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Human Factors Research and Design Trends for the Modern Exam and Hospital Room

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Although much research has been conducted on the impact of the electronic health record (EHR) and health information technology (HIT) on provider-patient interaction, challenges persist on how to effectively integrate these tools into healthcare environments, while maintaining patient-centered care. Panelists will present and discuss their experience relating to: the introduction of new technology and how it changes the nature of work; the positive impact of greater focus on the patient; the nature of interruptions and strategies to reduce their negative impact; enhancing the workflow of medication ordering; and designing collaborative spaces considering all relevant stakeholders (patient care team, patients, family members). These topics represent some of the latest human factors research and design trends with a common goal: advancing the design of the modern healthcare environment, with consideration of the additional complexity introduced by evolutionary changes in clinical information systems and HIT.

INTRODUCTION

Many providers have been concerned that incorporating HIT tools and computer use into patient encounters negatively impact the provider-patient relationship (Linder et al., 2006). However, integrating EHRs into the patient visit, while maintaining patient-centeredness, may help enhance, rather than negatively impact, this relationship. For example, rather than maintaining a focus on the computer monitor instead of the patient, the computer and monitor can viewed as a third party that can be used to mediate between the provider and patient. In other words, there is an awareness of the "triadic" relationship between provider, patient, and computer/EHR (Pearce, Dwan, Arnold, Phillips, & Trumble, 2009). This technology-enabled collaborative view opens new doors for integrating HIT into clinical workflow. In this session, panelists will discuss some of the latest human factors research and design trends in advancing the design of modern exam and hospital rooms, considering the additional complexity introduced by HIT. This panel includes a diverse set of human factors professionals with a wealth of combined healthcare experience in government, academe, and industry.

PANELIST STATEMENTS

How Introducing Technology Changes the Nature of Work in Healthcare

Militello, Applied Decision Science. Laura Militello is cofounder and senior scientist at Applied Decision Science. She has been studying decision making in complex settings for over 20 years. Recently she has had an opportunity to contribute to the design of a next-generation electronic health record (EHR) for the VHA and provide usability testing for the Indian Health Service EHR.

For this panel, Ms. Militello will explore five ways in which EHRs have changed the nature of work in healthcare. First, and perhaps the most visible, is the shift from a paper chart that can be easily held, skimmed, and written on while facing the patient and maintaining eye contact to a computer screen that requires more focused attention from the clinician. Some have reported reduced eye contact and degraded rapport with the patient. Others highlight the ability to leverage the computer screen as a tool to share graphs and visual data with patients to increase engagement in understanding and managing their own care (Militello et al., 2014; Montague et al., 2011).

Second, EHRs have increased the documentation demands on clinicians (Saleem, Adams, Frankel, Doebbeling, & Patterson, 2013). Digital data raises the possibility of better tracking of quality measures, longitudinal research, and a more complete record of an individual's health conditions and treatment over time. In order to achieve these aims, however, more detailed records of patient encounters must be maintained and the data must be purposefully captured, often in prescribed forms. The data entry burden on clinicians has increased, competing for time spent interacting directly with patients. In addition, reliance on the EHR as the repository of health information has decreased person-to-person communication within the healthcare team. In one high-visibility example, information about a patient's recent travel history was carefully documented by a nurse, but not read by

the rest of the healthcare team. As a result, the first Ebola patient in the US was discharged from the emergency department, exposing both healthcare workers and the public to the virus.

Third, expectations for access to patient data are increasing. In a project to re-design a leading EHR, clinicians and pharmacists report a need to integrate data from different locations in the EHR. They need to view laboratory data, medications, and vitals at the same time to determine whether a change in medication is having the desired effect. They need to compare lists of medications prescribed during a hospital stay with the medications prescribed by the primary care provider to identify duplications and potential drug-drug interactions unnoticed by individual prescribers. Because EHRs do not currently support this type of data integration, clinicians report using multiple screens or printing portions of the EHR to allow for careful analysis and integration.

