placed in critical care because of confusion about appropriate placement. Understaffing in the medical unit further contributes to delays in patient transfer from critical care. With telemetry, patients can also be unnecessarily placed because of confusion on appropriate placement. Lack of transport availability can result in a patient occupying a bed longer than necessary. With the medical/surgical unit, inefficient timing of tests means unavailability of test results during physician rounds causing a patient to often occupy a bed longer than necessary. There is also a lack of dedicated resources to address cases likely to be problem discharges again contributing to patients occupying a bed longer than necessary. With discharge, physicians may be unavailable to sign out a patient, test results may not be communicated, and there may be issues with patient transportation. Lastly, in the post-discharge care unit, there is slow post-discharge placement causing an increase in inpatient days and difficulty in finding appropriate care for problem discharges. All of these problems add to patients occupying beds longer than necessary affecting ED throughput.

The Health Care Advisory Board also discusses overall hospital bottlenecks with the Physician Office, ED, Operating Room (OR), Post Anesthesia Care Unit (PACU), Intensive Care Unit (ICU), and Medical/Surgical Floors [6]. In the Physician Office, bottlenecks occur due to physicians not being able to directly admit patients to a hospital because of a lack of available beds resulting in the channeling of patients through the hospital ED as an admission mechanism. In the ED, patients are often constrained in the ED due to a lack of available ICU or medical/surgical beds. The reason behind this bottleneck can be a lack of observation beds often resulting in medical/surgical beds being used for observation patents. In the OR, elective surgeries may be delayed or cancelled due to a lack of PACU or ICU capacity. Due to full medical/surgical beds, surgeries not requiring ICU recovery may be delayed. In the PACU, patients may be boarded in this unit longer than medically necessary because this unit serves as a buffer capacity for recovering surgery patients because of a lack of ICU or medical/surgical beds. In the ICU, patients may be discharged directly because of a lack of available step-down capacity. Anywhere from 15%-50% of critical care days are unnecessary possibly due to inappropriate utilization. Since the medical/surgical floors serve as ground zero for hospital capacity constraint, all other units' operations can be affected from a lack of beds. There are issues with bed management such as a lack of accurate and timely bed availability information, communication bottlenecks in bed status, and a lack of centralized authority for final bed placement decisions. Bottlenecks that occur within the clinical and/or geographical continuum contribute to the efficiency and safety bottleneck link. Overall, bottlenecks can be considered a great contributor to the profitless growth in hospitals. Hospitals remain open for medical patients but have to turn away patients for surgery affecting profits. With less profit, the remaining throughput issues are magnified with the domino effect occurring that results in patient safety being compromised.

There are global nurse shortages making it difficult to staff beds when they are available. The American Hospital Association suggests that the hospital vacancy rate for RNs is 11%, pharmacists is 21%, radiology technicians is 18%, coders is 18%, service workers is 9%, and lab technicians is 12% [2]. An ANA Staffing Survey (2001) published statistics on nursing staff feelings at the end of the workday and the time expected to stay in nursing [14]. As for the feelings at the end of the workday, 49% are exhausted and discouraged, 26% exhausted and satisfied, and 6% happy and satisfied. As for the time expected to stay in nursing, 31% plan on more than 15 years, 46% plan on 5-15 years, 14% plan on less than 5 years, and 9% are currently looking for a new career. The Health Care Advisory Board Company attempts to explain the talent gap as one of the reasons is poor working conditions [6].

Research is necessary to optimize processes through analyzing cognitive and physical demands on the worker and in providing recommendations to streamline operations to enhance efficiency resulting in less provider errors thus enhancing safety. For example, processes such as ordering tests, delivering care more quickly and efficiently, and admitting the most seriously ill patient first need to be further analyzed for streamlining opportunities. The Health Care Advisory Board discusses how hospitals that are expanding or building new facilities for the ED are building for yesterday's demand [6]. It is predicted that the hospitals with new ERs were already 60 beds short of 2002 patient load. If processes could be streamlined in advance of the new facility, the new facility would be built to better meet the current demands in patient load.

