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Electronic Health Records and Improved Patient Care: Opportunities for Applied Psychology

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Abstract

Healthcare is undergoing an unprecedented technology transition from paper medical records to electronic health records (EHRs). While the adoption of EHRs holds tremendous promise for improving efficiency, quality and safety, there have been numerous challenges that have been largely centered on the technology not meeting the cognitive needs of the clinical end-users. Clinicians are experiencing increased stress and frustration, and new safety hazards have been introduced. There is a significant opportunity for applied psychologists to address many of these challenges. I highlight three key areas: studying and modeling clinician needs, applying theoretically grounded design principles, and developing technology to support teamwork and communication.

Keywords

electronic health records; cognition; perception

During visits to your healthcare provider, you may have already noticed many providers no longer using paper records, working instead on electronic health records (EHRs). EHRs are replacing the traditional paper-based patient record and transitioning many clinical tasks that were once paper-based to the electronic medium. Clinical tasks such as documenting the visit, ordering medications, ordering diagnostic and laboratory tests, viewing test results, and tracking patients are now electronic. The promise of EHRs is that they will open the door to a digital future that allows for new capabilities that were never before possible leading to improved quality, efficiency, and safety.

We have seen a rapid adoption of EHRs in the United States with over 80% of hospitals using EHRs in 2015 compared to less than 10% in 2008 (Office of the National Coordinator for Health Information Technology, 2015), as shown in Figure 1. This increase has been driven by the federal government's Health Information Technology for Economic and Clinical Health (HITECH) act passed in 2009. Over \$40 billion dollars have been publicly

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invested to promote the adoption of EHRs with part of these funds being used to provide incentive payments for EHR use to healthcare providers leading to an unprecedented technology transition. The transition to EHRs has proven to be complex and expensive with some EHRs containing thousands of functions and taking years to design, develop, and successfully implement at the healthcare provider site. A large healthcare system adopting an EHR can spend hundreds of millions of dollars to purchase, implement, maintain, and train their staff to use these systems (Koppel & Lehmann, 2014).

Many other industries have experienced and realized the benefits of large-scale technology transitions. The banking industry's technology transition resulted in 24/7 customer access to money through ATMs, use of electronic funds transfers across institutions, and internet banking (Berger, 2003). Aviation and defense, which like healthcare are high-risk industries, have also successfully undergone technology transitions that have improved safety and efficiency. Similarly, the widespread adoption of EHR technology in healthcare has promise. If leveraged appropriately, the EHR and resulting digitization of health information has the potential for improved clinician performance and patient care by utilizing the inherent capabilities of software systems (King, Patel, Jamoom, & Furukawa, 2014). Information that was once limited by the constraints of paper can now be readily accessible in near real-time by multiple providers across the country. New capabilities can be developed such as decision support that provide automated and contextually relevant alerts based on a patient's history and current condition, or that highlight critical information in the record to complement the clinicians reasoning and decision-making process (Middleton, 2009).

Although certain benefits from EHRs have been realized (King et al., 2014), the transition to this technology has been challenging. Lessons learned from other high-risk industries have shown that it is important to recognize the entire socio-technical system (Carayon, 2006) when integrating technology and that applied psychologists are critical to understanding how people interact with the technology to perform their work. Engaging applied psychologists in design, development, and implementation of technology is critical for its safe, effective, and efficient use. Applied psychologists are formally trained in psychology, or a related field, and focus on practical problems.

While there are some applied psychologists and experts in human-computer interaction working in the area of health information technology, mostly in informatics (Zhang & Walji, 2014), given the recent rapid and large-scale adoption of EHR technology there are significant challenges and the number of applied psychologists do not meet current demand (Karsh, Weinger, Abbott, & Wears, 2010). Recent studies have shown that many EHR developers, which are the companies that design, develop, and sell EHR products, do not adhere to government standards that require these companies to consider the needs of clinician end-users and do not have enough staff with the skills to design and develop systems that meet end-user needs (Ratwani, Benda, Hettinger, & Fairbanks, 2015; Ratwani, Fairbanks, Hettinger, & Benda, 2015). Applied psychologists have a unique opportunity, and the ability, to dramatically improve the transition to, and use of EHR technology that will have a long-term impact on patient safety. In particular I focus on the potential contributions of psychologists specializing in experimental, cognitive, industrial/organizational and engineering psychology.

