Impacts of EHRs on Patient Health Outcomes

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Zayyad Siddiqui

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

Advisor

Sean M. Ferguson, Department of Engineering and Society

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Despite medical errors accounting for 251,000 deaths per year and being the third leading cause of death in the US, big data healthcare technology has only recently made progress to address this major concern for patients (Anderson & Abrahamson, 2017). Since 2009, the US federal government has spent over $3.8 trillion in healthcare annually (*Healthcare Spending Hits $3.8 Trillion*, 2020). This equates to over $10,000 spent per individual. However, Americans continue to suffer from low life-expectancy rates and high infant-mortality rates demonstrating that more spending does not necessarily mean better care.

As part of the Health Information Technology for Economic and Clinical Health (HITECH) Act of 2009, the mandate for primary care providers to adopt a meaningful electronic health record (EHR) system aimed to push the healthcare system into the modern digital age (Balestra, 2017). A meaningful EHR system is described as a digitalized repository of patient data that contains information such as medical history, medications, immunizations, laboratory data, and more. Over the past few years, the EHR system has automated and streamlined the clinical workflow thereby transforming the way patient care is delivered while hoping to drive down healthcare costs.

Prior to 2009, most clinicians utilized paper medical records that were prone to high error placing patients at high risk of misdiagnosis (Rodziewicz et al., 2021). By incorporating clinical decision support tools, the EHR system has transformed medical data into actionable insight for clinicians and consequently altered clinical treatment procedures and patient outcomes (Catalyst, 2018). An analysis of the impacts of the EHR system on patient health outcomes, the doctor-patient relationship, and the overall patient experience will highlight the significance of big data technology in healthcare**.** Actor-Network Theory (ANT) is being applied in order to show how

social effects, particularly patient health outcomes, are generated as a result of the dynamic relationships between human and non-human actors within the healthcare network (Cressman, 2009). The perspective provided by ANT demonstrates the need for these actors to reorganize their relationships around the EHR system in order to facilitate effective integration of the EHR system into the healthcare environment. Given the current uncertainty of whether the EHR system should be implemented in the US, ANT provides a deeper insight on the evolution of the EHR system and its role in revolutionizing the way care is provided to patients. In order to understand the implications of big data technology in healthcare from a patient perspective, the following question must be addressed: How does the implementation of the electronic health record (EHR) system in US healthcare impact patient health outcomes?

Actor-Network Theory in Healthcare

Actor-Network Theory (ANT) is an STS framework that considers human and non-human elements as actors within a heterogeneous network (Cressman, 2009). ANT helps map shifting networks of relationships, especially when a non-human actor, such as the EHR system, is introduced into a human-centric network, such as healthcare. The key stakeholders in the healthcare network that will be of main focus include the EHR system, the patient, and the clinician. However, the perspectives of the EHR companies and the federal government will be brought in to provide a comprehensive view on the impact of EHR systems. The purpose of ANT is to track the propagation of clinical knowledge insights and agendas amongst these key stakeholders while also highlighting who is empowered or hindered by the implementation of EHR systems. Prior to the implementation of EHR systems, clinicians were viewed as obligatory passage points who had domain expertise in medicine. In contrast, patients relied on clinicians for effective care, and therefore, patients were seen as passive recipients of healthcare due to lack

of clinical knowledge. This power dynamic structure is what has allowed healthcare to achieve temporary stability in the past.

However, the introduction of the EHR system in the US has disrupted and forced the healthcare network to restructure and reorganize its relationships. When the EHR system was first being introduced into medical practice in 2009, the adoption rate of EHR systems was less than 10% and met significant resistance from certain clinicians (Balestra, 2017). A 2013 National Academy of Medicine study found that some clinicians initially declined to integrate EHR systems into their clinical workflow with the fear of experiencing clinician burnout during data entry or losing clinical agency to technology. Other clinicians noted limited time, resource constraints, and lack of available training support as additional barriers to EHR system adoption (Ajami & Bagheri-Tadi, 2013). Given that clinicians would serve as the main end-users of EHR systems since they directly input much of the information, clinician resistance would greatly hinder widespread adoption of the EHR system. However, clinician resistance would be short-lived, because in 2009, the US government also began to provide financial incentives to clinicians who demonstrated meaningful EHR use in their practice. Furthermore, newly emerging evidence surrounding the benefits of using EHR systems would convince some clinicians to adopt them in the hopes of improving patient safety and quality of care.