4. MEDICAL ERROR LINK TO PATIENT SAFETY

Medical error such as transition errors have been identified as a major threat to patient safety. Through many national organizations such as IOM and JCAHO, the risks posed from medical error have been significantly linked to patient safety. JCAHO has listed sentinel events as being an outcome of medical error [10]. The Institute for Healthcare Improvement discusses how our care systems have built-in defect rates that are too high and how most medical errors have less to do with carelessness or neglect than with failures of systems [9]. The Institute further discusses that errors can be decreased through the redesign of systems that introduce the hazards in the first place. The term systems can be used to describe processes, procedures, medical informatics, etc. The National Database of Nursing Quality Indicators (NDNQI) is a project of the American Nurses Association's (ANA) Safety & Quality Initiative that addresses the patient safety and quality of care issues arising from changes in health care delivery [14]. NDNQI advances this Initiative through the development of an information resource that will be used to quantify the relationship between nursing and patient outcomes. The Leapfrog Group composed of more than 140 public and private organizations that provide health care benefits also acknowledges the need to identify problems and propose solutions that it believes will improve hospital systems that could break down and harm patients [12].

5. PATIENT SAFETY LINK TO TECHNOLOGY

Hospitals are migrating towards electronic medical records (EMR). There is a need for EMRs to have more intelligent features such as firing off alerts and warnings to end users as they document patient information or when system processes are out of sync by some decided upon measure. Modeling of the ER processes can provide information that will utilize statistical process controls that can be built into the EMR to further maximize process flow.

There are also three opportunities for the scientific advancement in patient safety. The Volunteer Health Association (VHA) has been successful in the development of tools for incident reporting. The tools address and track database fields in costs of incidents, full-time equivalents (FTE), volumes, staffing patterns, and negative outcomes in hours per patient a day. However, these tools are not emergency room (ER) based. Therefore, an incident-reporting tool that is ER based is needed. There are currently not any tools that address the dynamics that are truly unique to ER operations. Furthermore, there is a need to develop an incident-reporting tool fully usable for ERs. This tool would be able to produce meaningful reports that ERs could utilize in trending and forecasting data to help provide the information necessary for ERs to optimize processes through enhancing throughput, reduce bottlenecks during times ERs are overcrowded, and enhance staff performance. This tool would ultimately strongly contribute towards the reduction of human error and enhancement of patient safety. The second opportunity for advancement of scientific knowledge in patient safety is to develop an automated failure, modes, effects and analysis (FMEA) tool that would be useful in the evaluation of medical industry operations robust enough to be utilized in ER operations as well. The tool would automate listings such as potential medical errors, performance shaping factors, and barriers and controls. The tool could generate reports in spreadsheet format to display the data collected from different processes being analyzed. Furthermore, the tool could also have an artificial intelligence component to it so the tool becomes more intelligent as it is utilized. The third opportunity for advancement of scientific knowledge in patient safety is to develop a knowledge management system. This system would capture knowledge from different staff personnel regarding a patient as the patient transitions from an emergency van to the triage nurse, to the radiology department, to the doctor, etc. The purpose of the tool would be to reduce and mitigate the effects of transition errors as a patient moves through the illness to wellness continuum during the patient's hospital stay. It is evident in many industries such as the medical, space and aviation industries that errors occur at points of transition between one person to another. This device would aid in capturing knowledge to ensure communication even if not in a verbal form is achieved between personnel, departments, etc.

6. CONCLUSIONS

Research is necessary to drive the field of patient safety into new technological breakthroughs. A gap analysis was conducted through reviewing literature in the field of human error or specifically transition errors in emergency room (ER) operations to identify the current state of technology available. From this analysis, several future research opportunities were identified which could have a significant effect on the concepts or methods that drive the field of patient safety in the areas of an ER incident-reporting system, automated FMEA system, and knowledge management and capture system. It is important to fit the task to the human rather than fitting a human to the task [11]. New technology can be developed to assist medical personnel in better performing their jobs and more importantly reducing errors at the cost of patient safety.

The field of Human Factors strongly emphasizes the interfaces between workers, tasks and processes, and hardware or software systems in a specific work environment. The complete "system" illustrated in Figure 2 can signify any operation such as ER operations. Unfortunately, many system and task designers often emphasize hardware and software design without adequate consideration of workers, work processes, and work environments. Basic components within the ER operation system are hardware and software systems, workers, and tasks and processes. The technology should consider physical and cognitive human aspects. Figure 3 and Figure 4 are models that should be utilized when developing technology to ensure the researchers recognize the human as both a physical and cognitive being. Figure 3 shows an Information Processing Model that depicts the internal steps a human goes through in interacting within an environment in making a decision [20]. All of the human-machine interfaces (HMIs) are also shown in the model. It is important to fully understand all of the HMIs in any given environment to be able to appreciate the human carrying out his or her work functions. The upper half of the model shows all of the internal information processing the human goes through such as perception, interpretation, situation assessment, decision making, and action execution, and system control. The lower half of the model shows the external information processing such as receive input, machine operations, provide feedback back to the user. Figure 4 shows the SHELL model that gives more information in terms of various performance shaping factors (PSF) that can positively or negatively affect a human performing their work function [5]. SHELL stands for Software, Hardware, Environment, Liveware as it relates to the individual worker, and Liveware as it relates to team work.