Challenges with the Transition to Electronic Health Records

The transition to EHRs has created safety concerns and increased clinician frustration and stress (Friedberg et al., 2013; Walker et al., 2008). The poor design of EHRs is largely recognized as a major source of these challenges (Meeks et al., 2014; Zahabi, Kaber, & Swangnetr, 2015). Many EHR products are not designed with an in depth understanding of the cognitive or perceptual needs of the clinician (Ratwani, Benda, Hettinger, & Fairbanks, 2015; Ratwani, Fairbanks, Hettinger, & Benda, 2015). Consequently, the user interface, workflow within the EHR, and integration of EHRs into clinical routines has led to safety hazards, inefficiencies and overall dissatisfaction during use (Benda, Meadors, Hettinger, & Ratwani, 2016). In depth analyses of how clinicians perceive and store information in memory, process and reason with clinical information, and make decisions are often not part of the design, development, and implementation process for EHRs (Ratwani, Fairbanks, et al., 2015).

Several safety hazards associated with EHRs have been described and error taxonomies are being developed to understand these hazards (Magrabi, Ong, Runciman, & Coiera, 2010; Wetterneck & Walker, 2011). Some of these errors can have catastrophic consequences for patients. For example, one type of error that has been observed is wrong patient selection where a clinician mistakenly selects the wrong patient in the EHR and orders a medication, lab or imaging study, or takes some other action that was never intended for that patient (Adelman et al., 2013). This can result in patients receiving the wrong care (e.g. wrong medication, test, or procedure) resulting in adverse consequences. There are several causes of wrong selection errors, including the poor design of interfaces that do not protect against clicking on the wrong patient and do not make the patient's name salient in the record.

Complexities of Developing Electronic Health Record Technology

Designing and developing EHR technology that supports the needs of the clinician and overcomes the transition challenges is no small feat. There are complexities, unique to healthcare, that make designing and developing EHR technology a demanding process that requires a deep and nuanced understanding of the healthcare environment (Durso & Drews, 2010). First, healthcare is composed of numerous subspecialties (e.g. emergency medicine, cardiology, oncology etc.), each with their own particular information needs and workflows. Second, there are several different users of the EHR (e.g. physicians, nurses, technicians, environmental services, billing staff, etc.) and each user may have their own unique needs and goals. With staff needs varying by subspecialty and specific role, designing a uniform EHR solution is difficult; rather, the needs of each type of user and subspecialty must be taken into consideration and embraced by the EHR.

The rigorous industry timelines under which design, development, and implementation of EHR technology occur and the resource constraints during this process adds an additional layer of complexity (Ratwani, Fairbanks, et al., 2015). Software developers, product managers and other EHR development company staff are often working under rigorous design and development timelines in order to move their product to market as rapidly as possible.

Opportunities for Applied Psychologists to Advance EHR Utility and Safety

Many EHR developers do not have staff with the expertise required to understand the cognitive, perceptual, and workflow needs of clinicians, design and develop products that account for these needs, and effectively test products for efficiency, effectiveness, and safety (Ratwani, Fairbanks, et al., 2015). Similarly, most providers lack the expertise to understand where the EHR falls short in meeting the needs of users and optimizing to improve utility and safety. EHR developers and providers have limited resources to tackle the technology challenges that they face. Some EHR developers may not have easy access to clinical environments to study the clinician user population and may not have access to participants to test their products.

Below, I outline three key areas where applied psychologists can leverage their knowledge and skills to dramatically improve EHRs. Applied psychologists can advance the current state of EHRs by not only applying psychologically-based theories and principles, but also by developing new tools and techniques that meet the context specific needs of EHR developers and healthcare providers. Although there are safety science lessons that can be borrowed from aviation and defense, the healthcare domain, and EHR technology, pose new challenges for applied psychologists and provides the opportunity for developing innovative tools that can better support EHR developers and users.

Studying and Modeling Clinician Needs and Work Processes

Observing and documenting the behaviors and work processes of clinicians in their live clinical environment to develop an understanding of how clinicians do their work is still not a pervasive practice in the EHR industry. While there are select developers that have employed the appropriate experts to conduct these observational sessions and develop the appropriate knowledge base to inform their products, many vendors still have not adopted this critical practice (Ratwani, Fairbanks, et al., 2015). As a result, many products not only fail to support work processes, but they also do not account for (and compensate for) interruptions, distractions, and other environmental factors that have an influence on clinicians. The rigorous industry timelines for design and development are often highlighted as a barrier to conducting in-depth observational sessions (Ratwani, Fairbanks, et al., 2015).