Patient Health Outcomes

With its increased adoption in 2009, EHR systems have transformed the landscape of healthcare from solely relying on clinicians for medical knowledge to now integrating big data technology into the clinician's decision-making. As part of the government's meaningful use criteria, certified EHR systems have to be able to deliver the right information to the right person in the right intervention format through the right channel at the right time in workflow

(Campbell, 2013). Given the variety of proprietary EHR systems available for purchase, meaningful use requirements would ensure that the adopted EHR system prioritized quality, safety, and efficiency. To uphold these values, certified EHR systems were required to have the following three functionalities: clinical decision support (CDS) tools, computerized physician order entry (CPOE) systems, and health information exchange (HIE) interfaces. These 3 supplementary components of the EHR system were intended to create core linkages between the EHR system and the clinician in order to improve clinical work practices.

Clinical Decision Support

Clinical decision support (CDS) tools are software designed to be a direct aid to clinicians in decision-making by providing information that is filtered or targeted to a specific patient or situation. CDS tools mainly utilize machine learning algorithms to match a patient's characteristics to useful patterns in a clinical knowledge database to predict the likelihood that a patient's health will decline (HealthITAnalytics, 2020). Patient characteristics may include demographics, symptoms, or past medical history. CDS tools can then utilize artificial intelligence to present personalized recommendations to the clinician for a decision on the next step.

Basic CDS functions include alerting clinicians to potential errors such as medication allergies and reminding clinicians to provide preventative care. Advanced CDS functions include helping clinicians make diagnoses and assisting clinicians with patient-specific treatment plans (*What Are Clinical Decision Support Tools?*, 2020). For example, a group of researchers at the Geisinger Clinic developed prediction models using EHR data to identify patients at high risk for heart failure. Predictive analytics showed that heart failure could be predicted more than 6

months before clinical diagnosis therefore allowing clinicians to use this knowledge to preemptively intervene through aggressive treatment (Wu et al., 2010).

Several studies have also shown that CDS tools have been linked to an increased adherence to evidence-based clinical guidelines. A *New England Journal of Medicine* study has shown that after CDS implementation, computerized immunization reminders led to a jump in influenza vaccination rates from 0% to 35% for hospitalized patients (Menachemi & Collum, 2011). Metrics such as vaccination rates are population-based and therefore show the potential for EHR systems to improve the quality of care on such a large scale. Furthermore, a *Journal of the American Medical Informatics Association* case study found improved results as well after implementing CDS tools. After combining CDS tools with a computerized surveillance algorithm, clinical researchers noticed that sepsis mortality rates at an Alabama hospital decreased by 53% (HealthITSecurity, 2017). Researchers found that real-time analytics alerted clinicians to new diagnoses of sepsis through detection of worsening vital signs and provided recommendations for treating patients with the infection. As seen, CDS tools have demonstrated their ability to assist clinicians through informed decision-making.

While most clinicians initially disproved of being told what to do by CDS tools, several clinicians have realized that taking a hint from them could be a matter of life or death for the patient. Jerome Osheroff, MD, former chief clinical informatics officer, views CDS tools as "a process for enhancing health-related decisions and actions with clinical knowledge and patient information to improve health and healthcare delivery" (*Clinical Decision Support*, 2015). Similar to Dr. Osheroff, the majority of clinicians would realize that EHR systems aimed to reduce variations in practice by guiding clinicians to what is considered best practice as determined by the nation's leading clinicians and health informaticists. These same clinicians

would also appreciate the benefits of having a clinical companion, the EHR system, right beside them in the healthcare network that could understand medicine at the highest level.