Fourth, EHRs make it harder to tailor forms locally. Changes to electronic forms in the EHR often require considerable time and money. As a result, clinicians develop and use "shadow charts" and other paper-based job aids that allow for quick edits, and personalized strategies for organizing and representing key information to better support real-time assessment and decision making (Xiao et al., 2009).

Fifth, EHRs change the nature of decision making. Workflows are depicted as linear, discouraging non-linear problem-solving and communication patterns (Ash, Berg, & Coiera, 2004). Priorities shift as some activities (i.e., documentation) become auditable and others (i.e., developing rapport with the patient) are not. Often information is presented in a manner that violates expectancies, so clinicians must adapt a decision process to anticipate what the technology is "thinking".

Examples of the five ways in which EHRs have changed the nature of work in healthcare will be discussed.

Promoting Eye Contact in Primary Care Contributes to Positive Patient Outcomes

Montague, Northwestern University. Dr. Montague's research explores the role of trust in technology, as well as clinician-patient interaction in primary care. She has been an invited speaker on these topics at several prestigious conferences and universities.

To characterize the effects of clinician nonverbal behaviors on patient nonverbal interaction and perceptions of clinicians, a randomized controlled trial evaluated the effects of clinician training on improving patient perceptions of the clinical visit. 271 patients saw clinicians that they had no prior relationship with for cold symptoms. Clinicians were randomly assigned to behave in either a standard or enhanced condition. In the enhanced condition clinicians made efforts to create rapport by patient-oriented talk and by nonverbal behaviors such as making eye contact. The encounters were videotaped and the nonverbal interactions were analyzed. In this study, the clinicians were trained to interact with patients either in standard (type A) or enhanced modes (type B). The results of this study show that the training of enhanced behaviors was successful in increasing the clinicians' amount of positive nonverbal behaviors in the encounter. Additionally, when clinicians engaged in rapport-building nonverbal interactions such as eye contact, they were able to positively influence patient nonverbal behaviors and patient perceptions of clinicians. Results of this study could be used to develop training for physicians and to determine how technologies should be designed to facilitate positive interpersonal interactions in health encounters. If eye contact is important to rapport building and ultimately to improved health outcomes, then technologies should support and not impede such nonverbal cues.

Results. The total duration of the visit was longer for type B (enhanced) than type A (standard). Observed median visit time was 465 seconds for B versus 199 seconds for A, and in the mixed effects model (adjusting for physician effect), type B visits were 2.3 times longer than type A visits ($p < 0.001$). By visit phase, type B visits had a 1.91 times longer pre-exam phase, a 1.49 times longer exam phase, and a 7.36 times longer post-exam phase compared to type A visits (fit by mixed effects models, $p < 0.001$ for each).

Clinician gaze time at the patient was greater for type B than type A visits, both in absolute duration and as a percentage of the visit. Observed median clinician-to-patient gaze duration was 261 seconds for B versus 41 seconds for A, and the observed median percentage of total visit time the clinician spent gazing at the patient was 55% for B versus 21% for A. The mixed effect model estimated clinicians spent an additional 62% of the pre-exam phase, 14% of the exam phase, and 13% of the post-exam phase gazing at the patient for type B visits versus type A visits ($p < 0.001$ for each estimate).

Similarly, time spent by the patient gazing at the clinician was greater for type B than type A visits, both in absolute duration (median of 200 versus 46 seconds) and as a proportion of the visit (43% versus 24% of visit duration). The mixed effect model estimated patients spent an additional 32% of the pre-exam phase and 13% of the exam phase gazing at the clinician for type B versus type A visits ($p < 0.001$ for each estimate). Notably, for type B visits versus type A visits, patients spent 15% less of the post-exam phase gazing at the clinician ($p < 0.001$), but this translated into 5.82 times more gaze time because of the longer post-exam phase duration ($p < 0.001$).