As an example of the disconnect between how clinicians think about clinical information and the EHR interface Figure 2, below, shows how a clinician often documents vital signs on paper (left) and in one version of an EHR (right). Paper allows for the rapid collection of information in a generally standard format the clinician is accustomed to. The EHR represents the information in a different order and presents numerous options, some of which are unnecessary, for temperature, heart rate, and blood pressure that increase the amount of time to collect vital signs.

Many EHR developers do not employ standard methods for studying and modeling clinical processes such as conducting work domain and task analyses (Kirwan & Ainsworth, 1992; Vicente, 1999), developing human performance models, designing and developing interfaces based on these models, and testing interfaces with the appropriate experimental design and metrics. Consequently, EHRs are developed with poor support for clinicians. For example,

when physicians place certain medication orders through the EHR they may need to know the vital signs of the patient, however, many EHRs do not present this information to the physician on the same screen as the medication ordering procedure. Consequently, physicians have to either memorize the information which unnecessarily increases memory load and is error prone, or the physician has to exit the medication ordering process to check the vital signs resulting in inefficiencies during the ordering process.

There is a need for applied psychologists to develop models of clinician work to drive design and development, and a need for the development of processes and tools that can be easily used by different EHR developer staff in a short timeframe. Researchers have developed some tools to address this need (Zhang & Walji, 2011), however, these tools have not been widely adopted. The application of GOMS (John & Kieras, 1996) (i.e. Goals, Operators, Methods, and Selection Rules) modeling to understand human information processing in the context of computer interface development and other interface modeling methods could dramatically reduce the cognitive burden placed on clinicians and improve the safety of EHRs.

Application of theoretically grounded design principles

Many EHRs violate basic display principles and create significant information processing challenges for clinical users (Middleton et al., 2013). Oftentimes EHR displays are poorly organized such that critical information is not salient and cluttered with irrelevant information forcing clinicians to search for information that should be readily apparent (Moacdieh & Sarter, 2015). For example, when examining blood draw results some interfaces do not group the results under meaningful topics, do not utilize color to highlight abnormal values, or do not clearly display the time associated with the result leading to clinicians making decisions based on information that may be outdated.

Engineering psychologists, and human factors engineers, have leveraged well-developed theories of cognition and perception to develop numerous design principles that clearly describe display organization, such as proximity, similarity, and common fate (Köhler, 1967; Palmer, 1992; Wickens & Andre, 1990). Similarly, theories describing color perception (Breslow, Trafton, & Ratwani, 2009) and principles guiding the use of color to facilitate the efficient processing of information from displays are available, but have not been utilized extensively in the design of EHR interfaces. Many EHRs violate basic layout and color guidelines resulting in software that is difficult to interact with. EHR systems frequently truncate text resulting in information that is difficult to interpret and require clinicians to scroll through long tables to find pertinent information. The application of these principles has the potential to transform the way clinicians interact with EHRs and can alleviate much of the cognitive burden currently felt by clinicians by displaying information in a more logical and intuitive representation.

Using graphs and other data visualization techniques to effectively communicate information and support clinicians' ability to detect trends and patterns more easily is also a challenge for many current EHRs. There are several theories of graph comprehension, and resulting design principles, to guide the design of graphs and visualizations, yet few of these principles are followed (Aigner, Miksch, Müller, Schumann, & Tominski, 2007; Anscombe,

1973; Ratwani, Trafton, & Boehm-Davis, 2008). One recent study examined the graphical display of diagnostic test results in 8 different EHR systems and found most systems violated basic principles including failing to display the x and y-axis labels, graphing information in reverse chronological order, and erroneously graphing intermittent data as equally spaced data points (Sittig et al., 2015). Ambiguous information displays and displays that misrepresent information may lead clinicians to draw the wrong conclusions from clinical data resulting in missed diagnoses and inappropriate treatment plans.