Computerized Physician Order Entry

The second required EHR tool, a computerized physician order entry (CPOE) system, allows clinicians to prescribe medications electronically and send treatment instructions via a computer application. CPOE systems also allow providers to enter and send laboratory, admission, radiology, referral, and procedure orders through a computer application. A common norm amongst American hospitals is the idea that CPOE systems lead to "less paper pushing and lower administrative costs" (Holden, 2012). The purpose of a CPOE system is to ensure clinicians produce standard, legible, and complete orders thereby reducing paper-based medical errors (*What Is Computerized Provider Order Entry* , 2018). By limiting medical errors, CPOE systems decrease medical costs, morbidity rates, and mortality rates amongst patients paving the way to a safer and efficient healthcare system.

In a before-after randomized controlled trial for CPOE systems, hospital medication errors decreased by 55% from 10.7 events per 1000 patient days to 4.86 events per 1000 patient days (Bates et al., 1998). Furthermore, by having clinicians submit orders electronically, CPOE systems were able to directly deliver prescriptions and lab results to pharmacies and labs in a timely and efficient manner. When CPOE systems and CDS tools were combined, the collective EHR system was shown to prevent a significant number of medication errors by alerting clinicians of medication allergy risks in real-time as clinicians were electronically prescribing drug dosages.

Despite CPOE systems being able to streamline the clinical workflow, CPOE systems have met significant clinician resistance due to claims that they require time to understand its

logistics. In a 2017 joint open letter, 11 chief executives of medical centers warned that CPOE systems "radically altered and disrupted established workflows and patient interactions" and are a main contributor for clinician burnout (Hecht, 2019)**.** To alleviate these concerns, EHR companies like Allscripts and Epic Systems have focused on human-centered design. Through tools such as voice recognition and digital scribes, these companies are hoping to reduce the clinician's time spent entering information and increase the clinician's time spent with the patient (*Pandemic-Era Burnout*, 2020). In order to improve usability of CPOE systems, EHR companies have also focused on improving the user-experience to ensure that the voice of the end-user is factored into how the system is utilized. For example, generating pre-populated information fields based on a clinician's usage history or preference has become more common. In particular, if a clinician favors one drug over another, the CPOE system can suggest the preferred drug as one of the top choices to select from which in effect makes order entry quicker and more accurate ("EHR Usability," 2021). By addressing the workflow needs of clinicians, CPOE systems have been able to improve the clinician's productivity and efficiency in the hopes of contributing to a stable healthcare network.

Health Information Exchange

The third major EHR tool, a health information exchange (HIE) interface, allows clinicians to access and share patient information electronically in real-time with other clinical providers. Before HIE interfaces, patient information was shared between providers through mail, fax, or patients traveling themselves. Given that a clinical provider does not have access to information physically stored at another provider's location, HIE interfaces reduce the cost for redundant testing such as those done in imaging, laboratory, and radiology.

An outpatient study found that HIE interfaces led to a 14.3% decrease in the number of diagnostic tests ordered per visit demonstrating that EHR systems can help avoid wasting of resources (Menachemi & Collum, 2011). If resources can be conserved, then this could potentially translate into saved money for clinicians and patients. Furthermore, the shared structure of patient records also accurately reflects how throughout a patient's lifetime, personal medical data accumulates in a wide variety of different places ranging from clinician offices to pharmacies to hospitals. Therefore, the EHR system has the ability to follow patients in time and space and provide clinicians easy access to patient information.

From an ANT perspective, HIE interfaces serve as a stabilizing force of the healthcare network by allowing clinicians to communicate with one another and achieve interoperability. Interoperability is known as the extent to which EHR systems can exchange data and interpret the shared data. The Office of the National Coordinator for Health Information Technology has developed interoperability standards that govern the overall framework for creating clinical documents as well as mediums for sending information securely. Unfortunately, variations in the way EHR companies adopt and implement interoperable standards have limited the success of EHR systems in the past. In 2015, only 6% of clinicians were able to share patient data with other clinicians who used a different EHR system (Reisman, 2017). A lack of government incentives for EHR vendors to develop interoperable systems in the first place is partly to blame for the inability to formulate a fully integrated healthcare network.

In general, CDS tools, CPOE systems, and HIE interfaces make up the meaningful use criteria. When the three tools are collectively integrated, several past studies have shown that medical errors can be reduced by as much as 83% (Menachemi & Collum, 2011). The full-scale implementation of the three tools was consequently associated with a 15% decrease in patient

mortality rates in hospitals (Amarasingham et al., 2009). These statistical measures demonstrate the effects of the three tools on patient health outcomes. By combining clinical support, efficiency, and interoperability, the EHR system has altered the way clinicians practice medicine and the way patients are treated in the healthcare network.