Time spent in mutual gaze, defined as simultaneous clinician-to-patient and patient-to-clinician gaze was higher in type B versus type A visits: an additional 53% of the pre-exam phase ($p < 0.001$), an additional 10% of the exam phase ($p < 0.001$), and an additional 6% of the post-exam phase ($p = 0.012$) was spent in mutual gaze for type B visits.

The exam room of the future should consider the effectiveness of patient-centered exam room on patient outcomes such as adherence to medical advice. Patient-centered designs would minimize distractions that take physician attention away from patients. These designs may also include tools that afford better information exchange and dialogue between patients and care providers.

Mitigating the Negative Effects of Interruptions

Trbovich, University of Toronto. Dr. Trbovich is a leading human factors researcher in Canada in the area of how environments, technology, workflow processes, and human characteristics affect patient safety and the healthcare system.

Dr. Trbovich will present the results of studies assessing: (1) the effects of interruptions on clinician workflow, medication ordering, verification and administration tasks; and (2) the impact of various types of interventions at mitigating negative effects of interruptions.

Study 1. The first study focused on interruptions encountered by nurses during medication verification and administration in an ambulatory chemotherapy unit. A combination of ethnographic observations, laboratory-based simulations and focus group sessions were conducted to assess the relationship between interruptions and errors, to in turn support the design of successful and appropriate interventions. Ethnographic observations revealed that nurses were interrupted, on average, 22% of their time and were frequently interrupted during safety-critical stages of medication administration, which decreased task efficiency (Trbovich, Prakash, Stewart, Trip, & Savage, 2010). The laboratory-based simulations showed that significantly more nurses committed medication errors when interrupted than when uninterrupted (Prakash et al., 2014). Focus groups were used to identify interventions. Laboratory-based simulations revealed that technological solutions that automated tasks and relieved memory burden placed on nurses (e.g., clinical information technology systems with cueing functions that reminded nurses of outstanding verification items) were more effective at reducing errors of detections, whereas "people-dependent" interventions (e.g., visual signage and speaking-aloud) were more effective at reducing errors of commission. Given that interruptions represent a complex sociotechnical phenomenon, mitigation interventions must be tailored to the error types to be effective.

Study 2. The goal of this research was to examine the nature, frequency, and timing of interruptions during medication ordering and to quantify the use of coping mechanisms by oncologists (Trbovich et al., 2013). Ethnographic observations were conducted at a cancer treatment facility. On average, oncologists were interrupted 17% of their time and were frequently interrupted during safety-critical stages of medication ordering. When confronted with interruptions, oncologists engaged/multitasked more often than resorting to deferring/blocking. Results also showed that interruption must not necessarily be viewed negatively. The chemotherapy ordering process often requires oncologists to interact with other health professionals such as fellows, residents, pharmacists, other oncologists, nurses, and clerks, to share information. Therefore, practitioners engaged in managing and contributing to chemotherapy ordering must maintain a shared assessment of the situation. Understanding how to support a team member's situation assessments is an important consideration when assessing interruption mitigation strategies. That is, solutions that aim to reduce interruptions caused by communication must incorporate other compensatory ways of supporting team members' common situation assessment.

Study 3. The goal of this ethnographical study was to report on the rate of interruptions observed during primary tasks in a cardiovascular intensive care unit (CVICU) of varying severities (low, medium, high), with a particular focus on comparing different interruption contents (Sasangohar, Donmez, Easty, Storey, & Trbovich, 2014). Results of the study revealed that nurses spent approximately 50% of their time conducting medium-severity tasks (e.g., documentation), 35% conducting high-severity tasks (e.g., procedure), and 14% conducting low-severity tasks (e.g., general care). The rate of interruptions with personal content observed during low-severity tasks was 1.97 (95% CI: 1.04, 3.74) and 3.23 (95% CI: 1.51, 6.89) times the rate of interruptions with personal content observed during medium- and high-severity tasks, respectively. We concluded that interrupters might have evaluated task severity before interrupting. Increasing the transparency of the nature and severity of the task being performed may help others further modulate when and how they interrupt a nurse. Overall, rather than try to eliminate all interruptions, mitigation strategies should consider the relevance of interruptions to a task or patient as well as their urgency.