Supporting Teamwork and Communication

Healthcare often requires careful coordination as multiple clinicians with diverse backgrounds work together to deliver patient care, and communication failures are a major cause of error (Leonard, Graham, & Bonacum, 2004). Often EHRs do not support effective communication despite research highlighting high risk events where poor communication is known to be prevalent (Yackel & Embi, 2010). Patients are likely to experience shift changes which entail a “hand-off”, meaning one clinician is leaving and a new clinician is starting their shift. Shift changes are recognized areas of risk across industries (Durso, Crutchfield, & Harvey, 2007). During hand-offs it is critical that pertinent patient information is accurately communicated from the departing clinician to the arriving clinician (Kitch, Cooper, Zapol, & et al., 2008). Communication around medication ordering and administration is another area where communication failures have contributed to errors (Zhan, Hicks, Blanchette, Keyes, & Cousins, 2006). A common practice like placing a medication order often requires effective communication between the physician placing the order, the pharmacist reviewing the order, and one or more nurses administering the medication.

EHRs have fundamentally changed the social interactions between clinicians, and between the clinician and the patient. The introduction of EHR technology has, unfortunately, led to less face to face communication between team members, uncomfortable interactions between clinicians and patients, and decreased situation awareness (Taylor, Ledford, Palmer, & Abel, 2014). The complexity of EHR interfaces has led to ambiguity over what information is conveyed between clinicians, which can lead to critical information being completely missed. For example, a physician may place a medication order with special instructions typed in a comment field (e.g. only administer with food) which then gets communicated to the nurse through the EHR, but special instruction information is not salient when the nurse is administering the medication and is often missed. The design and implementation of EHR technology must consider the communication patterns of clinicians and support processes like hand-offs in order for clinicians to maintain situation awareness. Recognized communication processes like closed-loop communication should be designed into the EHR (McElroy, Ladner, & Holl, 2013). In addition, lessons learned about communication and technology from aviation and defense may translate to healthcare, and where necessary new models of teamwork and communication that support the unique complexities of healthcare may need to be developed.

Conclusion

As healthcare experiences a dramatic shift away from paper to EHRs there is an opportunity for applied psychologists to leverage their knowledge and skills to ease this transition and improve the safe use of this technology. With few experts available to address the challenges associated with EHRs I have outlined three key focus areas where applied psychologists can have a major impact: methods to understand and model user needs, interfaces that are driven by theoretically grounded design principles, and techniques for supporting teamwork and communication. These three areas are just the start, but will go a long way towards helping EHRs reach the promise of improved quality, efficiency, and safety.

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Recommended Reading

- A thorough book describing the transition to, and challenges associated with, electronic health records. Wachter, RM. *The digital doctor: hope, hype, and harm at the dawn of medicine*—a computer age. New York: McGraw-Hill Education; 2015.
- This paper describes current EHR vendor design and development practices. Ratwani RM, Fairbanks RJ, Hettinger AZ, Benda NC. Electronic health record usability: analysis of the user-centered design processes of eleven electronic health record vendors. *Journal of the American Medical Informatics Association*. 2015; 22(6):1179–1182. [PubMed: 26049532]
- A comprehensive report on health information technology and patient safety. Institute of Medicine. *Health IT and Patient Safety: Building Safer Systems for Better Care*. Washington, DC: The National Academies Press; 2012.
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Figure 1.

Electronic health record (EHR) adoption rate by year (from dashboard.healthit.gov).

Vitals				
Oral <input type="text"/>	Rectal <input type="text"/>	Axillary <input type="text"/>	Temporal <input type="text"/>	Tympanic <input type="text"/>
Apical HR <input type="text"/>	Peripheral Pulse Rate <input type="text"/>	Heart Rate Monitored <input type="text"/>	Respiratory Rate <input type="text"/>	
Automated				
Systolic/Diastolic BP <input type="text"/> / <input type="text"/>	Mean Arterial Pressure <input type="text"/>			
Manual				
Systolic/Diastolic BP <input type="text"/> / <input type="text"/>	Mean Arterial Pressure <input type="text"/>			
SpO2 <input type="text"/>	O2 Flow Rate <input type="text"/>	FI02 <input type="text"/>		

Figure 2.

Heart rate, blood pressure, respiratory rate, oxygen saturation, and temperature (Celsius) as generally written by clinicians (left) and as would need to be entered in one type of EHR.