Doctor-Patient Relationship

Considering that the dialogue between doctors and patients is pivotal in medicine, it is important to look at the EHR system's impact on the doctor-patient relationship (DPR). Some studies in the past have shown that EHR systems may introduce negative communication outcomes between doctors and patients. For example, Alkureishi et. al. (2016) demonstrated that during a physical visit, patients expressed concern about losing eye-contact with doctors who were more focused on their EHR computer screen than them. The study also noted interrupted doctor and patient speech patterns consisting of awkward pauses leading to unnatural conversation (Alkureishi et al., 2016). However, in the end, the systematic review found that EHR systems either led to no change or slight improvements in overall patient satisfaction and the DPR. In certain cases, patients even perceived the EHR system as a communication and discussion facilitator as it gave patients and doctors a shared resource to guide conversation. Plus, features such as patient-to-provider email or instant-messaging would keep patients connected to their doctor after the physical visit (*Post-EHR Changes in Communication*, n.d.). Furthermore, patients noticed that EHR systems also led to an increased efficiency amongst doctors in regards to the time needed to retrieve laboratory data. Instead of having the doctor pace back and forth between the lab and the exam room, EHR systems could rapidly upload the data from the lab technician and provide doctors quick access to the results. Overall, while EHR systems have solidified their presence as a third party in the exam room by fostering

collaboration between the doctor and patient, they have introduced unintended consequences that still need to be addressed. Therefore, future studies are needed in order to identify how best to use the EHR system to ensure quality doctor-patient interaction.

Patient-Centered Healthcare

The recent shift toward patient-centered healthcare has reaffirmed the belief that patient care is the number one priority in medicine. Patient-centered healthcare is defined as when the patient actively participates in one's own medical treatment through close cooperation with the clinician (Greene et al., 2012). To promote patient-centered healthcare, EHR systems provide web-based portals to give patients access to their personal medical information. Patient portals help streamline many tasks such as allowing patients to make appointments, request prescription refills, or ask clinicians questions through secure email. The patient portal also allows a patient to now serve as a clinical assistant by having the patient engage more with one's own data. Through patient portals, patients can even report errors present in their own record in order to help them better themselves through self-care.

However, a patient is not a disciplined clinical assistant as one does not have the clinical expertise to properly analyze and understand all the medical information presented in a record. Without proper health literacy, a patient can misinterpret sensitive information online which could lead to confusion or anxiety and ultimately jeopardize one's health. In hoping to increase the patient's understanding of clinical data, patient portals have integrated links to definitions of complex medical terms and detailed explanations, utilized graphics and animations to track trending data, and substituted non-technical language for medical terminology (Irizarry et al., 2015). By allowing patients to take ownership of their data, patient portals allow patients to educate themselves and feel responsible in improving their own health.

A major concern in patient-centered healthcare is whether the benefits of EHR systems outweigh the associated risks in the network. Nowotny and Schot (2018) provide a co-concurrent assumption of technology that in the end "the overall balance will be positive and everyone will benefit" (Nowotny & Schot, 2018). For EHR systems, this assumption is only possible if healthcare coverage (and therefore EHR coverage) is extended to all Americans. Furthermore, the double-edged sword nature of EHR systems is linked to how EHR systems have led to improvements in the accessibility and quality of care, yet the systems themselves are prone to security and privacy risks. The *HIPAA Journal* reports that since 2009, the number of healthcare data breaches in the US has been on the rise with more than 113 million records in total that have been either exposed, stolen, or impermissibly disclosed ("Healthcare Data Breach Statistics," 2020). One common explanation for the rise in breaches is that healthcare data is much more valuable than credit card information and therefore more lucrative for cybercriminals. The presence of personally identifiable information can allow cybercriminals to then use the data for extortion purposes or identity theft (TBConsulting, 2020).