In addition to summarizing the findings from these studies, Dr. Trbovich will discuss how these findings can be generalized and adapted to mitigate interruption-related errors in other settings where medication verification and administration are required.

The Workflow of Medication Ordering and Implications for Prescriber-Patient Interaction

Russ, Roudebush VA Medical Center. Dr. Russ is a human factors Research Scientist with the Veterans Health Administration (VHA) and has been leading research on informatics and medication safety since 2007. To date, her research has focused on the outpatient care setting, with a particular emphasis on the design and evaluation of computerized decision support tools for adverse drug reactions, drug-drug interactions, and drug-disease warnings (Russ et al., 2014). She has completed approximately 100 hours of observation to examine medication ordering workflow (Russ, Zillich, McManus, Doebbeling, & Saleem, 2012), and more recently, has been conducting critical incident interviews with prescribers. The goal of the latter is to reconstruct actual patient cases and identify cues that prescribers use to make effective medication decisions.

Medications are the most common therapeutic intervention for patients and medication errors are a common cause of preventable harm. In the outpatient setting, medications decisions are generally made during a brief encounter between the provider and the patient, which is often 30 minutes or less. Many important tasks occur in this brief period of time, including patient assessment, physical exam, treatment decisions, ordering medication through a computerized provider order entry system (CPOE), addressing patient questions and concerns, and counseling the patient on

the treatment plan. Thus, health information technologies must promote workflow efficiency and also support medication safety.

Dr. Russ' research has identified at least three major workflows for medication ordering in the outpatient setting (Russ A.L., Saleem J.J., McManus M.S., Frankel R.M., & Zillich, 2010). These workflows can be described as a 'discrete' approach, where a prescriber completes CPOE tasks after the patient encounter, and in a separate room; 'task switching' approach, where a prescriber shuttles back and forth repeatedly between a computing room and the patient's exam room to complete medication ordering; and 'integrated' approach, where a prescriber completes CPOE work as part of the patient encounter in the exam room. Each of these workflows has unique challenges and implications for the prescriber-patient interaction. For instance, while the 'integrated' workflow has many advantages, it may impede collaborative discussions with clinical colleagues and pharmacists, often necessary to resolve medication conflicts.

There has been recent emphasis on promoting shared decision-making between healthcare providers and patients, and it is not a stretch to propose that, in the future, this may include encouraging both parties to view the EHR interface simultaneously during the patient appointment. However, prescribers have raised concerns that if medication alerts - especially the numerous false alarms - are viewed by patients, this may cause patients to become unnecessarily anxious about their medications. Prescribers' concerns are not unfounded. Patients' lack of medication adherence is already a major barrier to effective treatment (Zullig, Peterson, & Bosworth, 2013). Patients' anxiety about highly technical alerts may only exacerbate poor adherence and negatively effect health outcomes. In addition, in one study, 21 out of 30 prescribers reported difficulty interpreting the alerts themselves (Russ et al., 2012). Thus, it could be challenging for prescribers to explain an alert to the patient and provide reassurance that the medication is necessary and safe. In this presentation, Dr. Russ will summarize findings from across her various studies with respect to workflow in the outpatient exam room and present case examples that illustrate facilitators and barriers to the prescriber-patient interaction.

Designing a Hospital Room to Meet the Needs of all Stakeholders

Patterson, The Ohio State University. Dr. Patterson's research in health informatics and transitions in care has been recognized as seminal in identifying negative unintended consequences associated with the implementation of HIT. Dr. Patterson was a co-author on three national standards, published by the National Institute of Standards and Technology (NIST), for assessing the usability of EHRs to improve their integration into clinical workflow and to enhance patient safety.

The Hospital Room Design Project, funded by the National Institute for Occupational Safety and Health (PI: Steve Lavender), has the overarching research question: "How can the modern hospital room be designed to meet the needs of all stakeholders, including patients and families, who enter the room?" A mixed methods study was employed, using focus groups, interviews, ethnographic observations, and interdisciplinary participatory design sessions using realistic mock-ups of modifiable room elements, including movable walls and doors.