Figure 2: Human Factors are Important in Any System

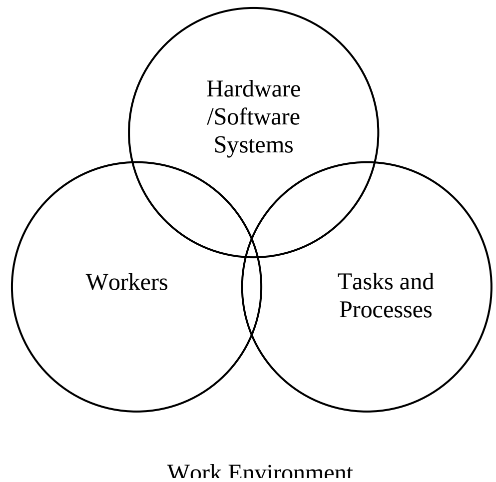
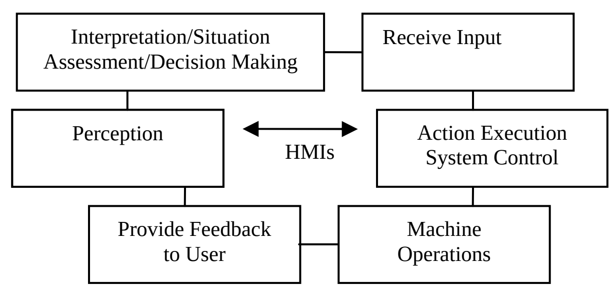
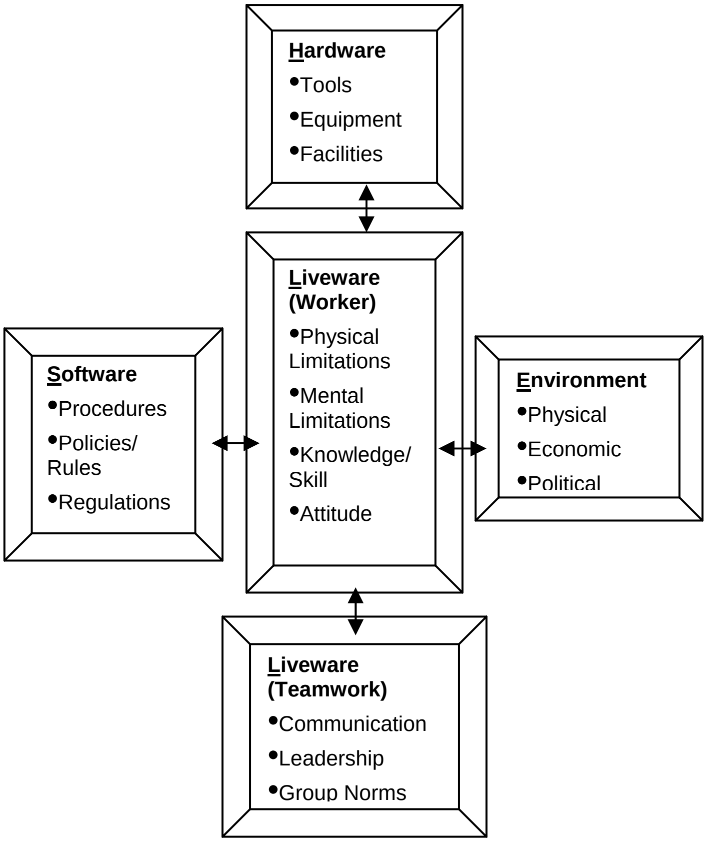


Figure 3: Information Processing Model [20]



New technological tools would be valuable in providing the health care industry with more ER based tools that improve efficiency while increasing patient safety. Combining human factors concepts in the design and development of new technologies would positively impact the field of patient safety. This would ensure that the tools developed take into account human limitations resulting in hospital personnel being more efficient and hospital procedures being safer for patients.

Figure 4: SHELL Model [5]



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