In response to this trend, a 2012 study demonstrated that 12% of patients withheld personal information from their providers in fears of having private information exposed (Campos-Castillo & Anthony, 2015). Security and privacy concerns amongst patients have been a major reason for the slow adoption of EHR systems. However, another similar study found that the benefits outweighed the risks where 64% of patients believed benefits, such as patient-provider communication and lower costs, outweighed privacy risks (Gaylin et al., 2011). In addition, HIPAA requires EHR systems to have the three pillars to securing health information: technical safeguards, physical safeguards, and administrative safeguards. These pillars consist of techniques ranging from controlling the physical location of EHR systems to the implementation

of firewall software to protect health information. To gain trust from patients, EHR systems must highlight the levels of built-in protection, including passwords and encryption of data. Through this development of trust, patients can only then realize the benefits of becoming actively engaged in their health.

The Healthcare System and its Future Stability

In review, for EHR systems to be effectively integrated into the healthcare network, trust must be established between clinicians and patients. While the network was initially unstable when the EHR system was first introduced, government incentives have fostered interdependent relationships between EHR systems, clinicians, and patients. Power dynamics have also changed where the doctor is now seen as a less central figure and the patient is viewed as a more involved clinical assistant. While the EHR system maintains the original knowledge hierarchical structure with clinicians as the top experts, the gap between clinicians and patients has become smaller thereby fostering a collaborative environment. One limitation with the utilization of ANT was that only a few prominent actors were considered during the analysis even though the healthcare network consists of several other stakeholders with their own personal agendas. While the introduction of dangerous stakeholders such as cybercriminals into healthcare is always possible, the EHR system has developed a new “Iron Triangle” with the patient and the clinician as the backbone structure for the healthcare network. Even though the network may evolve and change over time, these three stakeholders will not be easily eliminated. Given their collective efforts in fostering a stable healthcare system, the three stakeholders will hope to maintain power and overcome any health challenge that comes their way.

Conclusion

Given the recent rise of the coronavirus pandemic, the ability for clinicians to quickly access patient data has become of critical importance for diagnosis and treatment. As of 2018, 98% of US hospitals had installed a meaningful EHR system (EHRIntelligence, 2019). As the landscape of US healthcare evolves beyond the pandemic, EHR systems will continue to impact patient health outcomes, the doctor-patient relationship, and the overall patient experience. To understand these impacts, this paper has utilized the documentary research method to synthesize the varying arguments of clinicians and patients in order to create a comprehensive narrative of the EHR system. In addition, this paper has demonstrated strong connections between EHR implementation and improved patient health outcomes through metrics such as decreased medical errors and lower mortality rates. However, the impacts of EHR systems have shown to be more nuanced than originally assumed. While the EHR system has fostered collaboration between the doctor and the patient, it has also introduced several unintended consequences such as changes in clinical workflows for clinicians and privacy and security concerns for patients. Successfully addressing these challenges will require the collective effort of multiple stakeholders to voice their opinions and make significant contributions to the healthcare network.

In ANT, the primary actors that were focused upon were the EHR system, the patient, and the clinician. Through the utilization of ANT, the EHR system has shown to transform healthcare from relying on clinicians as obligatory passage points to now focusing more on patient-centered care. Furthermore, the EHR system has fostered the opening of knowledge-forming communities within healthcare by mentoring clinicians through clinical decision support tools and educating patients through web-based portals. Through tools such as CPOE systems and HIE interfaces, the EHR system has prioritized efficiency and interoperability thereby

promoting a stable healthcare network. The overall analysis through ANT has also demonstrated that the EHR system is not a solver of all problems, but that it can maximize the social good for patients and create the foundations for social progress.

In promoting social progress, EHR systems have already collected information on millions of Americans throughout the years allowing clinicians to generate new knowledge insights on a population scale. In the future, EHR systems will hope to harness the full power of advanced big data technology to sharpen our understanding of best practices and deliver personalized care. Such systems will help to incorporate the latest evidence-based treatments into a patient's care plan based on their health status and then monitor how each patient responds in order to improve the care plan for the next patient (Glaser, 2020). With time and proper integration into healthcare, EHR systems will become the standard to help clinicians make better informed decisions in order to further improve patient health outcomes and enhance the quality of life for all.

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