To date, twenty distinct room layouts have been generated by small, heterogeneous groups of study participants, hospital staff members who spend some or most of their time working in patient rooms, who were tasked with designing the room in which they would like to work. Issues of concern with current rooms were made known through focus groups, interviews, and observations involving a total of 193 participants representing 25 unique stakeholder groups, including patients and family members (Table 1). Two layouts have emerged as the dominant patterns: the patient bed against the left wall relative to the hallway door, with either an inboard bathroom with the bathroom door about midway between the hallway door and the patient bed, or with an outboard bathroom directly across the room from the hallway door. These two patterns represent differential weightings on fundamental tradeoffs such as minimizing patient falls and minimizing the need to move furniture to clear a path.

In this presentation, the data analysis is limited solely to the needs for supporting collaboration while in the modern hospital room. Primarily, these needs were met with whiteboards, information technology (desktop, laptop, tablet), lighting, entertainment systems (TV, monitors), controls for sound systems, and call buttons. Unlike some elements in the room (such as recliner, family sofa, staff sink), some of these elements had high variation in placement and use in the various room designs. In addition, interesting innovations were suggested, typically to meet the needs of their stakeholder group, patients, or families.

TABLE 1: Hospital room collaboration needs and innovations associated with various stakeholder groups

Stakeholder Group	No. Participants	Collaboration Needs	Innovations for Collaboration and Communication
physician	6	Look patient in the eye at eye level, educate patient using markers on whiteboards, show patients x-ray images, distance trainees from physician-patient interactions, look at both patient and family members without turning the body	"Whiteboard wall" next to patient bed, quickly turning off TV audio and turning on lights upon entering the room, benches on the far wall for trainees, stools
nurse	18	Look patient in the eye while typing on a keyboard, be in the room near the door while charting, write contact information that the patient can see	Monitors that swivel near the patient bed, night lighting to check IVs, night lighting to enter the room without tripping

nurse assistant	10	Do charting while in the room with the patient, coordinate care activities with the nurse	
speech language pathologist	5	Communicate with patient who cannot talk via a small portable whiteboard	Foldable tray to hold whiteboard or clipboard
dietitian	6	Review chart while in the room with the patient	
diet tech, nutrition aide	15	Order meals through the TV/remote/iPad	Foldable tray from wall to hold meal, shelf for tray in entry zone
sitter	3	Be able to see the patient while doing all activities in the room, including charting without full room lighting, seating within arms' reach of patient without standing	
x-ray tech, ultrasound tech, echo tech, vascular tech	18	Know if patient is engaged in activity that should be private to respect patient dignity or precautions to avoid infections (e.g., A-line placement) without first entering the room	
* clinical engineer	21	Be able to navigate to the patient room, know if patient is in the room ** this stakeholder group also includes building operation, construction tech, mechanical shop, system shop, zone tech*	
patient	21	See whiteboard from the bed without glasses, rest/sleep despite people entering the room, avoid being startled when people enter the room (want to face the door but be able to not be viewed from the hallway to protect privacy), access personal IT, control lighting, temperature, sound, blinds from the bed, view displayed personal items (flowers, religious objects, cards, photos), have dry surface for signing paper forms	Dedicated shelves and spaces for personal IT and items, outlets for personal IT, magnetic whiteboard for cards and photos
family member	10	Write down questions to remember to ask staff when they arrive on whiteboards, access personal IT, outlets for IT	Chair with movable wheels to come closer to the bed and move out of the way of staff without standing, fold-away surfaces for eating and IT use

Note: *In addition to the stakeholders listed above, 3 case managers, 11 physical therapists, 9 occupational therapists, 5 respiratory therapists, 10 patient transporters, 13 housekeepers, and 4 information technology staff also participated in the study, for a total of 193 participants during the observations, interviews, and focus groups and 280 participants overall including the simulation sessions.*

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